PROCEEDINGS

The 2018 International Conference on ICT for Rural Development (IC-ICT RuDev)

October 17-18th, 2018

At Pullman Bali Legian Beach Hotel

ICT Infrastructure and Application for Rural Development

ICT Ecosystem for Rural Development

Social Economic Implications of ICT in Rural Development

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PROCEEDING

2018 International Conference on ICT for Rural Development (IC-ICTRuDEv)

"Rural Development through ICT: Concept, Design, and Implication"

October 17th - 18th, 2018

Bali, Indonesia

ICT Research and Human Resource Development Agency
Ministry of Communication and Information Technology
Republic of Indonesia

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Foreword from Conference Chair

It is my pleasure to welcome you to the 2018 International Conference on ICT for Rural Development (IC-ICTRuDev) in Bali, Indonesia, on October 17th - 18th, 2018. The IC-ICTRuDev 2018 is the first international conference organized by ICT Research and Human Resource Development Agency, Ministry of Communication and Information Technology, Republic of Indonesia, which technically co-sponsor by IEEE Indonesia Section. This remarkable forum is held to aim at least 3 goals:
First, to get valuable input and ideas based on the results of empirical research or scientific critical review, from experts, practitioners, and researchers, from within and outside the country, on the issue of the use of ICT for rural development. Indonesia's government nowadays is actively developing policies/programs to improve the accessibility and usefulness of telecommunications and information in rural areas, based on evidence, facts and field data, specifically related to infrastructure and application solutions, ecosystem development, and socio-economic impacts of ICT development in rural areas. Therefore discussion in international forum related to this issue will be beneficial. *Second*, to build a network of collaboration between the ICT Research and Human Resource Development Agency of MCIT and industry, research institutions, and universities from inside and outside the country. And *third*, to provide space for researchers, practitioners and observers in the field of ICT and social sciences to publish the results of their research, to international forums, through IEEE publishers that have guaranteed its accreditation.

In this forum, we are honoured to have 8 experts related to ICT and rural development as the Speakers of the seminar: Mrs. Helani Galpaya, CEO of LIRNEasia SriLanka; Prof. Wataru Imajuku, from Kindai University Japan; Prof. Wolfgang Dechsler from Estonia; Dr. Roger W. Harris from Hong Kong; Dr. Masugi Inoue from NICT, Japan; Mr. Paul Scanlan, Huawei CTO from China; Mr. Agus Witjaksono, Vice President of Network Deployment & Services, Telkomsel; and Mr. Anang Latif, President Director of BAKTI MCIT.

After extensive reviews, about 32 from 48 submitted papers were accepted for the presentations at the conference and will also be forwarded for consideration to be published in the IEEE Xplore Digital Library. The presenters are researchers and practitioners coming from Indonesia, Malaysia, Australia, Japan and Portugal. The reviewers as many as 32 persons, 8 of them are from overseas affiliations: Australia, Malaysia, Denmark, and Portugal, have played an active role in assessing the papers with blind review.

Finally, we wish you a fruitful conference, and enjoyable moments in Bali. On behalf of the organizing committee, we would like to apologize for any inconvenience during the conference and express our gratitude to all parties for the support to make this conference outstanding.

Dr. Wiryanta, MA.
General Chair of IC-ICTRuDev 2018

2018 International Conference on ICT for Rural Development (IC-ICTRuDEv)
Bali - Indonesia, October 17th - 18th 2018

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Program Schedule

Day 1 – 17th October 2018

Room: Ballroom

08.00 – 09.00	Registration
09.00 – 09.30	Opening Ceremony National anthem "Indonesia Raya" Report Speech from General Chair of IC-ICTRuDev 2018 *Dr. Wiryanta, MA.* Welcome speech from IEEE Indonesia Section *Prof.Dr.Fitri Yuli Zulkifli, M.Sc* Opening Remarks from Head of ICT Research and Human Resource Agency *Dr. Basuki Yusuf Iskandar, MA.* Traditional dance
09.30 – 10.00	Keynote Speech 1: Secretary General of Communication and Information Technology, Republic of Indonesia, *Farida Dwi Cahyarini* "ICT Rural Development in Indonesia"
10.00 – 10.30	Keynote Speech 2: *Helani Galpaya* (CEO LIRNEasia, Sri Lanka) "ICT Access, Use and Impacts in the Global South"
10.30 – 11.00	Keynote Speech 3 : *Dr. Wataru Imajuku* (Kindai University, Japan) "Challenges and Solutions to ICT Deployment in Rural Area"
11.00 – 12.00	Q&A Session *Moderator: Prof. Ris. Gati Gayatri (MCIT)*
12.00 – 12.10	Souvenir Handover and Photo Session
12.10 – 12.15	Doorprize
12.15 – 14. 00	Lunch Break
14.00 - 16.30	Parallel Session (Paper presentation – 3 Tracks)

Room 1 – Track: ICT Application For Rural Development
Moderator: Dr. Didi Rosyiadi (LIPI)

14.00 – 14.20	**Knowledge Management Readiness in Local Government of Archipelago: A Case of South Halmahera, Eastern Indonesia** *Assaf Arief, Dana Indra Sensuse* (Faculty of Computer Science, University of Indonesia)*, Iis Hamsir Ayub Wahab* (Faculty of Engineering, University of Khairun Ternate, Indonesia)

14.20 – 14.40	**Revitalization of Warehouse Receipt System Through Business Process Improvement in order to Support National Food Security** *Yan Andriariza Ambhita Sukma, Emyana Ruth Eritha Sirait* (ICT Research and HR Development Agency of Ministry of Communications and Information Technology/MCIT, Indonesia)
14.40 – 15.00	**Cloud Computing and E-Commerce Adoption in Indonesia: Mind the Gaps** *Fahrizal Lukman Budiono, Sim Kim Lau, William John Tibben* (School of Computing and Information Technology University of Wollongong Australia)
15.00 – 15.20	**Forecasting the Number of Patients at RSUD Sukoharjo Using Double Exponential Smoothing Holt** *Rini Anggrainingsih, Alfath Prabanuadhi, Sarngadi Palgunadi Yohanes* (Informatics, Faculty of MIPA University of Sebelas Maret Surakarta)
15.20 – 15.40	**Bunda Cermat: Integrating Financial, Nutrition and ICT Literacy for Women in Indonesia** *Yoke S. Irawan, Annisa Riyani, Allya P. Koesoema, Dody Q. Utama* (Biomedical Engineering Research Group Institut Teknologi Bandung, Indonesia), Soegijardjo Soegijoko (Indonesian eHealth and Telemedicine Society Bandung)
15.40 – 16.00	**The Ebario Story: ICTs for Rural Development** *Roger Harris, Narayanan A, L N. Kulathu Ramaiyer* (Institute of Social Informatics and Technological Innovations Universiti Malaysia Sarawak), John Tarawe (Bario sub-District, Miri City Council Sarawak, Malaysia)
16.00 – 16.20	**The Design and Implementation of Data Visualization for Integrated Referral and Service System** *Kodrat Mahatma, Bayu Waseso, Wirdawati Darwin* (PENTA Foundation)

Room 2 – Track: ICT Infrastructure for Rural Development
Moderator: Mr. Satriyo Darmanto (IEEE IS)

14.00 – 14.20	**A Multi-dimension Data Traffic Forecasting Model for Rural Areas** *Annisa Sarah* (Electrical Engineering Department, Faculty of Engineering Atma Jaya Catholic University of Indonesia)
14.20 – 14.40	**Antenna Design for Multi-generation 2G–5G for Rural Area Wireless Communications** *Dammar Adi Sujiansyah, Budi Syihabuddin, Khoirul Anwar, and Nachwan Mufti Adriansyah* (Center for Advanced Wireless Technologies (AdWiTech), Telkom University)
14.40 – 15.00	**Development of Long-range Communication System for Fishermen: An Initial Study** *Trio Adiono* (School of Electrical Engineering and Informatics, Institut Teknologi Bandung), *Febri Dawani, Erick Adinugraha, Aditia Rifai, Muhammad Arijal, Syifaul Fuada, Irfan Gani Purwanda, Husnan Ahmad Samhany* (University Center of Excellence on Microelectronics, Institut Teknologi Bandung)
15.00 – 15.20	**Functionality Test of Communication Systems based on LoRa Technology in Oil Palm Plantations Area** *Trio Adiono* (School of Electrical Engineering and Informatics, Institut Teknologi Bandung), *Febri Dawani, Aditia Rifai, Syifaul Fuada, Irfan Gani Purwanda* (University Center of Excellence on Microelectronics, Institut Teknologi Bandung)

15.20 – 15.40	**Spectrum Considerations for 5G in Indonesia** *Alfin Hikmaturokhman* (Department of Electrical Engineering, Universitas Indonesia/Institut Teknologi Telkom Purwokerto), *Kalamullah Ramli, Muhammad Suryanegara* (Department of Electrical Engineering, University of Indonesia)
15.40 – 16.00	**Telkom University 5G Channel Models Under Foliage Effect and Their Performance Evaluations** *Evander Christy, Rina Pudji Astuti, and Khoirul Anwar* (Center for Advanced Wireless Technologies (AdWiTech), School of Electrical Engineering, Telkom University)
16.00 – 16.20	**The Potential Use of High Altitude Platforms Station in Rural Telecommunication Infrastructure** *Eddy Setiawan* (Study Group of HAPS Indonesia-ITU Concern Forum (IICF) Jakarta, Indonesia)

Room 3 – Track: ICT Ecosystem for rural development
Moderator: Mr. Suryanegara (University of Indonesia)

14.20 – 14.40	**ICT Development Strategies for Farmer Communities in Rural Papua** *Christiany Juditha* and *Maulia Jayantina Islami* (ICT Research and HR Development Agency, MCIT Indonesia)
14.40 – 15.00	**ICT Development Strategy for Rural Areas in West Java** *Diana Sari, Didit Praditya, C. Suprapti Dwi Takariani* (BPSDMP Bandung, ICT Research and Human Resources Development Agency, MCIT Indonesia)
14.00 – 14.20	**The Importance of the Internet for Economic Development: An Empirical Evidence from Indonesian Rural Household** *Kasmad Ariansyah* (Centre for R&D on Resources, Equipment, Posts and Informatics Operations, MCIT Indonesia/University of Indonesia)
15.00 – 15.20	**The Potential Adoption of the Internet of Things in Rural Areas** *Kautsarina* (Faculty of Computer Science Universitas Indonesia), *Diah Kusumawati* (Centre for R&D on Resources, Equipment, Posts and Informatics Operations, MCIT Indonesia)
15.20 – 15.40	**Assessing the Information Technology Governance Trust Using Readiness and Usability Models: A Model Development Study** *Resad Setyadi* (Bung Karno University, Jakarta), *A'ang Subiyakto* (Syarif Hidayatullah State Islamic University, Jakarta), *Aedah binti Abd Rahman* (Asia e University, Selangor, Malaysia)
15.40 – 16.00	**Blockchain-based Digital Currency and Financial Inclusion: Just a myth?** *Ibrahim Kholilul Rohman, Soumaya Ben Dhaou, Joao Marco* (UNU-EGOV Guimaraes, Portugal)

Day 2 – 18th October 2018

Room: Ballroom

09.00 – 09.10	Opening by MC
09.10 –11.00	Plenary Speakers "Addressing the ICT Sustainable Ecosystem and Maximizing Its Impact in Rural" Practitioners: 1. Danny Januar Ismawan (Director of IT Services for Government and Society, BAKTI) 2. Agus Witjaksono Sulistya (VP Network Deployment and Services, Telkomsel) 3. Mr. Paul M. Scanlan (CTO, Huawei) Academicians: 4. Prof. Wolfgang Dechsler (Tallinn University of Technology, Estonia) 5. Dr. Roger W. Harris (University Malaysia Sarawak) 6. Dr. Masugi Inoue (NICT, Japan) Moderator: Prof. Kalamullah Ramli (UI)
11.00 – 12.00	Discussion
12.00 – 12.10	Souvenir Handover and Photo Session
12.10 – 12.15	Doorprize
12.00 – 14. 00	Lunch Break
14.00 - 16.30	Parallel Session (Day 2: 3 Tracks)
16.30 – 17.00	Closing Remarks & Announcement of Best Paper

Room 1 – Track: ICT Application For Rural Development
Moderator: Mr. Satriyo Darmanto (IEEE IS)

14.00 – 14.20	**Telemedicine Design for Rural Areas as a Framework of E-Health Implementation** *Ahmad Budi Setiawan* (ICT Research and HR Development Agency, MCIT Indonesia), *Aries Syamsudin, Danny Ismarianto Ruhiyat* (National Cyber Security Defence)
14.20 – 14.40	**Sikesal Implementation Analysis for Developing Electronic Based Public Services at Jambi City** *Dede Mahmudah* (BPSDMP Jakarta, ICT Research and HR Development Agency, MCIT Indonesia), *Badar Agung Nugroho* (ICT Research and HR Development Agency, MCIT Indonesia)
14.40 – 15.00	**Towards Development of Academic Information System -as-a-Services** *Kautsarina, Haris, Assaf Arief, Dana Indra Sensuse* (Faculty of Computer Science, University of Indonesia)
15.00 – 15.20	**Village Library And Social Media: Communicating "Puro Village Library" To Costumers Through Facebook Account**

Monika Sri Yuliarti (Department of Communication Science, University of Sebelas Maret Surakarta, Indonesia), *Rahmat Setiawan Saefullah* (Department of Library Science University of Sebelas Maret Surakarta, Indonesia)

15.20 – 15.40 **COBIT-based Critical Asset Evaluation of Electronic Certificate Management in Government Bodies: Study and Analysis**
Yulandi, Yohan Suryanto, Kalamullah Ramli (Department of Electrical Engineering, University of Indonesia)

Room 2 – Track: ICT Application For Rural Development
Moderator: Mr. Satriyo Darmanto (IEEE IS)

14.00 – 14.20 **Digital Poverty and Empowerment Issue in Indonesia**
Anton Susanto (Centre for R&D on Resources, Equipment, Posts and Informatics Operations, MCIT Indonesia)

14.20 – 14.40 **Measuring Gender Gap on the Internet Access and Use in Indonesia**
Vidyantina, Kasmad Ariansyah (Centre for R&D on Resources, Equipment, Posts and Informatics Operations, MCIT Indonesia)

14.40 – 15.00 **Society Acceptance Strategies for Digital Public Broadcasts in Border Area**
Diah Yuniarti, Wardahnia (Centre for R&D on Resources, Equipment, Posts and Informatics Operations, MCIT Indonesia)

15.00 – 15.20 **Internet Information-Communication Skills and Overloads as influencing factors of ICT Rural Adoption**
Vience Mutiara Rumata (ICT Research and HR Development Agency, MCIT Indonesia)

15.20 – 15.40 **Preliminary Work on Design Thinking: Addressing Challenges Using Low-Fidelity Prototyping With Rural Teenagers**
Masitah Ghazali (ViCubeLab Research Group School of Computing Universiti Teknologi Malaysia), *Nurelida Mohd Efendi* (School of Computing Faculty of Engineering Universiti Teknologi Malaysia), *Norhaida Mohd Suaib* (UTM Big Data Centre Universiti Teknologi Malaysia), *Aminah Beran* (Mini RTC Layang-Layang Kulai, Malaysia), *Sarina Sulaiman* (UTM Big Data Centre Universiti Teknologi Malaysia)

Contents

A Multi-dimensions Data Traffic Forecasting Model for Rural Areas

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***Abstract*—Traffic forecasting is the baseline for planning future network. A failure to forecast traffic demand might lead to sloppy network design which needs to be rearranged later. That such rearrangement will require additional cost. The network infrastructure in rural area is not attractive for commercial based broadband network providers. But, it is important to provide internet access for villagers since internet may give positive impacts on social development. Hence, the mobile traffic demand forecast method needs wider perspectives other than technical records of network providers only. This research introduces a multidimensional model to predict data traffic demand in the future , by combining government spatial planning, demography statistics, and network records. Two different areas were studied and analyzed: Panimbang and Leuwidamar districts, which are located in Banten Province, Indonesia. Main parameter to compare single- and multi-dimensions model is the areal traffic demand. For Panimbang, the areal traffic demand for multi-dimensions model has 24 Mbps/km^2 higher, compared to the single-dimension model. For Leuwidamar, the demand for multi-dimension is 10 Mbps/km^2 lower, compared to the single-dimension. In Panimbang, a pessimistic forecasting might not be a big problem since adding cells in a dense area is not costly, however for Leuwidamar, multi-dimensions models could help to design a more efficient network since the single-dimension model is too optimistic and leads to a high capital investment for providers. This multidimensional model suits best for remote and sparsely distributed users(Leuwidamar). However, it might gives no high impact for residential or urban areas (Panimbang).**

***Index Terms*—Traffic modeling, Mobile Broadband, Data Traffic, Rural, Remote**

I. Introduction

Traffic forecasting is the initial step to plan an efficient cellular network. Forecasting the trend helps worldwide telecom companies to form corporate strategies globally. Reports such as [1] and [2] are successfully taking pictures of global, continental and national growth of mobile subscribers. One of the methods is by using historical data, such as regular traffic measurement of hundreds of live networks in major regions. Since the network subscribers are mostly live in urban areas, the global data is more suitable for big cities. What about other types of areas, such as rural and remote areas?

A published global forecast might not be useful for local situation, especially for marginal areas such as rural or remote areas. The argument is that there are so many differences between rural and urban areas in terms of population density, demography, social economy, geography, politics and others. Therefore, to understand data consumption behavior in rural areas, the study of other potential parameters should be included to predict the traffic in the future.

A failure in forecasting a suitable traffic in rural area may leads to a sloppy infrastructure development planning and would cause financial loss for the network providers. In most cases, after the network being deployed, the generated income might be way smaller than the investment cost. The network providers may relocate the installed network if that certain area does not generate profitable income for them. That relocation needs additional cost. Consequently, we need new approach to measure network planning in rural areas that differs in urban ones. In addition, we need to find an efficient solution to deploy a rural network to minimize the capital cost. There are studies to measure the techno-economic impacts of new technologies, with aim to maximize the technical aspects and minimize the capital and operational expenditure, e.g. for LTE Deployment [3], [4] and porspective 5G [5].

However, deploying a telecommunication network is not only about generating profit. A socio-economic analysis shows that such service would improve people welfare [6]. In rural area, villagers are able to access information to educate themselves, enable remote health-services, and enable small business (e.g. rural banking, smart-farming, etc). As telecommunication network could help many kinds of sectors, it is important to consider the multidimensional aspect that this paper aim to contribute to. The first and main aim of providing rural connectivity is to improve people welfare, so all effort should be centralized to society. The Ministry of ICT of Republic of Indonesia has a nation-wide project, to provide fiber optic connection that aims to serve as a backbone [7]. Yet, to reach the ”last-mile”, we need to address the needs of it carefully.

Techno-economics and socio-economics analysis of broadband development has been studied. However, there is lack of study that combine them all: technical, economical, and social aspects. This research aims to answer: 1) What parameters that important to be considered when modeling a traffic demand?; and 2) What are the impacts of using multidimensional-based

data traffic modeling compared to a single dimensional (e.g. commercial values) model?. The traffic model is simulated by using case studies in Indonesia rural districts: Leuwidamar and Panimbang Area, in Banten Province, Java Island.

This paper is structured as follows: In Section II, we discuss related works and literature research to address current knowledge of related topics. In Section III, we provide research method that includes the parameters and assumptions. In Section IV, we provide the simulation based on cases study. Lastly in Section V, we summarize and conclude the research results.

II. Literature Review

Generally, researchers and engineers use existing traffic records to model the traffic which leads to a detailed measurement-driven model [9], [10]. Such measurement-driven model successfully captured a traffic characteristic (mostly dense urban) to forecast global future traffic demands. In [10], they characterize future traffic by: number of sessions, inter-arrival time, volume of traffic, and session duration. With around 1 billion sessions, it is highly possible to model traffic with the advantage of a big amount of data, which mostly were generated from urban areas. However, the number of subscribers in rural areas is very limited, and the gathered data might not be enough to capture the generic trends.

If we look closely to social impacts of telecom technology, studies show that there are behavior relations between traffic generated to several factors, e.g. age, gender, human behavior of using spaces, etc [11], [12]. Since a big amount of data could depict human behavior, it can be used in other sectors to make their strategic planning in the future. For example, in [12], the traffic records were used for future strategic planning in tourism. Specifically, research in [11] could help the municipality to address people movement in urban districts. In other words, if the recorded data could be interpreted to several factors, we could say that there is causality between mobile traffic to those factors. Thus, it is important to deploy network considering those factors, to have an efficient network with high impact to society.

However, most of traffic modeling studies uses urban areas cases. Yet, the behavior and characteristics between urban and rural areas are different in many factors. Thus the published, generic, and common traffic model (such as in [1]) could not be adapted for rural. There are several efforts to modeling traffic demand specifically for rural. For example, Energy Aware Radio and Network Technologies (EARTH) research teams introduce a traffic model for Europe, corresponds to a specific area: dense urban, urban, suburban, rural, and wilderness areas [13]. Rural characteristic with the case of Europe areas was defined as follow: 100 citizen/km^2 on average for rural, 25 citizens/km^2 on average for sparsely populated and wilderness; rural has less heavy users i.e. few users who need a data-heavy app such as streaming; Steady daily traffic variation, i.e. peak hours has no significant difference compared to normal hours.

EARTH uses population density as a parameters to classify areas of study and to define traffic profile based on UMTS forum's mobile traffic forecast to see a variation of users. EARTH model shows that traffic modeling should be different in regards to population density, devices capability (normal user, heavy user), and daily traffic profile. The more data that is considered to, the more suitable the model to realistic cases.

For this paper, firstly we address the impacts of providing data service in rural, to find an opportunity for additional parameters that need to be considered for the traffic model. Then, we study realistic cases current condition as a pilot project.

A. Addressing Rural condition in Indonesia

Three main social aspects that related to ICT which are Social Welfare, Social Bonding, and Social Culture [14]. In terms of social welfare, the local governments in Indonesia have designed a Long-Term Development Plan of the Region (*Rencana Pembangunan Jangka Panjang Daerah*, RPJPD). RPJPD is a government's strategic planning for about 20 years span, with the main aim is to address natural and human resources to develop the area, from spatial usage to economic growth.

Traffic modeling is used to map a telecommunication infrastructure network in the future, so it also depends on the mapping of people, or spatial planning. RPJPD has been the main reference for further strategic actions, one of them is Regional Spatial Plans (*Rencana Tata Ruang Wilayah/RTRW*). Based on this RTRW, we could know whether the area is meant to develop as industrial areas, habitation, plantation, etc. Such spatial utilization will highly affect the traffic forecasting model.

B. Technology Indicators in Rural

There is wide social and technological gap between urban and rural. Among 34 provinces in Indonesia, Banten is located nearby to Jakarta the capital city. However, the gap between two provinces remains exist. We study two samples of South Banten area: Panimbang in Pandeglang Regency, and Leuwidamar in Lebak Regency. The main reason is that both regencies have quite a large area (28% and 35% of total area), and lowest population density compared to other regencies (435 and 371 people/km^2 respectively). The Ministry of CIT (the MCIT)'s survey research shows that only 32% of the rural population using an internet. However, based on a provider's record in the studied area, the mobile data users might be way smaller than that.

III. Methods

The main workflow and process of this research are discussed in Subsection III-A, and the parameters used for simulation is in Subsection III-B.

A. Framework and Work Diagram

For the main framework, we adopt the EARTH model to classify rural traffic demand and add several parameters as considerations to mimic the real situation in Indonesia. The traffic forecasting accounts four main processes: Population

density and its growth, Device Capability, User Type, Average Subscription. The flow process diagram can be seen in Fig. 1.

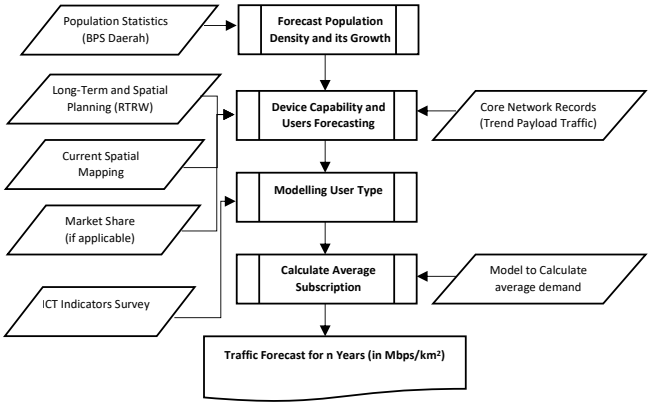

Fig. 1. Workflow of Traffic Forecasting

1) Population Density and Growth of Users: We investigate population density records for past years to estimate the expected number of population in the future. The increase in population growth might differ from the increase in the number of users, for user penetration might sharply increase because of cheaper devices or other reasons. As the situation between Leuwidamar and Panimbang is different, statistical data from the regional Central Bureau of Statistics *(Badan Pusat Statistik, BPS)* shows a different population increase. Statistics and local current conditions are gathered from the yearly report of regional BPS, both province, and district. The YoY Population growth in Pandeglang District (Which Panimbang located) is 0.55%, and in Lebak District (Leuwidamar) is 0.83% *(Kabupaten)*, details can be seen in Table II [18]–[20].

2) Device Capability: It represents a total number of users that capable to access 2G, 3G, and/or 4G in the area. We consider only 3G and 4G users that have a high possibility to access mobile data. Device capability records can be gathered from the core network of telecommunication providers. Data records that used in this research were from one provider only, thus to mimic actual users, we study current market-share and found that 60% of fishermen and farmer users nation-wide are using our studied providers [21], [22]. We took this specific job title, as most people in Panimbang and Lewidamar work in fishery or agriculture. Next, we calculate Total User by using (1).

$$\text{Total User} = \frac{Subscribers}{0.6} \tag{1}$$

To define the growth of users (in percentage), we need to study the spatial planning, main occupation (major job title), and other potential aspects (such as tourism area) that might relate to data access. According to RTRW of Banten, Panimbang would mostly develop as residential areas, and Leuwidamar mostly planned as plantation area, and partly for nature preservation and production forests. Moreover, both areas are potential to develop their tourism sector. In Panimbang, there is Tanjung Lesung beach. Leuwidamar is also the main entrance to Baduy village, a historical and cultural attraction. The summarize aspects that need to be consider is depicted in Table I [15]–[17].

TABLE I. CONDITIONS AND LOCAL POTENTIAL ASPECTS

Area	Land Use	Job Sectors	Potentials
Panimbang	Residential Areas	Fishery, Aquaculture	Tourism (Tanjung Lesung Beach)
Leuwidamar	Nature preservation, Production Forests	Agriculture, Farming	Tourism (Entrance of Baduy)

3) User Type: The type of users represents typical devices that would be accessed by a user to surf the internet. We consider three type of devices. The first device is a mobile phone which considered as normal-user, second and third devices considered as heavy-user: Mobile PC/Laptop, and Tablet. Considering situations in Panimbang and Leuwidamar, the number of heavy users in Panimbang is higher compared to Leuwidamar, for Panimbang is planned to be a residential area. The base data is mobile phone users that taken from "device capability" data from the core network. For Panimbang, Mobile PC users are 20% of mobile phone users, and Tablet users are 10% of mobile phone users. For Leuwidamar, we take 10% and 5% for Mobile PC and Tablet respectively, based on the number of mobile phone users.

4) Average Subscription: The Average Subscription is able to give us a picture of overall traffic demand. We adopt the EARTH model, that enables us to mix the traffic which generated from several types of terminals. The Ericsson Mobility Report for South East Asia and Oceania Region shows that the average subscription for mobile is 1.2 GB/Month [23]. However, a survey from providers and sales report shows that the subscription of a user in the studied area is around 2 GB/Month. As there is no clear classification between the normal or heavy user, we assume that Mobile PC user has 1.5 times subscription, and Tablet has 1.25 times, compared to mobile phone subscription. The average traffic demand per subscriber can be calculated by (2). The r_k represents the monthly data demand and s_k is the ratio of subscribers for type k device.

$$r_{av} = \sum_k r_k s_k \text{ in [GB/month/subscriber]} \tag{2}$$

Assumptions were taken by considering data gathered from BPS, reports from companies (such as Ericsson), and survey result. To forecast, we take a sample of five years span. The reason is that normally the time of telecom technology is 10 years span (1G in 1990, 2G in 2000, 3G in 2010, etc). Thus forecasting for 5 years is reasonable, since the next 5 years, we need to prepare for the future technology that might not yet be discovered.

The detail parameters which consider multidimensional

aspects are summarized in Table III. To model the generalized traffic for a particular area, we calculate the traffic demand (Ω_i) by using (3).

$$\Omega_i = (r_{av})_i \ \frac{8 \times 10^3}{30 \times 12 \times 3600} \text{ Mbps} \tag{3}$$

We first need to define a busy hour which represents traffic usage during a time unit. In this research, we assume that the traffic is spreading uniformly in 12 hours for 30 days, as in rural area most people not having exact office hours such in dense urban. Usually, urban areas have a shorter busy hour, e.g. 8 hours in 20 days. The traffic demand also dependent to $(r_{av})_i$, which previously calculated in (3). Lastly, the Ω_i is used to calculate areal traffic demand in Mbps/km^2, as shown in (4).

$$\tau_i = \frac{\rho_i \ \Omega_i}{A} \text{ in Mbps/km}^2 \tag{4}$$

ρ is number of users for year *i*, r_{av_i} is the average subscription per user for year *i*, and A is a total area understudied. Panimbang has a total area as 132.8 km^2, and Leuwidamar has 176.61 km^2.

B. Parameters

The main references to set parameters in Table II are from regional BPS yearly reports and Regional Spatial Planning reports. This table is used as the foundation to set other parameters which shown in Table III.

TABLE II. YOY INCREASE PARAMETERS

	Singledimension		**Multidimensional**	
Parameters	Panimbang	Leuwidamar	Panimbang	Leuwidamar
Population	0.55%	0.83%	0.55%	0.83%
Users	2%	2%	Increase of prev. year + 1%	1%
Subscription	2 GB	2 GB	2 GB	2 GB (bi-yearly)

Single-dimension means that we neglecting government spatial planning or other potentials. We set a flat increase for the number of users and amount of subscription, regardless of either Panimbang or Leuwidamar area. The Multi-dimensions means that we consider all the aspects that discussed before, as in Table I.

For Panimbang multidimensional scenario, the number of users has accelerated by 1% yearly. It means that if year 1 increase 2%, then year 2 increase 3%, year 3 is 4%, etc. The reason is that Panimbang is planned to be a residential area, so a higher number of users is expected. On the other hand, Leuwidamar is planned to nature reservation and forest products, thus the increase is quite steady. The subscription increases for both areas is the same, except in multidimensional scenario for Leuwidamar. The same reason as the number of users background. The single-dimension is set to be a baseline of comparison, and the increase is the same for Panimbang and Leuwidamar (2% per year), neglecting the government spatial planning [15]–[17].

Detail parameters that used for traffic estimation are shown in Table III. The population density and number of subscribers are calculated based on reference in [18]–[23].

TABLE III. TRAFFIC ESTIMATION OF MULTI-DIMENSIONS SCENARIO

Details	2019	2020	2021	2022	2023
Panimbang Subscriber					
Population Density	397	400	404	408	412
Total Population	52,722	53,120	53,652	54,183	54,714
Mobile Phone User	21%	26%	32%	39%	47%
Mobile PC User	4%	5%	6%	8%	9%
Tablet User	2%	3%	3%	4%	5%
Subscription (GB/Month per Subscribers in Panimbang)					
Mobile Phone	6	8	10	12	14
Mobile PC	9	12	15	18	21
Tablet	7.5	10	12.5	15	17.5
Leuwidamar Subscriber					
Population Density	373	376	379	382	384
Total Population	65,876	66,406	66,936	67,466	67,819
Mobile Phone User	6%	7%	8%	11%	16%
Mobile PC User	0%	1%	1%	1%	1%
Tablet User	0%	0%	0%	0%	0%
Subscription (GB/Month per Subscribers in Leuwidamar)					
Mobile Phone	4	4	6	6	8
Mobile PC	6	6	9	9	12
Tablet	5	5	7.5	7.5	10

As we can see in Table III, the increasing of several parameters for Panimbang and Leuwidamar case are different. The detail increase of each parameter is shown in Table II. Noted that in Table III, it is written 0%, yet it still accounts for the number of users but less than 1% of total population i.e. 0.5% of the population.

IV. RESULTS AND DISCUSSIONS

In this section, we discuss the result of traffic forecasting simulations and compare the multidimensional scenario and single-dimension.

A. Average Subscription

The average subscription for Multi-dimensions scenario and Single-dimension scenario are depicted in Fig. 2. The description of the average subscription is described in Section III-A4.

For Panimbang case, the area that planned to be residential, are not having much difference in terms of average subscription, 15.38 GB/Month/User for single-dimension and 15.36 GB/Month/User for the multi-dimensions scenario. Yet in Leuwidamar, the difference is quite significant, 14.77 GB/Month/User for single-dimension and 8.47 GB/Month/User for the multi-dimensions scenario.

The slight difference in Average Subscription of users in Panimbang is mainly because of the almost similar amount of subscription. Although the number of mobile users is increasing, it is followed by the same subscription scenario for both single- and multi-dimensions: 2 GB/Month/User. Thus, the different increase in population and user does not significantly influence the amount of average subscription.

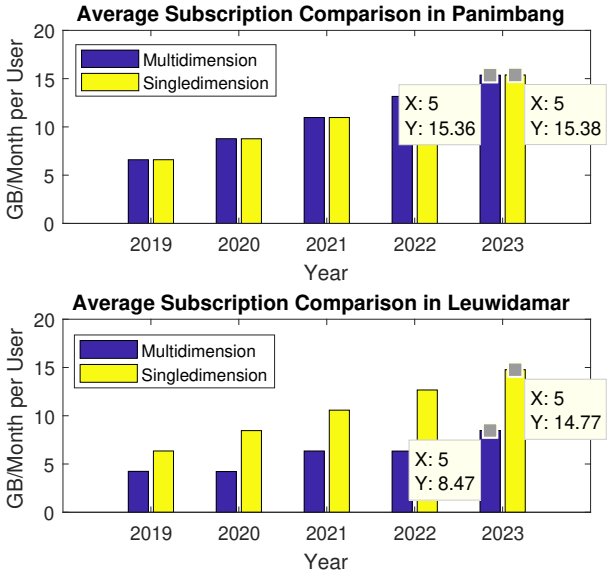

Fig. 2. Average Subscription Comparison

In Leuwidamar, however, shows a relatively difference between single- and multi-dimensions scenario. The main reason is that in the multi-dimensions scenario, we took an increase of 2 GB/user/month bi-yearly when in single-dimension we took 2 GB/user/month each year. For the multi-dimensions scenario in Leuwidamar, the area is not planned to be residential, thus the increasing amount of subscription will not as significant as Panimbang. The scenario of using data traffic in such area is might be meant for researchers, engineer, or local people that only use the network for basic communication.

B. Areal Traffic Demand Comparison

By using (4), we calculate an areal traffic demand for single- and multi-dimensions scenarios. Noted that the busy hour of both scenarios are the same, 12 hours each day and accounts for 30 days. The comparison of areal traffic demand between single- and multi-dimensions scenarios is depicted in Fig. 3.

For the multi-dimensions scenario in Panimbang, the areal traffic demand sharply increases up to about 54 Mbps/km^2 in 2023, while for the single-dimension scenario is only reach 30 Mbps/km^2. The big difference is because the single-dimension scenario only takes a flat increase of the number of users, which is 2%, while in the multi-dimensions scenario, the increase is adding 1% more each year. In 2023, the multi-dimensions scenario has 47% mobile phone users among the population, yet for another scenario only account for 26% of users. The subscription between single- and multi- scenarios in Panimbang is the same. Thus, the higher impact of a big difference in areal traffic demand for Panimbang is the increasing percentage of users.

In Leuwidamar case, the areal traffic demand for the multi-dimensions scenario remains steady with a slight increase up to 4 Mbps/km^2 in 2023. Yet, the single-dimension scenario has climb gradually and reach 14 Mbps/km^2. The reason for the steady increase of areal traffic demand in the multi-dimensions scenario is that the regional spatial planning, which stated that the Leuwidamar area is mostly for nature preservation and forest. Thus it is reasonable to account less subscription per user. Moreover, the increase of population density for the multi-dimensions scenario is only 1%, rather than 2% as in single-dimension scenario.

We can see that, if we took the single-scenario in a populated area, we might forecast less traffic compared to real future demand. However, this scenario might not be too problematic since adding more cells in a densely populated area might need small capital investment, e.g. no need to build such high tower individually to cover a wide area.

However, for a remote area such as Leuwidamar, considering a single-dimension scenario to forecast network, might leads to a high loss of profit. When we take a single-dimension scenario and neglecting local spatial planning, we might have a miss-forecasting and invest too much in deploying a network to fulfill high demand. Then, providers need to expend additional cost to relocate the installed network. On the other hand, when we take RTRW as consideration, we might not expect high subscription and a high number of users. By using this model, we could combat the high investment cost of covering wide, low-utility and low-income area.

V. Conclusions

The aim of this research is to study what kind of parameters that need to be considered when forecasting traffic and simulate the impact of using the multi-dimensions traffic model compared to single-dimension.

In terms of parameters needed, we first need to address the impact of an Internet on rural society. Internet or telecommunication network is provided to support social welfare, and the development planning usually has been formulated by the regional government, as in RPJPD, RPJMD, and RTRW. Thus, to simplify of accounting social aspect for this research, we use Regional Spatial Planning (RTRW) for modeling future traffic. Aside from the social aspects, we surely need the technical records that can be gathered from providers network (usually from core network). To support in modeling future traffic, we also use survey records or reports from companies and government. To summarize, there are plenty of parameters that could support traffic forecasting. However, the main step of parameter processing is: Forecast population density, study the device capability, define user type, and calculate average subscription. There are also other data needed to support this process, which depicted in III-A.

The impact of using the multi-dimensions traffic model is that we could decrease the opportunity of deploying a network that not suitable for futuristic traffic demand. For rural that planned to be a residential area, the single-dimension scenario might look too pessimistic, because we neglecting the possibility of a sharp increase in the number of users that might come from the transmigration program. However, to make a denser network in high utilization area is easier because

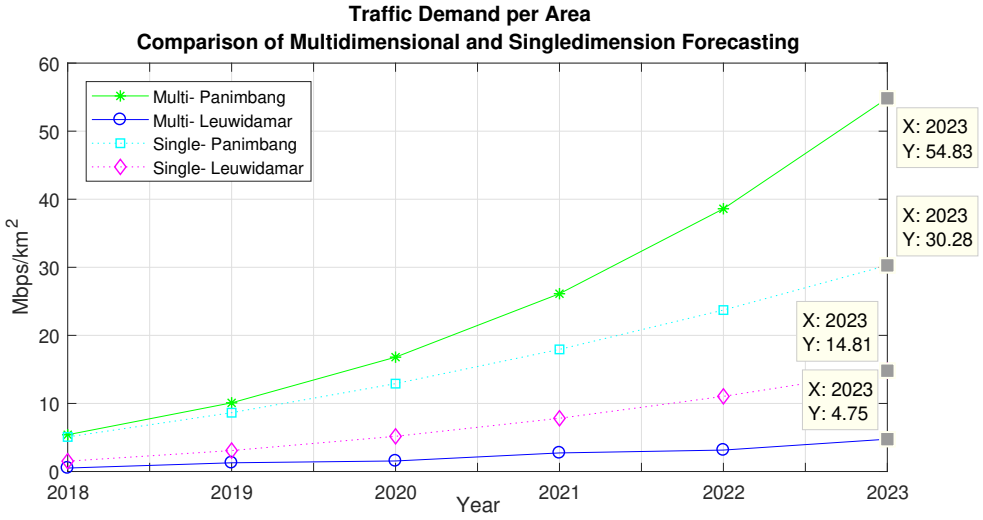

Fig. 3. Traffic Forecasting Comparison

generally for a densely populated area, the generated income could outweigh the investment cost of network providers.

Yet, for Leuwidamar area, which most villages are remotely located, the single-dimension scenario might be too optimistic. In single-dimension, we assume a steady increase, neglecting the fact that the area is meant to be nature preservation and product forests.

ACKNOWLEDGMENT

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Antenna Design for Multi-generation 2G-5G for Rural Area Wireless Communications

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***Abstract*—The development of telecommunication generation is faster compared to the development of infrastructure in rural areas. This paper proposes an antenna having capability of multi-generation (MG) communications of 2G, 3G, 4G and 5G for rural area wireless communications. The antenna is also functioning for mobile cognitive radio base station (MCRBS) for post-disaster communications in either rural or urban areas. In this paper, the antenna is designed to work at the operating frequencies of 2G–5G in Indonesia, which are expected in between 0.8 GHz to 6 GHz. To cover any areas with radius of 5 km, we propose a Vivaldi antenna, called as MG-Vivaldi antenna, tested by a series of computer simulations, which is realized using aluminum with dimension of 50 cm $\times$ 100 cm. We obtain an MG-Vivaldi antenna having return loss $RL \leq -10$ dB with gain $G > 8$ dB. We expect that the proposed MG-Vivaldi antenna contributes to the development of rural area communications as well as contributions for disaster mitigations.**

***Index Terms*—Vivaldi, Antenna, Ultra-wide Band, 2G, 3G, 4G, 5G, Disaster, rural area.**

I. Introduction

Cognitive Radio is a revolutionary technology which leads to significant improvement in the spectral efficiencies [1], [2]. In this technology, several applications can work in one devices. Frequencies from 0.8 GHz to 2.4 GHz are allocated In Indonesia to mobile communications, where about 0.8 GHz are allocated to the code division multiple access (CDMA), 0.9 GHz and 1.8 GHz for global system mobile (GSM). Frequency of 1.9 GHz for CDMA, 2.1 GHz for universal mobile telecommunication services (UMTS), and 2.4 GHz for broadband wireless access (BWA) with time division duplexing (TDD) [3]. Indonesia government is also considering frequency allocation for the fifth telecommunication generation (5G) mobile communication, where sub 6 GHz band is also one of options. In this paper, we consider any frequencies of multiple generations (MG) from 0.8 to 6 GHz.

Some antennas have been designed for 5G for 28 GHz [4]. Other several types of antennas have also been designed to operate at wideband frequencies for supporting cognitive radio technology, e.g., Vivaldi antenna, Log Periodic antenna and Biconical antenna. These three antennas can serve ultra wide band (UWB) communications to support communications of 2G, 3G, 4G and 5G [5], [6]. The previous research have designed Log-Periodic antenna, where the antenna can also work for ultra wideband (UWB) communications. However, the design still have a dimension, which is unsuitable for use as mobile antenna [7].

Biconical antenna has also been implemented for UWB communications. However, the UWB antenna has a small gain, which is difficult to cover large areas of rural environments [8]. Rural area is an area having low residential density and geographical condition such as mountain and desert, where antennas with high gain and directivity are needed [9].

In this paper, we propose a Vivaldi antenna to provide high gain to serve communications of both rural and urban areas, as well as support for disaster relief, where it may happens every where either in rural or urban areas. The Vivaldi antenna is designed to meet the requirement of multi generation communications, of which the challenge is mostly on the dimension and structure of the antenna such that it meets the requirements of both rural and urban communications and for post-disaster wireless network recovery in via a mobile cognitive radio base station (MCRBS).

We design the Vivaldi antenna based on Gibson in 1979 and improve its return loss (RL) by adding a circular slot [5], [10]. We use aluminum as conductor to make the antenna as a body antenna. We expect that our design has good reliability to transmit at high power mobile transmitter for rural area.

The rest of the paper is organized as follows. Section II describes the details of the proposed antenna. Section III presents the design optimization followed by the verification. Finally, Section IV concludes the paper with some concluding remarks.

II. Proposed Vivaldi Antenna

UWB can be considered as a system having fractional bandwidth (B_f) bigger than 20% as

$$B_f = 2\frac{(f_h - f_l)}{(f_h + f_l)}, \tag{1}$$

where f_h is the highest frequency and f_l is the lowest frequency. UWB also has bandwidth of more than 500 MHz.

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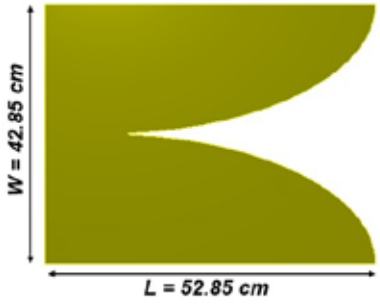

Fig. 1. First design: MG-Vivaldi I as an original Vivaldi antenna covering large bandwidth.

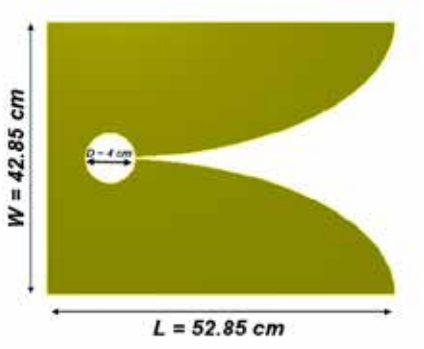

Fig. 2. Second design: MG-Vivaldi II with addition of circular slot to reduce RL.

Vivaldi antenna was discovered by Gibson in 1979 having an exponential shape knwon as Exponentially Tapered Slot Antenna (ETSA) [10] and wide bandwidth with high directivity [5] [6].

A. Bandwidth

The length of a Vivaldi antenna is calculated as

$$W = L < \frac{c}{f_l}, \tag{2}$$

where L is width of antenna, c is speed of light, and f_l is the lower frequency. We choose a lower frequency of 0.8 GHz to obtain 45.25 cm as the length of the antenna.

We design the first antenna, called multigeneration Vivaldi I (MG-Vivaldi I), with length and width as shown in Fig. 1. At MG-Vivaldi I, we change the dimension of width into 42.85 cm with length of 52.85 cm as our initial design.

Furthermore, we also propose a modification on the Vivaldi antenna by adding circular slot to RL as shown in Fig. 2, called as MG-Vivaldi II. We also cut the antenna corner, referred to as "corner-cut", to improve the performance of antenna for larger bandwidth as shown in Fig. 3, called as MG-Vivaldi III. The frequency response of MG-Vivaldi I, II, and III are shown in Fig. 4, where the design with circular slot and corner-cut has lower RL for wider bandwidth indicated by the solid line.

In Fig. 4, we can observe that the additional circular slot, with the same initial dimension, to the antenna with size of

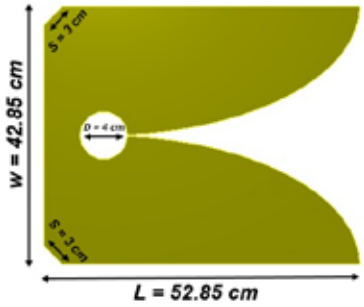

Fig. 3. Third design: circular slot and corner-cut for both reducing RL and increasing the bandwidth.

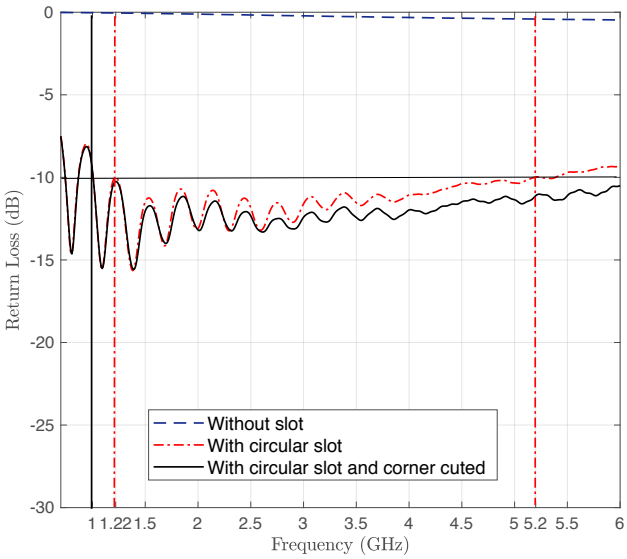

Fig. 4. Return Loss (RL) of non-circular slotted and circular slot Vivaldi antenna.

42.85 cm and length of 52.85 cm can provide lower RL. At 0.8 GHz to 6 GHz, for the first design, the antenna has RL above -5 dB, which is closer to 0 dB. We can conclude that the antennas do not work at this frequency range.

In the MG-Vivaldi II, we introduce a circular slot to obtain RL less than -10 dB with a lower frequency of 1.22 GHz and high frequency of 5.2 GHz resulting the total bandwidth of 3.98 GHz.

In the MG-Vivaldi III, we introduce two corner-cut as shown in Fig. 3 to obtain best performances having lowest RL and wider bandwidth. However, the design can not achieve RL less than -10 dB at low frequency. It has ripple at frequency of less than 1 GHz, of which the total bandwidth is more than 5 GHz.

B. Gain

Rural area is an area having less building, where antennas with high gain is required to enlarge the coverage area. We

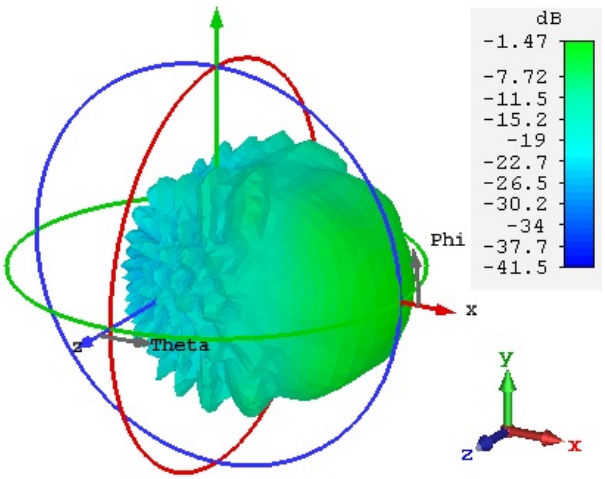

Fig. 5. MG-Vivaldi I: an original of Vivaldi antenna.

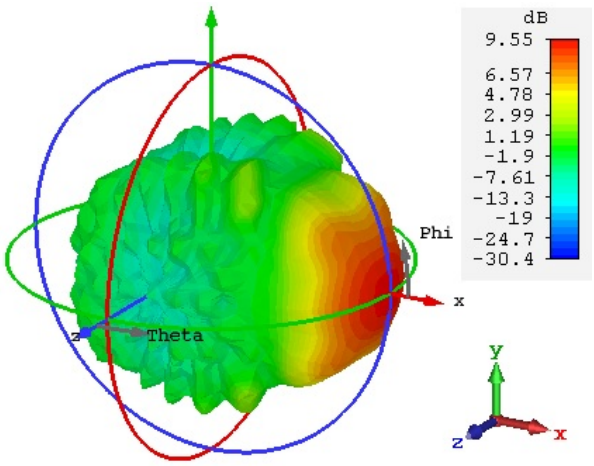

Fig. 6. MG-Vivaldi II: addition of circular slot to Vivaldi antenna.

consider a coverage area of 5 km, where 6 GHz is set as the highest frequency. The path loss is

$$\begin{aligned} L_{fs} &= 92.44 + 20\log_{10}(\mathrm{R}) + 20\log_{10}(f), \\ &= 121.98 \text{ dB}. \end{aligned} \tag{3}$$

We assume a rural area having line of sight (LOS) condition. In this paper, we design an UWB antenna, therefore, calculation of L_{fs} uses the highest frequency of 6 GHz to assume effective isotropic radiation pattern (EIRP) as the biggest loss of a communication system as

$$\begin{aligned} EIRP &= P_{Device}(\text{dBm}) + G_{Device}(\text{dB}) - L_{Cable}(\text{dB}), \\ &= 25 + 0 - 1, \\ &= 24 \text{ dBm}. \end{aligned} \tag{4}$$

With a minimum gain of antenna mobile base station of 8 dB, we predict that power received at the mobile base station is

$$\begin{aligned} P_r &= EIRP(\text{dBm}) + Gain_{RX}(\text{dB}) - loss_{system}(\text{dB}), \\ &= 24 + 8 - 121.98, \\ &= -89.98 \text{ dBm}. \end{aligned} \tag{5}$$

The received power P_r is acceptable since it is confirmed bigger than -104 dBm, which is the common sensitivity in mobile station. Therefore, antenna with 8 dB of gain is expected to be enough to cover an area with radius of 5 km.

Figs. 5–7 shows the simulation results for gain of the three proposed antenna designs. The first design has gain of -1.47 dB, which is unable to cover 5 km in rural areas. In the second design, we add a circular slot to reach gain of 9.55 dB, which is bigger than the minimum gain required to cover 5 km of rural area.

In the last design, we add circular slot together with corner-cut to reach biggest gain as indicated in the simulations, followed by the wider bandwidth. We use the third design, MG-Vivaldi III, as the proposed MG-Vivaldi antenna for both rural and post-disaster communications.

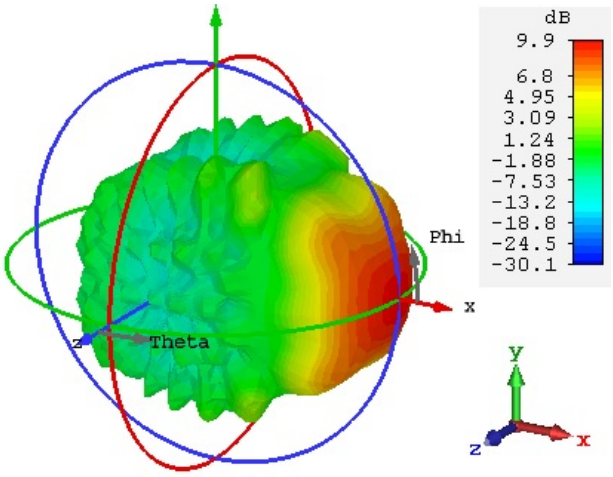

Fig. 7. MG-Vivaldi III: circular slot and corner-cut for better performance.

III. Antenna Optimization and Verification

A. Optimization

Now we have a new initial design of Vivaldi antenna with circular slot and corner-cut, MG-Vivaldi III as shown in Fig. 3. We optimize the design by changing dimension of antenna. We set 50 cm of width antenna and length of antenna from 52.85 cm to 100 cm. The results on frequency responses are shown in Fig. 8.

From the initial design with width antenna of $W = 42.85$ cm and length antenna of $L = 52.85$ cm, the lower frequency has RL of bigger than -10 dB. When the width and the length antenna are changed to become the same in dimension, the RL is worse followed by the smaller bandwidth. The lowest RL can be achieved with the dimension of $W = 50$ cm and $L = 88.2$ cm. However, the lower frequency is still unchanged, although the RL is above -10 dB. The details of RL and the ripple at the lower frequency can be seen in Table I.

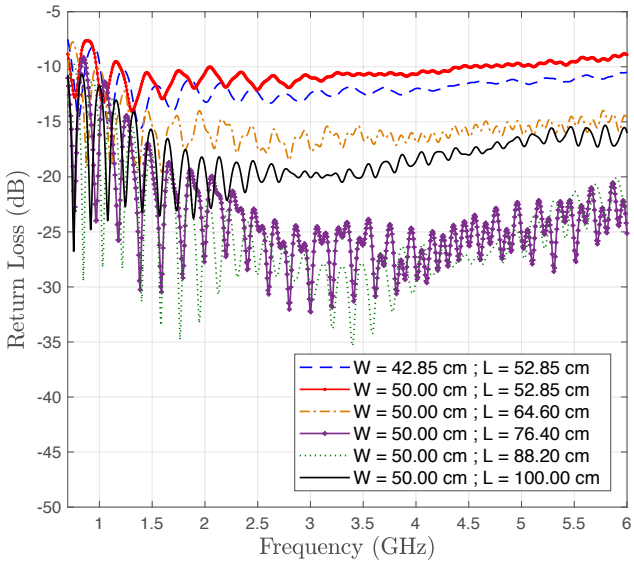

Fig. 8. Antenna dimension and RL of MG-Vivaldi antenna.

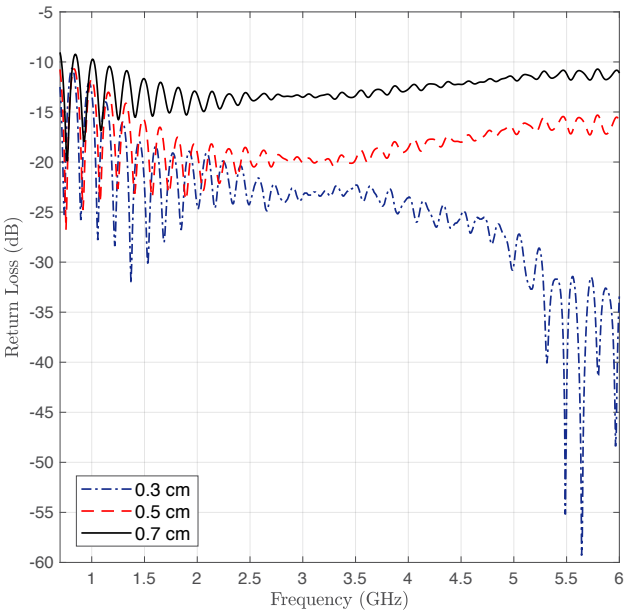

Fig. 9. Thickness antenna and Return Loss.

TABLE I
ANTENNA DIMENSION AND RL OF MG-VIVALDI ANTENNA.

Antenna Width	Antenna Length	Return Loss
42.85 cm	52.85 cm	-7.53 dB
50.00 cm	52.85 cm	-7.61 dB
50.00 cm	64.60 cm	-7.74 dB
50.00 cm	76.40 cm	-9.16 dB
50.00 cm	88.20 cm	-9.71 dB
50.00 cm	100.00 cm	-10.60 dB

When the third design is optimized, RL is -7.53 dB. We then changed the width to 50 cm to obtain the RL of -7.61 dB. The better performance can be achieved at $L = 76.4$ cm and $L = 88.2$ cm with RLs of -9.16 dB and -9.71 dB, respectively. However, it still does not satisfy the requirement.

The best RL of less than -10 dB is obtained when the width of antenna is 50 cm and the length of antenna of 100 cm. The last obtained dimension has RL of -10.6 dB at lower frequency and satisfy the requirement of the antenna working for 2G, 3G, 4G, and 5G applications for rural areas.

Besides the width and length of antenna, we also simulate the thickness of the antenna to obtain the best design prior-to-the manufacturing process for realization. Fig. 9 and Table II show RL of antenna with several thickness at 0.3 cm and 0.5 cm. The result of RL is less than -10 dB. Thickness of 0.5 cm is chosen because it has the most optimal RL with the RL of -10.67 dB. Fig. 10 shows antenna realization with optimal dimension with thickness of 0.5 cm, width of 50 cm, length of 100 cm, radius of 4 cm for circular slot, and corner-cut of 3 cm.

TABLE II
THICKNESS AND RETURN LOSS OF THE PURPOSED MG-VIVALDI ANTENNA.

Thickness	Return Loss
0.3 cm	-10.64 dB
0.5 cm	-10.67 dB
0.7 cm	-9.06 dB

Fig. 10. Antenna realization according to the design parameter, which is ready for real-field measurement and applications.

B. Verification

We measured RL using network analyzer, of which the result is shown in Fig. 11. The simulation results show that antenna works from 0.8 GHz to 6 GHz with RL of less than

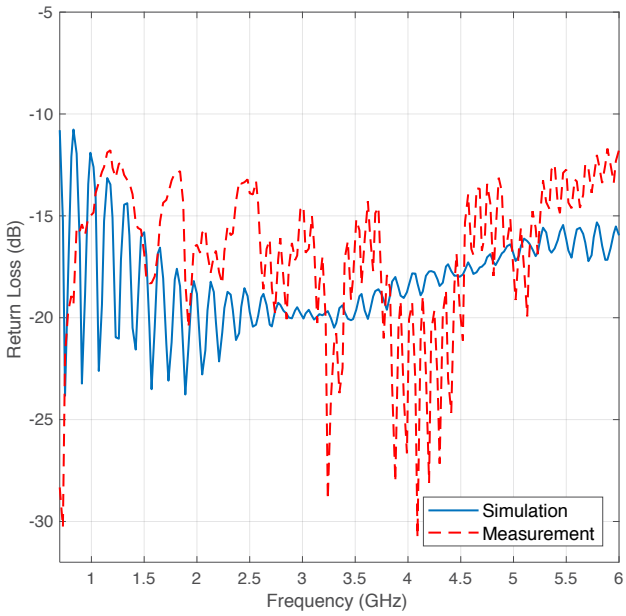

Fig. 11. Return Loss of the proposed antenna.

TABLE III
ANTENNA GAIN

Frequency	Optimization	Realization
0.8 GHz	9.63 dB	6.64 dB
0.9 GHz	10.4 dB	8.57 dB
1.3 GHz	10.7 dB	9.50 dB
1.8 GHz	11.5 dB	10.6 dB
1.9 GHz	11.7 dB	9.90 dB
2.1 GHz	11.8 dB	10.57 dB
2.3 GHz	12.2 dB	10.89 dB
3.3 GHz	13.1 dB	8.92 dB
3.5 GHz	13.5 dB	9.78 dB
5.6 GHz	16.1 dB	10.16 dB
6 GHz	16.3 dB	14.40 dB

-10 dB, which is confirmed by the realized antenna showing the operating frequency of 0.8 GMHz to 6 GHz with RL of less than -10 dB.

Since MG-Vivaldi III is a UWB antenna, we measured gain of antenna at several frequencies. We consider 0.8, 0.9, 1.8, 1.9, 2.1, 2.3, and 6 GHz as representatives of mobile frequencies in Indonesia. Furthermore, we also consider other frequencies to verify antenna designs. Table III shows antenna gain obtained from optimization and realization. Antenna gain can be observed from Figs. 5, 6, and 7, where we only noted the antenna gain value.

We measured the antenna gain using three antenna methods. We used UWB microstrip and horn antennas with similar bandwidth of the realized Vivaldi antenna. We set the distance between antenna of transmitter and antenna under test to comply with the minimum distance for far field of both antennas.

Table III shows that antenna gain is bigger than 8 dB for the simulation result at all observed frequencies. It indicates that the proposed antenna has satisfied the requirement for UWB and gain bigger than 8 dB to cover areas with radius of 5 km. We verify the antenna performance using Fig. 11 for the antenna bandwidth and Table III for antenna gain.

Measurement for antenna gain in Table III shows that difference of maximum gain between optimization and realization is 5.94 dB at frequency of 5.6 GHz. The minimum gain of 0.9 dB is obtained at frequency of 1.8 GHz. All realized antennas gain are lower than simulated antenna gains. Except at 0.8 GHz, all realized antenna gain is bigger than 8 dB.

At frequency 0.8 GHz, antenna gain is 6.64 dB, which is lower than our requirement. We recalculated (4) and changed the antenna gain from 8 dB to 6.64 dB, of which the total power is -91.34 dBm, which is bigger than the power sensitivity in mobile transmitter. It indicates that antenna with gain of 6.64 dB can still cover an area with radius of 5 km.

IV. CONCLUSIONS

We have proposed an MG-Vivaldi antenna having wide band capability and low RL to serve mobile devices for 2G–5G serving rural and post-disaster communications. The antenna can cover areas with radius of 5 km with $RL \leq -10$ dB and gain $G > 8$ dB. We have also introduced (a) a circle slot in the middle of MG-Vivaldi antenna and (b) corner-cuts at the both sides of the antenna providing the benefit on reducing the RL and widen the bandwidth. The realization of the MG-Vivaldi confirmed the practical results of antenna design.

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Development of Long-range Communication System for Fishermen: An Initial Study

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***Abstract*— In this paper, we report the initial study to design and development of long-range wireless communication system based on LoRa technology for Indonesian fishermen in which the targeted ship is under <5 GT (small-ship category). The developed system consists of 1) customizable end-node; 2) Android apps equipped in a smartphone as a user interface (namely *e-Nelayan app*); 3) gateway; 4) and a server application for online monitoring purpose. The *e-Nelayan* app covers three features: the SOS button, chat, and recent weather information. While the end-node part includes Bluetooth module, Microcontroller, Long-range radio module, power regulator circuit, and Li-Po battery for main supply, all of them are packed based on the consumer product. The discussion of this paper focuses on a) the brief description of the proposed system; b) the profile of developed android app, c) and anatomy of the hardware. Moreover, the tests (both for laboratory test and field test) also have been observed. Since the proposed system is an initial study, hence we conduct on the demo of 'ping connection' in lab scale test. While for the field test, we used RSSI analysis and object tracker test.**

***Keywords*— Communication system Fishermen, LoRa, Small-scale ship**

I. INTRODUCTION

The existing communication technologies, *e.g.* Wi-Fi, ZigBee, and Bluetooth, have an insufficient coverage area. While popular mobile technologies such as LTE, is not the best solution as it requires enormous power and costly. One of the solutions is employing Long-range Radio (LoRa) technology. The use of LoRa networks is applied to provide connection services that require an extended range of distance, low-bitrate, and low-power as well. Today, the implementation of LoRa for significant applications in daily human life become one of the most popular topics, *ex.* local scale application [1], wide-scale [2-3], or a rural area [4]. Another LoRa implementation is at over water such as reported by [5].

According to research finding, the studies of LoRa's performance test in the sea area are still limited. A number of papers reported the evaluation of LoRa performances in sea area, such as [6-8]. Nevertheless, the Lora utilization as a two-way communication for fishermen integrated with an Android application installed on their smartphones.

Therefore, in this paper, we will focus on LoRa application as a fundamental technology for fishermen's communication device involving several features such as: SOS, chat, and GPS tracking.

II. SYSTEM DESIGN

A. The Condition of Indonesia Fishermen

Considering the condition of Indonesian fishermen, the advanced navigation equipment or privileged communication are rarely used for small ship category [9]. It happens because the cellular telephone signals are still reaching the cruise distance to the shoreline (as described in Table I). Generally, the fishermen perform a "one-day" fishing method, that is a fishing activity for one day and one night by a small ship category as illustrated in Fig. 1.

TABLE I. CHARACTERISTICS OF FISHING SHIPS AND ITS ICT-BASED DEVICE USED

Type	Small ship (< 5GT)	Medium ship (5 s/d 60 GT)	Large ship (> 60 GT)
Navigation	No require an exclusive device	Alternative communication using Vessel Monitoring System (VMS)	Alternative navigation using VMS
Telecomm.	Cellular communication (maybe can not be used). The alternative way is by using RF	Long-range telecomm. (using RF)	Satellite telecomm. (VSAT)

Fig. 1. Example of a fishing ship under a 5GT category

Although the cellular signal still reaches the shore or even the territorial zone, a special communication device should be used by fishermen. It will be ineffective if they only use a smartphone as a communication device without additional modules because the signal strength of the cellular network can not be predicted accurately. Therefore, we propose a specific communication device that can be integrated easily with a smartphone. Moreover, the proposed

communication system can reach about 5-10 km distance from the shore.

The system consisting of 1) hardware module (end-node), 2) an android application: *e-Nelayan*, functioning as two way communication device in which the protocol used is LoRa, 3) the radio frequency (RF) gateway and server, and the last part is 4) web-based app for monitoring aim. The proposed system has three functions as follows:

1. as a communication device during sailing via chatting service;
2. Our system provides comfort aspects for fishermen because their activities can also be monitored. That is, the incidence of crews lost due to disasters occurring in the sea can be minimized. The fishermen can press the SOS button available on their smartphone. It is used to ask for the first aid and inform their position at that time. The mentioned android app and related apps are explained in section II.
3. This proposed system can be employed as a fishermen tracker device. We assume that it will give benefits to the state sovereignty: when the policies applied in Indonesia that all fishermen (beginners and professionals) must use this system and register with the specific database. Hence, the illegal fishing supervision will be more easily detected. Because if there are indications of unknown ships entering the residental sea area and according to the monitoring results are unlisted ship in a database. Afterward, that ship can be determined as an illegal ship (foreign fishermen). In other words, by this proposed system, the Indonesian fishermen can also assist in the state defense surveillance (in a case of the sea).

B. System Architecture

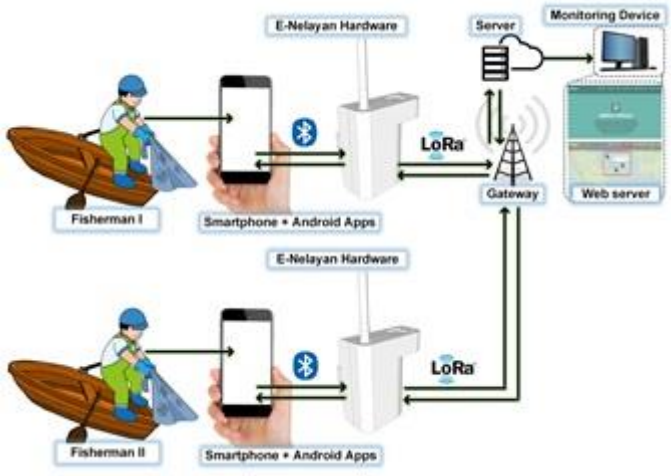


Fig. 2. The whole of a proposed system

This work is related with previous research that develops LoRa-based communication that has been tested in the urban area [10]. Thus, the developed system is identical to [10], but the difference is in the hardware packing. In this work, the LoRa radio module and smartphone are designed separately. Thus, the end-node is more portable, lightly carried, and practice to be used by fishermen in fishing activities.

The designed system is shown in Fig. 2 which is divided into three parts namely end-node (smartphone with special Android apps installed), radio module, and tracking server application which serves to accommodate the tracking data of end-node cruising. Instead of Fig. 2, we only develop one device for a single user application for this preliminary study.

C. Casing Concept

A casing is needed for the prototype protection from external disturbances (*e.g.*, dust) or protects the inner part of the end-node prototype when it falls during field testing. The casing is designed using *Sketchup 2017* software as visualized in Fig. 4, and then it was printed by using a 3D printer device.

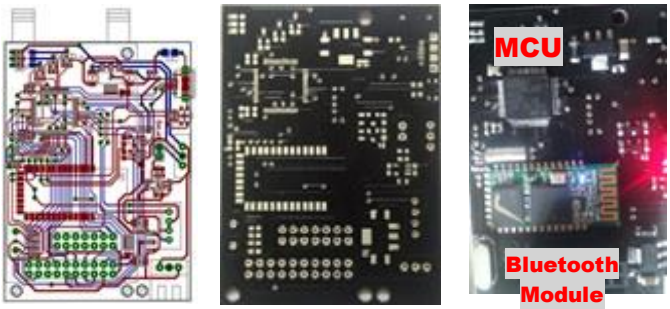
III. System Implementation

A. E-Nelayan Hardware

The *e-Nelayan* hardware act as end-node in the system. It is enabled to transmit and receive data over distance radio frequencies. The developed end-node consists of Microcontroller Unit (MCU) using STM32L100 chip, Bluetooth module, and LoRa radio module.

To produce a PCB design of electronics module that is more minimalist than [10], we designed PCB boards through the hardware engineering process includes:

1) PCB filmmaking as shown in Fig. 3(a);
2) PCB printing as shown in Fig. 3(b);
3) Components mounting on PCB as shown in Fig. 3(c);
4) device testing to determine whether the prototype produced has appropriately functioned or not;
5) Casing implementation; and
6) System integration as shown in Fig. 5 and Fig. 6.



(a) (b) (c)

Fig. 3. Hardware engineering process: (a) PCB design; (b) PCB printing; (c) PCB mounting

Fig. 4. Casing design in 3D view (top figure) and its transparency format (bottom figure)

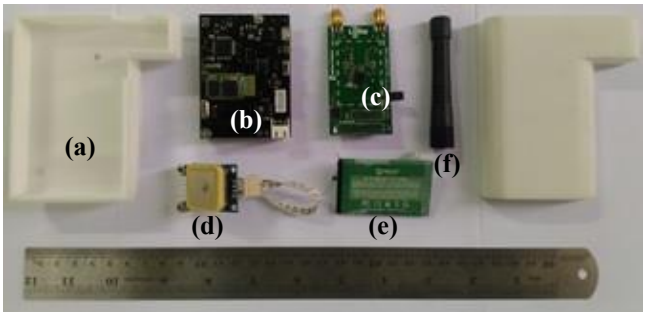


Fig. 5. The developed end-node: (a) case; (b) electronics module; (c) LoRa radio module; (d) GPS module; (e) LiPo battery; (f) LoRa antenna

Fig. 6. Hardware integration: flat position (left) and standing position (right)

B. *Client Software of e-Nelayan*

Client software is an application that will be installed on an Android OS-based smartphone. It serves for connecting the fishermen who engage in fishing activities to *e-Nelayan* system. As described in the introduction, there are three features offered:

- Weather feature: a feature that informs a fisherman about weather forecasts as shown in Fig. 7 (a).
- Chat feature: this feature is used between fishermen to communicate with each other through text chats as shown in Fig. 7 (b).
- SOS feature: the feature can be used by fishermen to broadcast transmit an emergency signal to other fishing boats and onshore servers as shown in Fig. 7 (c).

C. *Server Software of e-Nelayan*

This software is a web-based application and installed on PC server devices. We designed a server application for fishermen to interact with the administrator/admin who manages data (information uploaded by the e-Fisherman client application). The collected data can be used as a reference to provide added value for users. Also, it can provide knowledge that can support government policies in advancing the fishermen's economy.

(a) (b) (c) (d)

Fig. 7. The realized software: (a) main menu; (b) weather update menu ("*perkiraan cuaca*"); (c) chat menu ("percakapan"); (d) SOS menu

IV. Performance Test

A. Laboratory Test

The laboratory test is conducted at the 4G research center, university center of excellence on microelectronics, Institut Teknologi Bandung. The test scenario is depicted in Fig. 8. We did a "ping" test. While Fig. 9 shows that the ping test is well performed.

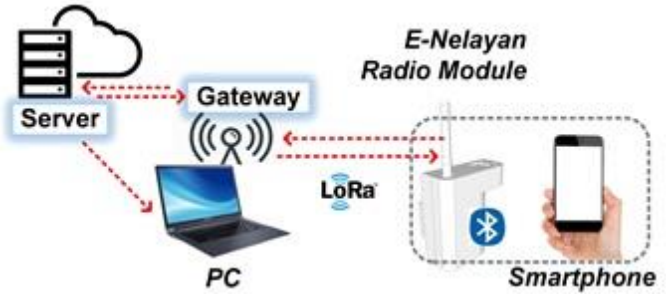


Fig. 8. Test scenario on a laboratory scale

Fig. 9. Laboratory testing result (ping connection)

B. Field Test

We develop a server application focusing on having features to collect the field testing data, namely recording and measuring the coverage area capabilities of the end-node prototype in specific areas. The coverage area capability can be viewed from how far the cruising distance of the end-node to the gateway server, along with the strength signal of the obtained RSSI signal. So far, the server applications are built in Python script. Therefore, the GUI display is still limited and not interactive yet. However, based on the test result as shown in Fig. 10, the application can display essential data such as latitude, longitude, RSSI, and the frequency used.

The field test is conducted on the sea located in *Karangsong* beach, *Indramayu*, a Bandung district in West Java Province, Indonesia. The sea area characteristic for this test provides line-of-sight (LOS communication); therefore this configuration makes us comfortable for measuring the received signal strength as there is no obstacles object. The gateway is installed about ±5 meters from the ground. We used a small ship as sea transportation for LOS tracker.

```
JSON Object is rxpk
-------------------
tmst: 2029781436
freq: 433.575
rfch: 0
modu: LORA
datr: SF12BW125
codr: 4/5
chan: 6
stat: 1
lsnr: 6.2
rssi: -99
size: 60

Id Node      : 2
Payload Data:
7:40:18.0, 6 53'16'' S, 107 36'36'' E, 92

Latitude    : -6.88777777778
Longitude   : 107.61
Counter Tx : 92
```

Fig. 10. A sample result of the position data recording and RSSI data on the *e-Nelayan* server application

In this work, we used RSSI metrics to characterize the connectivity between receiver and transmitter. The field tests are carried out for several days. We investigate the maximum signal distance that can be reached by the end-node to the gateway position. Thus the ideal coverage area of *e-Nelayan* system can be determined.

Firstly, we install a gateway in the shore area. We installed the gateway in the ship's tower that resides at the shore. After the installation is completed well, the fishing boat carrying the end-node and smartphone moves slowly away from the shore area. The end-node is then periodically sending the GPS positions from a fishing boat that move away. Later, GPS position data are stored on the server application. The scenario is depicted in Fig. 11, while Fig. 12 shows the field test situation in the sea.

Fig. 11. Field test scenario

(a) (b) (c)

Fig. 12. (a) A photograph of the area used for field test purpose; (b) the gateway installation; (c) user in the sea act as a fisherman

Fig. 13. Mapping of tracking test on the Karangsong beach, West Java Province, Indonesia (November 14–16, 2017).

Fig. 14. The maximum distance of communication device testing on the Karangsong beach, West Java Province, Indonesia (November 14–16, 2017)

From the testing result at *Karangsong Beach*, we obtained GPS data of the fishing boat position with 429 sample data. Table II presents the sample data of the test results. The server application can read four data such as the test date, received power in dBm, gateway position and end-node position.

TABLE II. THE SAMPLE DATA OF TEST RESULTS ON THE KARANGSONG BEACH (WEDNESDAY, NOVEMBER 15, 2017)

Date of test	Received power	Gateway position	End-node position
2017-11-15 12:29:04,	2,	-118,	-6.29888888889, 108.39, 173
2017-11-15 12:29:09,	2,	-112,	-6.29888888889, 108.39, 174
2017-11-15 12:29:13,	2,	-119,	-6.29888888889, 108.39, 175
2017-11-15 12:29:18,	2,	-118,	-6.29888888889, 108.39, 176
2017-11-15 12:29:22,	2,	-118,	-6.29888888889, 108.39, 177
2017-11-15 12:29:27,	2,	-117,	-6.29861111111, 108.390833333, 178
2017-11-15 12:29:32,	2,	-113,	-6.29861111111, 108.390833333, 179
2017-11-15 12:29:37,	2,	-119,	-6.29861111111, 108.390833333, 180
2017-11-15 12:29:41,	2,	-119,	-6.29833333333, 108.391666667, 181
2017-11-15 12:29:45,	2,	-119,	-6.29833333333, 108.391666667, 182
2017-11-15 12:30:09,	2,	-119,	-6.29833333333, 108.391944444, 187
2017-11-15 12:30:14,	2,	-118,	-6.29777777778, 108.393055556, 188
2017-11-15 12:30:20,	2,	-118,	-6.29777777778, 108.393333333, 189
2017-11-15 12:30:26,	2,	-119,	-6.29777777778, 108.393333333, 190

Afterward, we get the maximum distance that explored by small fishing boat about 3.73 Km from the gateway position with RSSI of -119 dBm (Fig. 13 and Fig. 14). We summarized the resulted field test in Table III.

TABLE III. PERFORMANCE TEST

Variable	Value
Gateway position	-6.30527777778, 108.369166667
End-Node position	-6.2963889, 108.4016667
Maximum distance	3.73 Km
RSSI	-119 dBm

V. CONCLUSION AND FUTURE WORK

The *e-Nelayan* device has been designed, implemented and tested. It employs the LoRa network as a telecommunications medium between LoRa devices and LoRa gateway. It is expected that *e-Nelayan* device acts as the primary communication device owned by fishermen, and it can support their fishing activities. In other words, they can increase their productivity in catching the fishes.

The maximum distance from field testing at Karangsong Beach can be further enhanced by adjusting the two factors as follows: high gate and type of boat used. The gateway can be installed on towers up to 50 meters high that placed at the shore area. Furthermore, a boat for navigating can use a medium scale because it can explore up to 10 km distance from the shore.

In this work, we only designed a server application only to monitor the fisherman position (GPS tracker) in real-time.

Other information will be developed in further research. Moreover, we focus on integrating Android apps into the *e-Nelayan* system. Therefore, the proposed features of SOS, chat, and weather updating can be demonstrated.

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Functionality Test of Communication Systems based on LoRa Technology in Oil Palm Plantations Area

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***Abstract*— In general, the communications equipment that used for the oil palm plantations area in Indonesia is still employing a handy-talky device or SSB radio. In some densely populated areas, the communications are using cell phones that connected to the telecommunication operators' networks. Nevertheless, most of the oil palm plantation in Indonesia is located in rural and remote areas which lack of network services. With OWNGrid product, we expect that it can be used as a long-range communication device alternative for oil palm plantations. OWNGrid uses LoRa technology as base and smartphone with specific android apps for chatting service. Hopefully, it can help in improving the efficiency and effectiveness during oil palm harvest.**

Keywords—LoRA, Rural area, Oil palm plantations area

I. INTRODUCTION

The total production of crude palm oil in Indonesia can dominates the world market share by up to 53 per cent. With such enormous potential, the support for palm oil production in the various stages has always prioritized to increase the yield production. The most significant potential is in Riau Province that has a total area of oil palm plantations up to 2.3 million hectares. To support the operational activities that are relatively extensive is required a communication device. It should be reliable and easy to use by farmers when doing harvest activities in oil palm plantations [1].

Looking at the oil palm plantations condition in Indonesia, most of them are located in remote areas which far away from telecommunication operator services. Hence, the oil palm farmers employ single sideband (SSB) radio or handy-talky for voice communications. In some densely populated areas, the cell phones based on telecommunication operators' networks are already used. However, not all oil palm plantations in Indonesia receive services from telecommunication operators.

Thus, an alternative telecommunication device is needed that in which it should independent from local operators, user-friendly, and it offers several features such as chatting, tracking, monitoring, etc. We expect, it can support the farmer activities. Therefore, the efficiency and effectiveness of operational activities in oil palm plantations can be improved. There are several options of the communication module, which one of them is LoRa™. This module is appropriate for remote areas because it has several advantages (based on datasheet) such as:

1. *Long range*: coverage area is relatively far, about 5 km to10 km in Line of Sight (LoS) configuration.
2. *Low bitrate*: provides data communication services with relatively low-speed (0.3 kbps to 50 kbps) [2].
3. *Low power*: with this feature, we can use the lithium battery for a long time.

A number of scientific works presented the LoRa test and evaluation in rural area or remote area, such as [3-6]. However, there are fewer works that tackle data transmission in oil palm plantation area for two ways communication device utilizing LoRa technology.

LoRa has three elements, *i.e.* end-node, LoRa network server, and Gateway [7]. In this work, we used network server and LoRa Gateway, but the end-node is designed for a two-way telecommunication device based on Lora technology as shown in Fig. 1, namely OWNGrid in which it has been tested in the over sea area [8] and urban area [9].

The OWNGrid has advantages such as 1) having low-power consumption, 2) having a dedicated network and independently of other telecommunication network operators, and 3) easy to install. The detailed of this product is elaborated in the second part. In this work, we test our product, OWNGrid, in the rural area in a case of oil palms plantation.

Fig. 1. A photograph of OWNGrid radiophone

II. System Overview

The telecommunication device that is shown in Fig 1, mainly can be divided into three main parts: the radio module, Android smartphone, and casing. Fig 2 shows the mockup design of OWNGrid, while Fig 3 is OWNGrid structure.

1. Android smartphone acts as a bridge between a device and the user. The user interacts through apps that are designed and installed above the Android platform. The Android smartphones are chosen as they support many advanced features and APIs such as mapping, processing of many types of data, etc.
2. Casing part, it serves as a protection device and acts as housing between the smartphone with a radio device module.
3. Radio module part, it serves as a modem device for data exchange mechanism.

Fig. 2. Mock-up illustration of OWNGrid

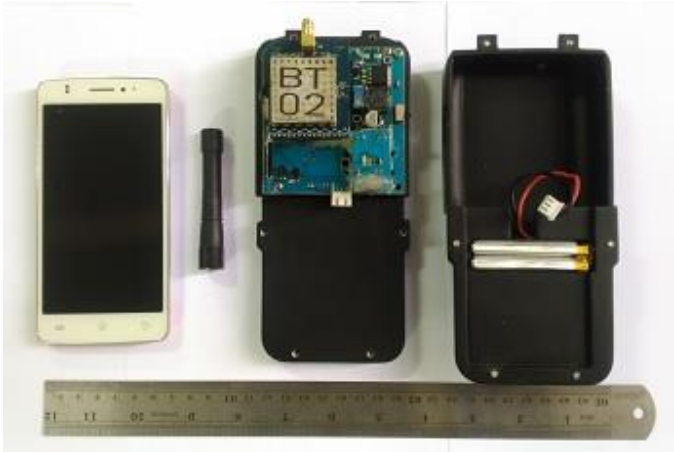

Fig. 3. OWNGrid anatomy

The OWNGrid is designed separately with the Android smartphone part. Therefore, the radio module in OWNGrid is not integrated directly with smartphone devices. For application cases in the oil palm plantation, OWNGrid has the potential to be applied because of several reasons, such as:

1. It has a relatively wide range of the signal, ranging in 2-3 km in Non-Line-Of-Sight (NLOS) configuration. OWNGrid is also equipped with some modulation features: FSK, GFSK, MSK, GMSK, LoRa™, and OOK. Thus, it is suitable for use in broad areas like oil palm plantations.
2. OWNGrid is a portable device that making it easy to be installed and operated by oil palm farmers. It has dimensions: 17 cm x 10 cm x 5.5 cm
3. OWNGrid has a radio module that works on UHF: 434 MHz and 868 MHz which is a free license frequency. Hence OWNGrid usage does not follow the frequency regulation in Indonesia.

III. Methods

A. *Defining the System Specification*

The communication scheme is required to implement the OWNGrid in the broad areas (like palm oil plantations). Therefore, the system environment should have four functions: 1) monitoring: to provide harvests information on a site; 2) chatting: for two-way communication in a real-time between oil palm farmers apart; 3) tracking: information for fast route in taking the harvest, and 4) scheduling: information the harvesting schedule. Finally, the OWNGrid can be easily used by farmers or supervisors who are on duty at a palm oil plantation site. The scenario of system functionality is depicted in Fig. 4.

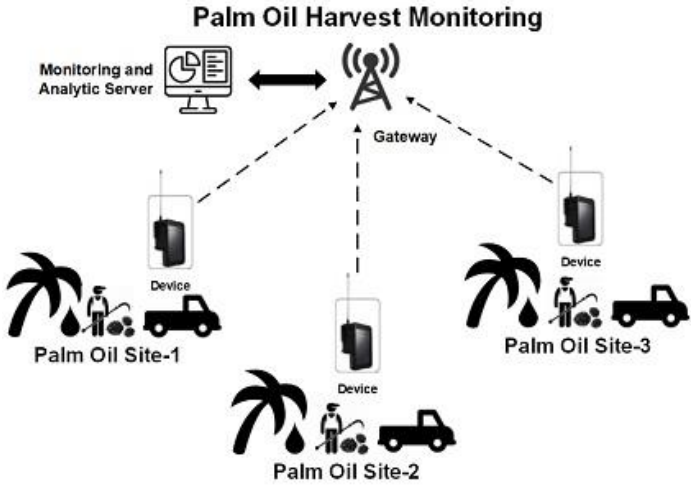

Fig. 4. scheme of OWNGrid implementation in oil palm plantation area

While on the server part, an application can display four features as mentioned above, i.e., posting the harvest locations that presented in a map. Moreover, the short path/route can be displayed to the driver who uses the vehicle carrying the harvest. The whole system of OWNGrid can establish a platform which can support the oil palm activities in online access and in real-time as well. Oil palm plantation managers can obtain harvest production data and then use it for statistical, analytical purposes, and to support policy-making to increase the oil palm plantations production.

B. Research Limitation

This research is a preliminary study. Thus we set the research limitation. We only perform single OWNGrid product to be tested in the oil palm plantation area which includes: 1) Radio signal functionality testing at a defined point with a variable of "well received" or "not received." 2) Observing the GPS positioning on the end-node side, and 3) analyzing the received signal strength by varying end-nodes range/distance to the tower gateway. The purpose of these three tests is for characterizing the OWNGrid whether reliable or not when it used in the oil palm plantation area.

C. Location for testing

Location the selected test is the oil palm plantation area owned by PT. Sawit Asahan Indah (SAI), Rokan Hulu, Riau Province (Fig. 5). Date of test: March 21-24, 2017.

Fig. 5. Field condition

D. Test Procedure

This research starts from 1) determining the gateway position and then the gateway installation in a tower. 2) Activating the end-node (OWNGrid product). 3) Opening the Android smartphone application that has installed the 'test Lora's app. 4) Connecting the OWNGrid device with the smartphone via Bluetooth connection. 5) Performing OWNGrid connectivity with the gateway via Lora connection and 6) varying the end-node distance to the gateway. In this process, the authors use the Google Map feature for the position plot and Path profiler software to plot the contour (*http://www.heywhatsthat.com/*).

To measure the distance, the following steps should be made: 1) Open the google map (*https://maps.google.com/*); 2) Enter the position or coordinates of the first point in the text box; 3) Right click on the map section, then select measure distance; 4) Click the position or coordinates for the second point location and the distance on the google map will appear. As for contour mapping, the following step as follows: 1) Go into the profile feature link; 2) Enter the position or coordinates of the first GPS points; 3) Enter the position or coordinates of the second GPS points; the last step is 4) Click show profile, the contours map will display.

The data analyzed is the "Received Signal Strength Indicator" (RSSI) which states the signal strength level received by the Lora radio device [10]. Commonly, RSSI represented by using dBm units. High RSSI values indicate that the Lora radio device well receives the transmitted signal, the lower RSSI value indicate the received signal is weak.

IV. Results and Discussion

A. System Implementation

Fig 6 shows the photograph of the end-node and Gateway installation in the oil palm plantations area. The transmission tower for antenna placement is installed at ± 20 meters height.

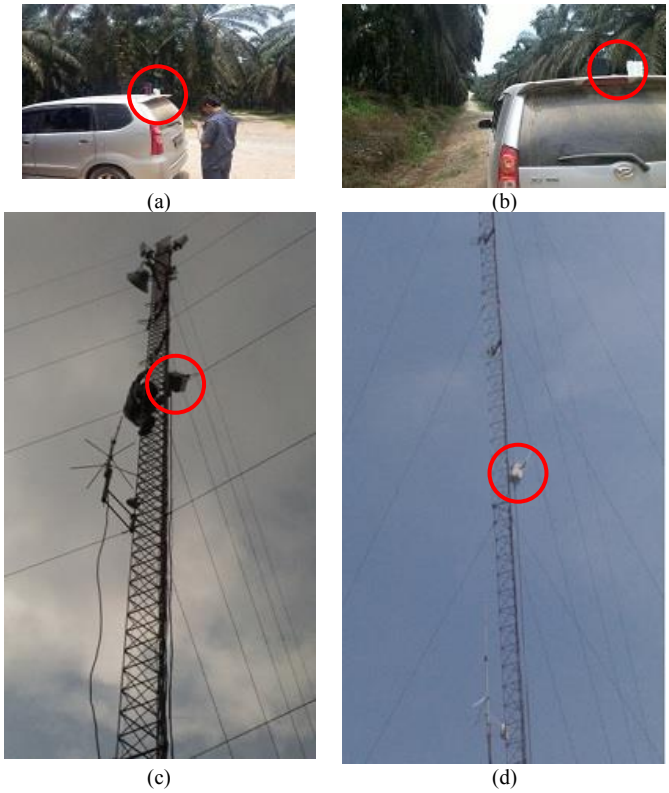

Fig. 6. Test documentation: (a) End-node installation; (b) End-node ready for test; (c) Gateway installation; (e) Gateway ready for test

Fig. 7. A Map of Gateway position (PT. SAI office center)

The position of Gateway is located in the central office of PT. SAI, Rokan Hulu, Riau Province as shown in Fig. 7, i.e., on GPS coordinates 0.761452, 100.518693.

Fig. 8 visualizes the test results with the following parameters: the end-node position (X2) at 0.756942,100.519904 which is 0.5 km distance from the Gateway position (X1). It shows that the signal is well received with RSSI -104 dBm. Furthermore, the end-node position is moved away with the car transportation help. The LoRa sensitivity is -120 dBm, under that sensitivity value, may the signal can not be received well.

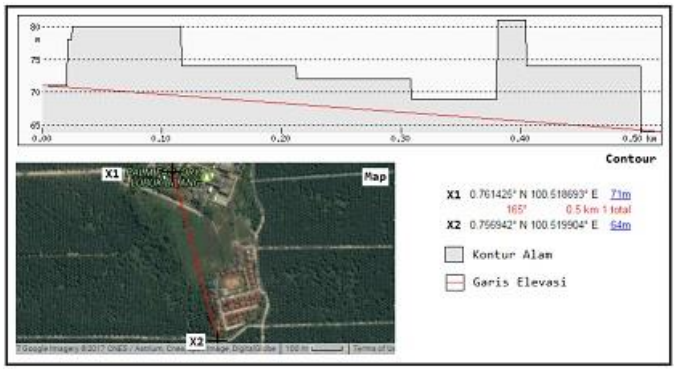

Fig. 8. Test result for initial measurement (point-1), *kontur alam* means natural contours, *garis elevasi* means elevation line

B. *Performance test*

Table I is a testing scenario with varying distances randomly from 0.3 km to 3.9 km. If "Yes", it means that the signal is well received and vice versa. The reason for positioning the randomly end-node because we are adjusting the main transportation path within the PT. SAI area. In the other hands, since it is difficult to classify the scenario test where is LoS, Near LoS, or Non-LoS, hence the random test is the best way at the moment.

The test results are shown in Fig. 9 to Fig. 16. The OWNGrid capable of reaching 500 meters to 1.7 km distance with a relatively flat field. For Point-5, the received signal of end-node is unstable, even for Point-8 the signal is not acceptable at all because of the hilly terrain. For Point-9, the RSSI value cannot be displayed because it exceeds the transmission distance limit.

TABLE I. END NODE POSITION FOR THE TESTING PURPOSE

Point	Position of end-node	Distance	Received Signal	RSSI
2	0.753844, 100.512104	1.2 km	Yes	-104 dBm
3	0.747827,100.512063	1.7 km	Yes	-103 dBm
4	0.750171,100.516163	1.3 km	Yes	-107 dBm
5	0.752583,100.508540	1.6 km	Unstable	-107 dBm
6	0.752186,100.508618	1.6 km	Yes	-102 dBm
7	0.753284,100.510164	1.4 km	Yes	-105 dBm
8	0.763726,100.520981	0.3 km	No	-
9	0.745150, 100.488209	3.9 km	No	-

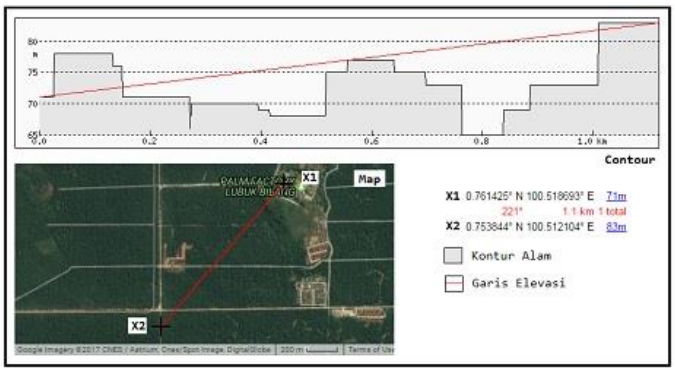

Fig. 9. The test result for Point-2

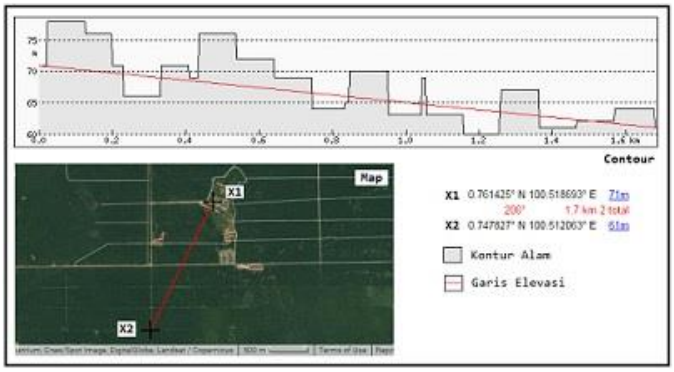

Fig. 10. The test result for Point-3

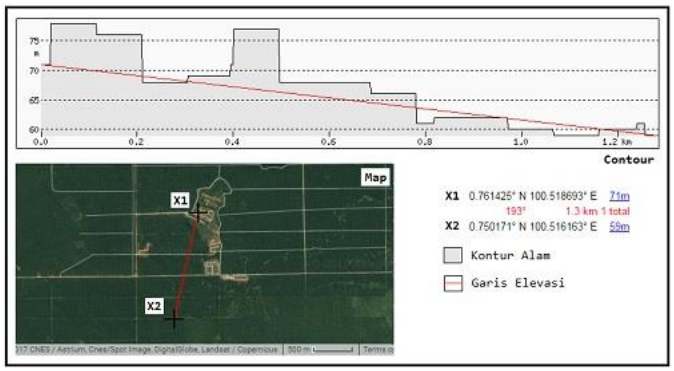

Fig. 11. The test result for Point-4

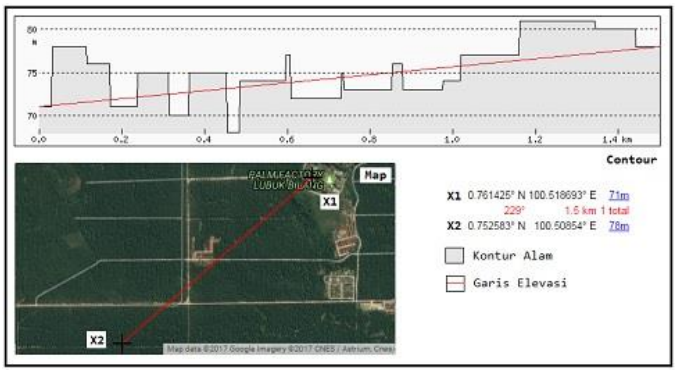

Fig. 12. The test result for Point-5

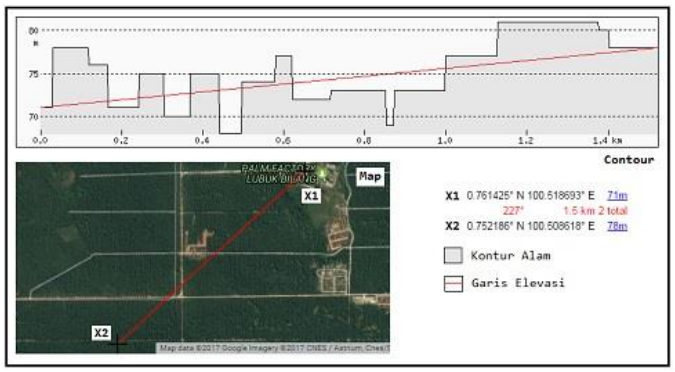

Fig. 13. The test result for Point-6

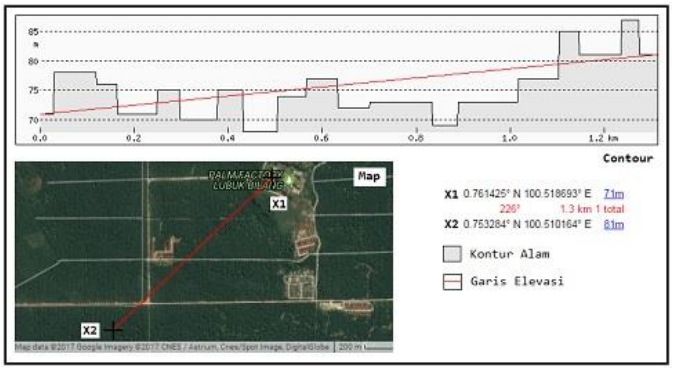

Fig. 14. The test result for Point-7

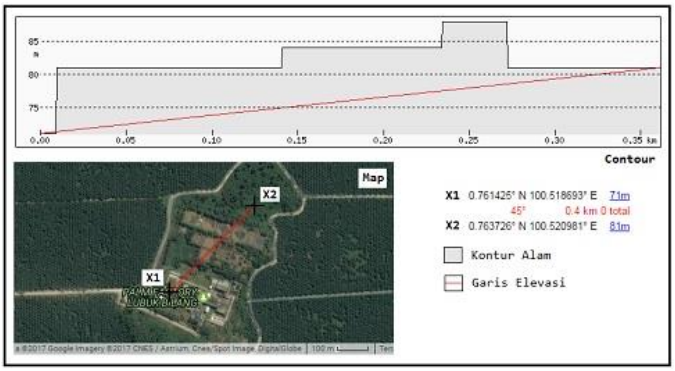

Fig. 15. The test result for Point-8

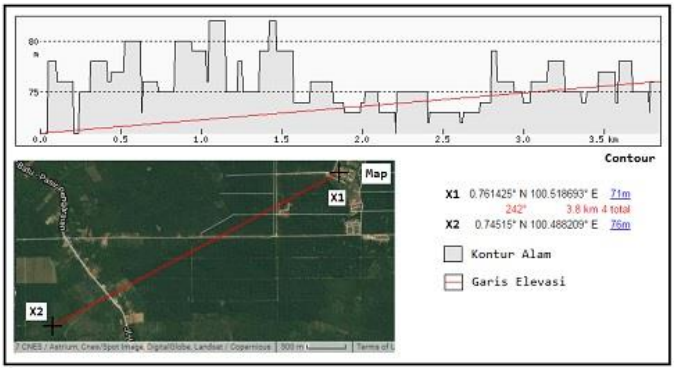

Fig. 16. The test result for Point-9

V. Conclusion and Future Work

A specific telecommunications infrastructure is needed in the palm oil plantation area. Thus the users (farmers) can reach out another user within the same area considerably. This paper discusses the functional testing of OWNGrid products to be used for communication devices in oil palm plantations. The results show that communication between Gateway to end-node can be done up to 1.7 km distance. However, in the conducted experiments, we do not use the specific Android application in a smartphone yet In future. We will develop an Android application to support the operational activities of oil palm farmers harvest including monitoring, auto GPS tracking, scheduling, etc.

Later, we will develop a power transmission device for OWNGrid, so the distance is further. Furthermore, the proper gateway placement also needs to be done to reach a wider area. To improve the Lora's sensitivity, antenna costumes (e.g., sectoral antennas) is worthed to develop. Once all is done, research can be focused on the development of telecommunication equipment applications.

Acknowledgment

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Spectrum Considerations for 5G in Indonesia

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Abstract—The capabilities of fifth generation (5G) mobile communication systems will make possible massive new levels of connectivity; very fast data transfer rates, from 10 Gbps to 20 Gbps; and high reliability of mobile communications. Developments in technology to meet these capabilities will be deployed in the existing frequency bands identified for cellular broadband communication systems, but they will also require new spectrum band resources in low, mid, and high frequencies to specifically provide high bandwidth resources that can efficiently deliver high data rate services. The main goal of the research was to investigate the available spectrum bands and data rates according to the available bandwidth assumptions in Indonesia as a study case.

Keywords—5G, spectrum planning , spectrum allocation Indonesia, 5G data rate

I. INTRODUCTION

The total number of mobile subscribers in Indonesia was 371 million at the end of 2017, and the penetration ratio has exceeded 141% of the general population (264 million). Indonesia , the country with The number of 3G and 4G mobile broadband subscribers Indonesia exceeded 46% (170.66 million) by the end of 2017 [1], and mobile Internet traffic as a percentage of total web traffic in Indonesia as of January 2018 was ranked sixth over the worldwide, with mobile devices accounting for 72% [2] .

As a major carrier of mobile communications, radio spectrum resources have a decisive effect on the scale of academic research and development of industry. Among studies about the fifth generation (5G) for wireless communications, spectrum issues such as wide spectrum, appropriate band spectrum, efficient use of the band spectrum, and management of the spectrum are cited as the most important factors in the move toward 5G [3].

5G will mark the start of new types of applications that require unprecedented bandwidth, ultra-low latency, and massive sensing capabilities. Uses of 5G are planned for a broad spectrum of applications in the enhancement of mobile broadband delivery for hot spots; public transportation; high-resolution multimedia; connected vehicles; infrastructure connected to railways, highways, and airfields; tactical Internet for critical operating machines; and massive sensory networks [4].

5G is anticipated to make it possible to efficiently enable a wide range of services that will connect a landscape of varied devices accessing diverse networks.

Researchers have studied spectrum bands above 6 GHz and millimeter Wave (mmWave) for 5G, and various frequency bands were considered in relation to ongoing 5G R&D developments in considering the allotment of frequency bands for the European Union, the United States, and Japan. Five candidate frequency bands were picked [5] , [6] but there have been no discussions about the status of spectrum allocation for developing countries such as Indonesia.

Considering the above issues, this paper will discuss the available 5G spectrum bands and 5G data rates according to the available bandwidth assumptions, using Indonesia as a case study.

This paper is arranged as follows. Section II discusses the 5G usage scenario and possible future 5G frequency bands in several countries. Section III is dedicated to a discussion of the current cellular spectrum and the candidate 5G frequency bands at low-, mid-, and high-frequency bands in Indonesia. Then, Section IV is devoted to discussing 5G data rates related to the bandwidth for each frequency band in Indonesia.

II. 5G USAGE SCENARIO AND SPECTRUM ALLOCATION

A. 5G Usage Scenario

According to recommendation ITU-R M.2083-0 from the International Telecommunication Union (ITU), which has defined an international 5G vision and requirements [4], potential 5G services and applications can be grouped into three usage scenarios.

Enhanced mobile broadband (eMBB): 5G is expected to provide much faster and more reliable mobile broadband, offering consumers a richer application experience. The eMBB usage case brings new and powerful capabilities to improved connectivity, system capacity, and high data rates. Example applications are wideband Internet access, augmented reality (AR), and virtual reality (VR). The specific requirements are a minimum of 100 Mbps user-experienced data rate and 20 Gbps peak data rate.

Ultra-reliable and low latency communications (URLLC): The highest priorities for this usage scenario are latency and mobility parameters. The latency requirements for the URLLC scenario is 1 ms. Example applications for this usage scenario are autonomous vehicles, distribution automation in a smart grid, and remote medical surgery, among others.

Massive machine-type communications (mMTC): This usage case is characterized by very large-scale or massive applications of the Internet of Things (IoT). For mMTC, peak data rates are not important, and connection density is the highest priority. mMTC devices are required to have a very long battery life and be low-cost. Example applications for this usage scenario are smart homes, smart offices, real-time health monitoring of patients, smart buildings, and smart agriculture. Fig. 1 shows International Mobile

Telecommunications (IMT) usage scenarios for 2020 and beyond or 5G usage scenarios.

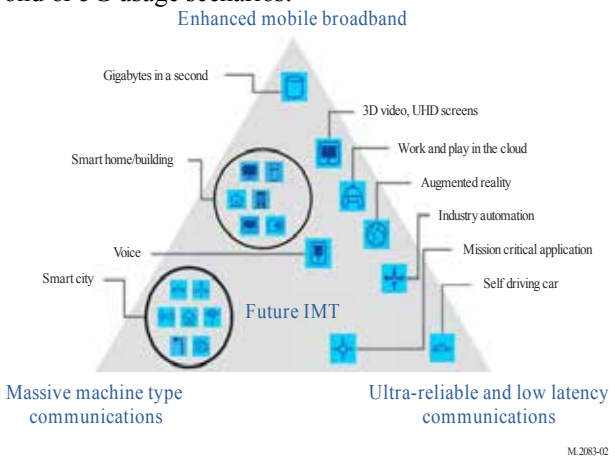

Fig. 1. 5G Usage scenarios. [4]

The eMBB scenario is an expansion of the available 4G network, but the mMTC and URLLC scenarios are new usage scenarios that have been presented specifically in regard to the 5G network. Table 1 shows 5G capabilities [4].

TABLE I 5G CAPABILITIES

Parameter Key	Value
Peak data rate	10–20 Gbit/s
User experienced data rate	100 mbit/s for wide area coverage and 1Gbit/s for hotspot
Latency	1 ms
Mobility	500 km/h
Connection density	106 devices/km^2
Energy efficiency	100x times more than IMT-Advanced
Spectrum efficiency	3x times more than IMT-Advanced
Area traffic capacity	10 Mbit/s/m^2

B. *Possible Future 5G frequency bands*

The spectrum is an important component of wireless networks, especially in 5G. The future cellular broadband communication network will have a relatively large number of different cell sizes, from macro cells to small cells. Small, or micro, cells will be for capacity boosters, and macro cells will be for ubiquitous connectivity. Low-frequency bands are appropriate for macro cells because of their better penetration and wide coverage, while high-frequency bands are appropriate for strengthening cells because of capacity. Therefore, spectrum bands needed for 5G networks can be split into three groups: low-, mid-, and high-frequency bands (respectively, low band, mid band, and high band) [7]. Fig. 2 shows 5G radio spectrum and its uses for different coverage areas [8].

- Low band: Spectrum at a frequency below 1 GHz to allow 5G coverage of a large area. This spectrum can be used for IoT applications.
- Mid band: Spectrum at higher frequencies, between 1 and 6 GHz, to offer the capacity needed to assist a large number of connected devices and allow higher speeds for devices connected together.
- High band (mmWave): Spectrum at very high frequencies above 24 GHz with large bandwidth, short range radius (between 50 and 200 m), very low latency, and more capacity [8].

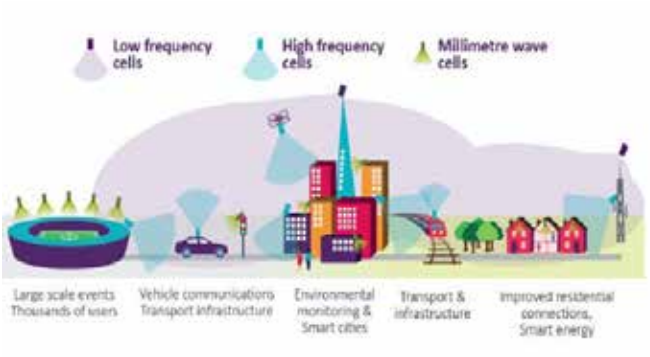

Fig. 2. 5G Radio spectrum and its uses. [8]

Fig. 3 shows how many countries have considered, published, or issued a spectrum that is set aside, or can be used, for 5G. This shows clear centers of activity around 700 MHz; 3400 to 3800 MHz; 24.25 to 27.5 GHz; and 26.5 to 29.5 GHz. Not all countries currently work with the same spectrum range, so the graph shows the level of variation by dividing the larger bands into smaller spectrum pieces [9].

Candidate bands identified for further study for use [9] in the Asia Pacific area are shown in Table II.

TABLE II CANDIDATE BANDS FOR 5G IN ASIA PACIFIC AREA

No	Country	Spectrum Band
1	Australia	3575–3700 MHz; 25.25–27 GHz
2	China	3300–3600 MHz ; 4800–5000 MHz; 24.75–27.5 GHz; 37–43.5 GHz
3	Hong Kong	3300–3400 MHz; 3400–3600 MHz; 4830–4930 MHz; 24.25–28.35 GHz
4	India	3600 MHz; 3600-3700 MHz, 24.25–27.5 GHz, 27.5–29.5 GHz; 29.5–31.3 GHz, 31.8–33.4 GHz; 37– 43.5 GHz
5	Indonesia	24.25–27 GHz; 27–29.5 GHz; 3.4–3.6 GHz
6	Japan	3.6–4.2 GHz; 4.4–4.9 GHz; 27–29.5 GHz
7	South Korea	3.42–3.7 GHz; 26.5–28.9 GHz
8	Malaysia	700 MHz
9	New Zealand	3410, 3690 MHz; 24.25–28.35 GHz; 1427–1518 MHz
10	Pakistan	3500 MHz
11	Singapore	800 MHz; 1427–1518 MHz; 3400–3600 MHz; 24.25–29.5 GHz
12	Taiwan	3400 MHz; 3600 MHz; 28 GHz
13	Thailand	850 MHz; 1800 MHz
14	Vietnam	700 MHz ; 2600 MHz ; 24.25–27.5 GHz; 27–43.5 GHz

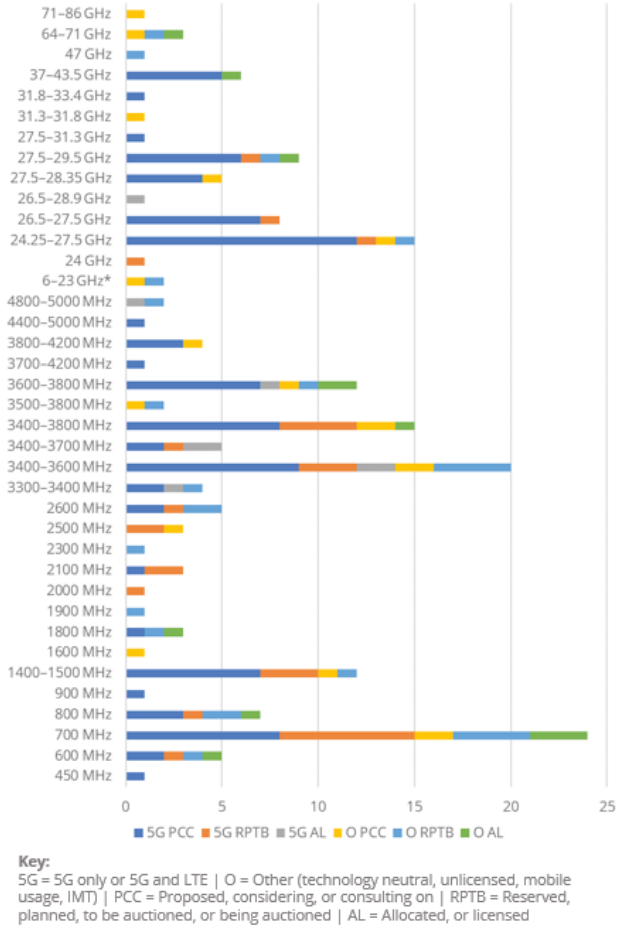

Fig. 3. 5G spectrum bands for various countries. [9]

III. CURRENT CELLULAR SPECTRUM AND 5G SPECTRUM BAND CANDIDATE IN INDONESIA

A. *Current Cellular Spectrum* in Indonesia

For cellular communication, lower-frequency bands provide a better coverage area. At present, almost all countries, including Indonesia, utilize low band and mid band (below 6 GHz) spectra for 2G, 3G, and 4G systems. In addition to achieving a high level of data throughput, this is also important for ensuring a wide area and outdoor coverage. Accordingly, the spectrum band below 6 GHz represents a highly significant section of the 5G spectrum solution. There are currently existing operators' frequency bands and technology already identified for the current cellular spectrum, as shown in Table III [10], [11], [12], which shows that almost all frequency ranges used by operators in Indonesia are focused in the spectrum below 3 GHz, and the spectrum used for cellular communications is several tens of megahertz.

TABLE III OPERATORS, FREQUENCY BANDS, AND TECHNOLOGY BEING USED

Operator	Frequendy Band (Mhz)		Technology
	Uplink	Downlink	
Telkomsel	900–907.5	945–952.5	2G/3G/4G
	1762.5–1785	1857.5–1880	
	1935–1950	2125–2140	
	2300–2330	2300–2330	
Indosat	890–900	935–945	2G/3G/4G
	1742.5–1762.5	1837.5–1857.5	
	1965–1980	2155–2170	
XL Axiata	907.5–915	952.5–960	2G/3G/4G
	1710–1732.5	1805–1827.5	
	1950–1965	2140–2155	
H3I	1732.5–1742.5	1827.5–1837.5	2G/3G4G
	1920–1935	2110–2125	
SmartFren	824–849	869–894	4G
	2330–2360	2330–2360	
STI	450–457.5	460–467.5	4G
Bolt	2360–2390	2360–2390	4G

B. *5G Low- and Mid-Spectrum Band Candidates in Indonesia*

Aside from the frequency spectra described in Table III, there are two other frequencies that can be used as candidates for the 5G frequency spectrum, the low band, at 700 MHz, and the mid band, at 3400 to 3800 MHz, which will provide capacity and better penetration through obstacles from outdoors to indoors for new 5G services [13].

In September 2011, Asia Pacific Sustainable Electronics Telecommunications Group adopted the Implementation Problem Report associated with the use of the 698 to 806 MHz band, or so-called 700 MHz, with cellular service allocations up to two 45 MHz FDD blocks [14]. Fig. 4 shows the 700 MHz spectrum band. Currently, this spectrum is allocated for terrestrial broadcast TV services [15]. Therefore, the application of 5G technology in Indonesia at the 700MHz frequency spectrum will certainly depend on the implementation of digitization of terrestrial broadcast TV but will be very good for rural and in-building coverage.

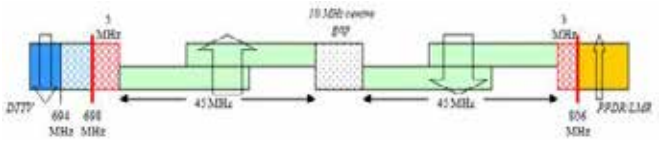

Fig. 4. 698–806 MHz band. [15]

In addition to the 700 MHz frequency previously explained, there is one mid band frequency at 3.3 to 3.8 GHz (called 3.5 GHz,), which will be the candidate frequency spectrum to be used by 5G (Table IV shows the 3.3 to 3.8 MHz spectrum bandwidth in Indonesia and the ITU Region 3 [16]).

TABLE IV SPECTRUM BANDS IN INDONESIA AND ITU REGION 3

Spectrum Frequency (Mhz)	Indonesia&ITU Region 3
3 300–3 400	Amateur Radiolocation
3 400–3 500	Fixed Satellite Amateur
3 500–3 600	Fixed Satellite Amateur Mobile Except Flight
3 600–3 700	Fixed Satellite Mobile Except Flight

3700–4200	Fixed Satellite Mobile Except Flight Mobile

According to Table IV, the primary frequency band suitable for introducing a 5G usage case in Indonesia would be the 3300 to 3800 MHz band (up to 400 MHz channel bandwidth). This band is an important addition to the mid band, offering a mix of capacity and coverage and has the potential to put Indonesia at the forefront of pre-5G or 5G deployments. However, this frequency spectrum is used for satellite purposes not only by Indonesia but also by other countries (Singapore, Japan, Hong Kong, India, New Zealand, South Korea, Pakistan, Australia, China, and Taiwan). Telecommunications operators owning or controlling a satellite registered with the ITU on behalf of the Indonesian Telecommunications Administration are PT Telkom, LAPAN, PT PSN, PT Indosat, PT ACeS, and PT Media Citra Indostar [12].

A recent GSA report [9] details the spectra in specific bands for which auctions or long-term designations are being considered. These include new 5G/New Radio (NR) bands defined by 3rd Generation Partnership Project (3GPP) in Release 15, which are being defined in two frequency ranges, designated as FR1 for the 450 to 6000 MHz band and FR2 for the 24250 to 52600 MHz band. Table V shows a breakdown of the FR1 Band.

TABLE V FR1 BAND

NR operating band	Uplink (UL) operating Band (Mhz)	Downlink (DL) operating band (Mhz)	Duplex mode
n1	1920–1980	2110–2170	FDD
n2	1850–1910	1930–1990	FDD
n3	1710–1785	1805–1880	FDD
n5	824–849	869–894	FDD
n7	2500–2570	2620–2690	FDD
n8	880–915	925–960	FDD
n12	699–716	729–746	FDD
n20	832–862	791–821	FDD
n25	1850–1915	1930–1995	FDD
n28	703–748	758–803	FDD
n34	2010–2025	2010–2025	TDD
n38	2570–2620	2570–2620	TDD
n39	1880–1920	1880–1920	TDD
n40	2300–2400	2300–2400	TDD
n41	2496–2690	2496–2690	TDD
n51	1427–1432	1427–1432	TDD
n66	1710–1780	2110–2200	FDD
n70	1695–1710	1995–2020	FDD
n71	663–698	617–652	FDD
n75	N/A	1432–1517	SDL
n76	N/A	1427–1432	SDL
n77	3300–4200	3300–4200	TDD
n78	3300–3800	3300–3800	TDD
n79	4400–5000	4400–5000	TDD

C. 5G High-Spectrum Band (Above 6 GHz) Candidates in Indonesia

The increased demand from cellular broadband users for services in the cellular sphere with large data throughput rates and technologically developed cellular broadband communication systems will require more band spectra to be available in the future. Those very large data transfer rates may only be found in mmWave or high-frequency bands above 6 GHz.

According to current ITU simulations, theoretical measurements, assessments, prototyping, and technology developments explained in the ITU's report ITU-R M.2376-0, the utilization of frequency bands between 6 and 100 GHz should be considered for the development of 5G [17].

Most studies evaluate 26 GHz and 28 GHz performance as one of the future cellular broadband communication solutions (3GPP Band n258 refers to the range between 24.25 to 27.50 GHz, commonly called 26 GHz, and 3GPP Band n257 refers to 26.50 to 29.50 GHz, commonly called 28 GHz). Table VI shows the FR2 band, indicating there would be up to 3.5 GHz of bandwidth proposed for cellular broadband communication. The bandwidth could provide significant capacity, but this frequency spectrum is currently used for microwave point-to-point communication, earth exploration satellites, and space research in Indonesia. However, a 26 GHz and 28 GHz link would suffer from high propagation and penetration loss, especially in rural or remote areas, where wide coverage is required [18],[19].

TABLE VI FR2 BAND

NR operating band	Uplink (UL) & Downlink (DL) (MHz)	Duplex mode
n257	26500–29500	TDD
n258	24250–27500	TDD
n260	37000–40000	TDD
n261	27500–28350	TDD

IV. 5G MAX DATA RATE FOR BANDWIDTH ALLOCATION IN INDONESIA

Spectrum frequency management for 5G technology is a crucial issue and will affect the implementation of 5G in Indonesia. Because of the challenges described in Section III regarding the use of the 700 MHz band for terrestrial broadcast TV services, the 3.5 GHz band for satellite services, and the 26 GHz and 28 GHz spectrum frequencies, the simulation in this study consisted of two scenarios. The first was observing the data rate without band combinations, and the second scenario was observing the data rate with the use of band combinations. These are necessary for evaluating data rates in the recommended spectra above, according to the bandwidth assumptions described in Section III. Table VII shows the scenario parameters. In this paper, we focus only on the downlink transmission, with the influence of various modulations from QPSK, 16QAM, 64QAM, and 256QAM against the data rate. For 5G, the approximate data rate for a given number of aggregated carriers in a band or band combination can be expressed as [20].

Data rate (Mbps) =

$$10^{-6} \cdot \sum_{j=1}^{J} \left(v_{Layers}^{(j)} \cdot Q_m^{(j)} \cdot f^{(j)} \cdot R_{\max} \cdot \frac{N_{PRB}^{BW(j),\mu} \cdot 12}{T_s^{\mu}} \cdot \left(1 - OH^{(j)}\right) \right) \quad (1)$$

wherein J is the number of aggregated component carriers in a band or band combination, and R_{max} = 948/1024. For the j-th CC, $v_{Layers}^{(j)}$ is the maximum number of layers; $Q_m^{(j)}$ is the maximum modulation order; $f^{(j)}$ is the scaling factor (1 and 0.75); μ is the numerology (as defined in TS 38.211 [21]); and T_s^{μ} is the average OFDM symbol duration in a subframe for numerology μ i.e., $T_s^{\mu} = \frac{10^{-3}}{14 \cdot 2^{\mu}}$.

Note that a normal cyclic prefix is assumed.

$$N_{PRB}^{BW(j),\mu}$$

is the maximum RB allocation in bandwidth $BW^{(j)}$ with numerology μ, as defined in 5.3 TS 38.101-1 [22] and 5.3 TS 38.101-2 [23], where $BW^{(j)}$ is the UE supported maximum bandwidth in the given band or band combination.

$OH^{(j)}$ is the overhead, which takes the following values:
[0.14] for frequency range FR1 for DL;
[0.18] for frequency range FR2 for DL;
[0.08] for frequency range FR1 for UL; and
[0.10] for frequency range FR2 for UL.

TABLE VII SCENARIO PARAMETERS

Scenario	Low Band	Mid Band	High Band
$v_{Layers}^{(j)}$	8	8	8
$Q_m^{(j)}$	8	8	8
$f^{(j)}$	1	1	1
SCS	15	30	120
$N_{PRB}^{BW(j),\mu}$	216	273	66
BW	40 Mhz	Min 100 MHz Max 400 Mhz	Min 100 MHz Max 400 Mhz
$OH^{(j)}$	*0.14*	*0.14*	*0.18*

A. Analysis of the Data Rate Without Band Combinations

This paper assumes different bandwidths without band combinations as the first scenario (low band, 40 MHz; mid band, 100 MHz; and high band, 100 MHz). Fig. 5 and Table VIII show data rates against modulation for all bands, using 8x8 MIMO

TABLE VIII DATA RATE VS. MODULATION FOR ALL BANDS

Freq Band	Modulation			
	QPSK	16 QAM	64 QAM	256 QAM
700 MHz	0.46 Gbps	0.92 Gbps	1.39 Gbps	1.85 Gbps
3.5 GHz	1.17 Gbps	2.34 Gbps	3.51 Gbps	4.67 Gbps
26/28Ghz	2.16 Gbps	4.31 Gbps	6.47 Gbps	8.62 Gbps

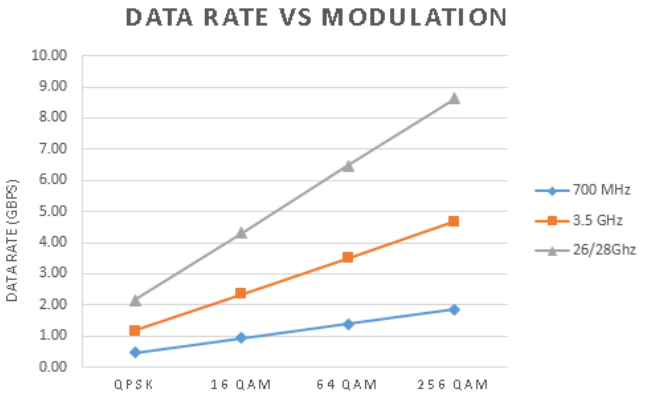

Fig. 5. Data Rate vs Modulation for All Band.

First, we compared the data rate values of the low band at 700 MHz, the mid band at 3.5 GHz, and the high band at 26 GHz and 28 GHz with respect to the various modulations. Based on Fig. 5 and Table VII, the data rates generated from bandwidth without band combinations do not meet the IMT-2020 requirements (shown in Table I), which sets the required peak data rate between 10 and 20 Gbps and the mean at more than 40 MHz for the low band or more than 100 MHz for the mid and high bands.

B. Analysis of the Data Rate with band combination

For the second scenario, we assumed different bandwidths with band combinations. We calculated only the mid band for 400 MHz and the high band for 400 MHz. We did not calculate the low band because the 700 MHz frequency band only allows 2x45 MHz. Fig. 6 and Table IX show the data rates versus modulation for the mid and high bands using 8x8 MIMO.

TABLE IX DATA RATE VS. MODULATION FOR MID & HIGH BAND

Freq Band	Modulation			
	QPSK	16 QAM	64 QAM	256 QAM
3.5 GHz	4.67 Gbps	9.35 Gbps	14.02 Gbps	18.70 Gbps
26/28Ghz	8.62 Gbps	17.24 Gbps	25.86 Gbps	34.48 Gbps

Fig. 6. Data rate vs. modulation for the mid and high bands.

First, we compared the data rate values of the mid band at 3.5 GHz and the high band at 26 GHz or 28 GHz with respect to the various modulations. The calculation shows

that the enhanced band combination from 1 becomes 4 used in the transmission, and the data rate is also enhanced. Based on Table IX and Fig. 6, the data rates generated from bandwidth with band combinations meet the IMT-2020 requirements (shown in Table I).

Specifically, we achieved a peak data rate that meets the IMT-2020 requirements by using 64 QAM and 256 QAM for modulation at 3.5 GHz. Peak data rates that meet the IMT-2020 requirements are also achieved if we use 16 QAM, 64 QAM, and 256 QAM at 26 GHz/28 GHz. According to these results, a spectrum in the 3.5 GHz, 26 GHz, and 28 GHz ranges have been identified as potential key bands for realizing 5G and would be suitable for supporting eMBB, a key element of 5G.

V. CONCLUSIONS

This paper selected candidate frequency bands for future cellular broadband communication systems based on global study trends and the recent status of worldwide frequency bands allotment. As a result, the 700 MHz, 3.5 GHz , 26 GHz, and 28 GHz frequency bands are selected as best for the Indonesian case study.

There are, however, conflicts between 5G uses and the 700 MHz, 3.5GHz, 26 GHz, and 28 GHz bands because of their use for incumbent services such as broadcasting and satellite services. Satellite services can be accommodated by reallocation of the Ext. C-Band or through adopting a policy of geographical separation for VSAT and 5G, to avoid interference. For broadcasting (700 MHz), the problem can be solved by terrestrial broadcast TV digitization with a defined analog switch-off (ASO) date, because delays in implementing ASO would have an impact on neighboring countries. The application of 5G technology in Indonesia at 700MHz would be very good for rural development because of the coverage, but these proposed solutions need time to be implemented.

Dividing the spectrum into three bands, the low, mid (below 6 GHz), and high (above 6 GHz) bands, it can be concluded that, if using the 3.5 GHz, 26 GHz, and 28 GHz frequencies, the highest data rates that would meet the IMT-2020 requirements could be achieved by using 4 x 100 MHz spectrum band combinations at 64 QAM and 256 QAM for 3.5 GHz and at 16 QAM to 256 QAM for 26 GHz and 28 GHz.

Since the spectrum band is important in proportion with data rate requests, the spectrum band that can provide the maximal bandwidth should have the greatest priority for future cellular broadband communication systems.

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Telkom University 5G Channel Models Under Foliage Effect and Their Performance Evaluations

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***Abstract*—This paper proposes Telkom University 5G channel model under foliage effect. The channel model is obtained from series of computer simulations by considering operating frequency of 3.3 GHz, bandwidth of 40 MHz, and real-field parameters of Telkom University environments. We also present the performances evaluation including the outage performance evaluated under Telkom University 5G channel model with and without foliage effects. The bit error rate (BER) and block error rate (BLER) curve of cyclic-prefix orthogonal frequency division multiplexing (CP-OFDM) numerology zero with 5G New Radio (NR) complex-binary phase shift keying (C-BPSK) and Polar codes are presented in this paper to validate the outage performance of Telkom University 5G channel model. We found that the Telkom University 5G channel model has 16 paths for the case of model without foliage effect and has 8 paths for the case when foliage effect is taken into account. The results show that foliage attenuation causes performance degradations indicated by worse outage performance and smaller number of paths at 3.3 GHz frequency. The obtained outage performance from the proposed Telkom University 5G channel model is expected to be a reference for 5G system implementation in Telkom University and Indonesia such that an optimal 5G system implementation in Telkom University and Indonesia can be achieved.**

***Index Terms*—5G New Radio, channel model, foliage effect, power delay profile, outage probability.**

I. Introduction

The continually increasing demand for user capacity in wireless communication systems has motivated the development of fifth generation mobile communication New Radio (5G NR) [1]. One of the key goals of 5G NR is to natively support the different use-cases of mobile communication which can be characterized using three requirements, i.e., enhanced mobile broadband (eMBB), massive machine type communications (MMTC), and ultra-reliable low latency communication (URLLC) [2].

The performance of 5G NR system depends on the propagation channel in which it is implemented. Unfortunately, the research on 5G NR propagation for mobile communication system in Indonesia is relatively small. Study on Indonesia 5G channel model has been presented in [3] without focusing on foliage attenuation. Thus, the measurement of 5G channel model by considering foliage attenuation in Indonesia is needed to be a reference for the design and deployment mobile wireless communication system [4] in Indonesia since Indonesia is mainly covered by foliages.

5G NR utilizes orthogonal frequency division multiplexing (OFDM) technique with numerology as described in [5]. Hence, OFDM numerology is envisioned for 5G NR [5] and is used in this paper.

Foliage is a common aspect in urban or suburban outdoor environments, and impacts to the quality of 5G NR communication system propagation due to scattering, depolarization effects, and additional induced attenuation [6]. Since Indonesia is a tropical country having several types of foliage, understanding and calculating the foliage effects on propagation is of significant importance for future 5G NR communication system design.

Foliage attenuation is a function of a multitude of parameters, including foliage thickness, tree types, foliage depth, etc [7]. Research on foliage attenuation effect to the propagation channel has been widely conducted around the world. The foliage attenuation of mango and oil plantation using 0.4–7.2 GHz frequency carrier is measured in Malaysia and compared to the other foliage model [8]. Furthermore, foliage attenuation effect on 73 GHz outdoor wideband using channel sounder is evaluated in [9].

Implementation of 5G systems in Telkom University (Tel-U) and Indonesia is in general without considering the channel mode that may cause inefficiency in terms of time and is lack of scientific rigors. When the channel model is known, various performances can be predicted as well as the optimal parameter settings of the transmitter and receiver infrastructures. Thus, Tel-U 5G channel model is needed to design an optimal 5G system implementation in Tel-U as well as in Indonesia.

The main objective of this paper is to obtain the Tel-U 5G channel model under foliage effect. *The contributions* of this paper are summarized as follows:

(i) The Tel-U 5G channel model is developed based on real-field parameters of Tel-U, Bandung, Indonesia.
(ii) A framework to calculate and validate the channel model and its performances, which is extendable for other locations in Indonesia with real-field parameters.

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TABLE I
NYUSIM INPUT PARAMETERS.

Description	Parameter	Value
Frequency	F_c	3.3 GHz
RF Bandwidth	B_w	40 MHz
Scenario	-	Urban Micro
Environment	-	LOS
Tx–Rx Separation Distance	-	Follows Fig. 1
Tx Power	P_{tx}	30 dBm
Number of Rx Locations	P_{tx}	1000 for each Tx–Rx link
Barometric Pressure	Bar	1011 mbar
Humidity	H_m	75%
Temperature	T	27^{o}C
Rain Rate	R_r	130 mm
Polarization	Pol	Co-Pol
Foliage Loss	-	Set into "yes" if we take foliage into account
Distance Within Foliage	d	Follows Fig. 1
Foliage Attenuation	L_{ITU-R}	Calculated from (1)

(iii) Outage, bit error rate (BER), and block error rate (BLER) performances of Tel-U 5G channel model under foliage effect, which can be used as a reference to set the parameter of 5G system implementation in Tel-U and in Indonesia.

The rest of the paper is organized as follows. Section II presents system model of the Tel-U 5G channel model simulation and calculation. Sections III presents a framework to calculate the 5G channel model and outage performance, while the performance results of Tel-U 5G channel model are shown in Section IV. Finally, Section V concludes this paper with some concluding remarks.

II. SYSTEM MODEL

Tel-U 5G channel model is represented by a power delay profile (PDP) obtained from a series of computer simulation with a real-field parameters of Tel-U environments. Since PDP is changing depending on time and locations, we need a representative PDP calculated from a set of instantaneous PDP to model Tel-U 5G channel and observe its performance. We use New York University simulator (NYUSim) to generate instantaneous PDPs of Tel-U, because NYUSim has a wide range of operating frequency and bandwidth with an option of foliage attenuation.

NYUSim is an open source software to simulate a channel by using a real-field parameters of any locations. The input parameters for NYUSim are shown in Table I and are adjusted with Tel-U parameters. The operating frequency F_c of 3.3 GHz with bandwidth B_w of 40 MHz is used based on the regulation of the Ministry of Communication and Informatics of Indonesia (MENKOMINFO) about broadband wireless access in Indonesia [10] and the specification of OFDM numerology

Fig. 1. Area of Telkom University considered for simulation.

TABLE II
OFDM NUMEROLOGY ZERO PARAMETERS [11].

OFDM ($\mu = 0$) Parameter	Value
Frequency carrier	< 6 GHz
Sub carrier spacing	15 kHz
Minimum bandwidth	4.32 MHz
Maximum bandwidth	49.5 MHz
Symbol duration	66.77 μs
CP duration	4.69 μs

zero [11]. In this paper, we consider OFDM numerology zero with parameters shown in Table II, where it has a smallest subcarrier spacing, fast Fourier transform (FFT) size, and bandwidth, which is suitable for applications requiring low latency and low-power consumption.

The simulation scenario are set into urban micro, where the maximum distance between Tx and Rx in this simulation does not exceed 200 m. Furthermore, we do not consider any obstacles except the foliage, and therefore we set the environment into line of sight (LOS) condition. We examine 1000 Rx locations for high accuracy, which means that there are 1000 instantaneous PDP generated from each Tx–Rx links. The environment data of Tel-U, e.g., barometric pressure, temperature, humidity, rain rate are collected from Badan Meteorologi, Klimatologi, dan Geofisika (BMKG) of Indonesia and are averaged for the latest year [12]. The Tx–Rx separation distance, foliage loss, distance within foliage, and foliage attenuation are set based on simulation area in Fig. 1, Tel-U, Bandung, Indonesia.

We consider two simulation areas to obtain more number of instantaneous PDP for simulation accuracy, where 2 Tx locations and 19 Rx locations are accompanied with omni-directional antennas. We measure the Tx–Rx distance, and the distance involving foliage for each Tx–Rx link by using Google Earth. Moreover, foliage loss are obtained based on the F_c and the distance using International Telecommunication Union (ITU) P. 833-9 standard about attenuation in vegetation [13] in (1). We also generate instantaneous PDP without foliage attenuation to complete the comparison and analysis of foliage effect by setting the foliage loss in NYUSim with

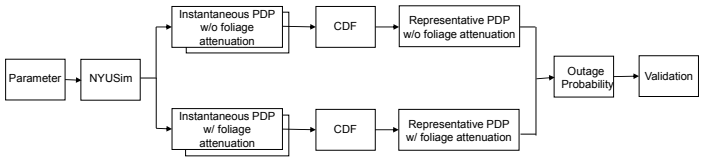

Fig. 2. A framework to obtain Telkom University 5G channel model under foliage effect.

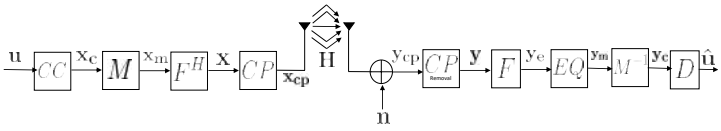

Fig. 3. CP-OFDM structure to validate the channel model results.

"No" and distance involving foliage to 0 m.

Fig. 2 shows the block diagram of the framework to calculate the Tel-U 5G channel model, which is summarized as follows:

- First, real-field parameters of environment in Tel-U, Indonesia, are collected as parameters of simulation area.
- Second, the instantaneous PDPs from NYUSim are generated using the measured real-field parameters. To observe the foliage effect to the Tel-U 5G channel model, we need to generate a set of instantaneous PDP without foliage attenuation and a set of instantaneous PDP with foliage attenuation.
- Third, the cumulative distribution function (CDF) of received power are calculated from set of instantaneous PDP without foliage attenuation and set of instantaneous PDP with foliage attenuation.
- Fourth, several steps in Sections III are used to obtain the representative PDP of Tel-U 5G channel model without foliage and with foliage effects.
- Fifth, the theoretical outage performance is obtained by assuming that Shannon capacity is achieved by setting that the channel coding rate R is equal to channel capacity C.
- At last, we validate the obtained outage performance of proposed Tel-U 5G channel model using BER and BLER performance of CP-OFDM numerology zero with 5G complex binary phase shift keying (C-BPSK) and Polar codes.

Fig. 3 shows the structure of CP-OFDM numerology zero with 5G C-BPSK modulation and Polar codes to validate the outage performance of Tel-U 5G channel model. C-BPSK is considered since it is suitable for applications with very low latency and low-power consumption. Furthermore, we compare the BER and BLER performance between Polar codes as a capacity-achieving codes used in 5G and convolutional codes as conventional codes.

Bit stream $\mathbf{u}$ in Fig. 3 are encoded using Polar codes with $R = \frac{1}{2}$ to generate codewords $\mathbf{x_c}$. Codewords $\mathbf{x_c}$ is then mapped using 5G C-BPSK in M module to generate symbol $\mathbf{x_m}$. The output from modulation block is then transformed using inverse fast Fourier transform (IFFT) F^H with block length of 128 and become $\mathbf{x}$.

The function of cyclic prefix CP module is to insert some portion of the last OFDM symbols of block in $\mathbf{x}$ to the early part of the symbol becoming $\mathbf{x_{cp}}$. The symbol is then transmitted through the measured Tel-U 5G channel. At the receiver side, noise is added to the received signal of $\mathbf{y_{cp}}$. Cyclic prefix in $\mathbf{y_{cp}}$ are than removed in $CP_{removal}$ module to generate $\mathbf{y}$.

Transformation of $\mathbf{y}$ using fast Fourier transform (FFT) are conducted in F module to generate $\mathbf{y_e}$ followed by equalizer in module EQ to generate $\mathbf{y_m}$, where the equalization process are explained, e.g., in [14]. The equalized symbol $\mathbf{y_m}$ is then demodulated in M^{-1} module to become codewords $\mathbf{y_c}$. Decoding process are conducted in D module to obtain $\hat{\mathbf{u}}$. We consider soft decoding and soft demapper based on log likelihood ratio (LLR) to increase the performance of the systems.

III. Proposed 5G Telkom University Channel Model and Outage Performance Calculation

Fig. 2 shows the framework used in this research to calculate the Tel-U 5G channel model. The framework generally consists of three main parts.

A. Instantaneous PDP Calculation

The environment parameters of Tel-U is observed to generate a set of instantaneous PDP from NYUSim. The environment data, e.g., barometric pressure, temperature, humidity, rain rate are collected and averaged from 1^{st} May 2017 to 1^{st} May 2018 from BMKG Indonesia website. We use Google Earth in Fig. 1 to calculate the distance between Tx and Rx, and also tree depth or distance within foliage. Fig. 1 shows that there are 19 Rx locations from two simulation areas in Tel-U with average, minimum, and maximum distance between Tx and Rx of 119 m, 45.9 m, and 169 m, respectively.

To calculate and observe the foliage effect to the Tel-U 5G channel model, a set of instantaneous PDP with foliage attenuation and without foliage attenuation are needed. We consider ITU-R foliage attenuation in this paper, which is expressed as [13]

$$L_{ITU-R}(dB) = 0.2 \cdot F_c^{0.3} \cdot d^{0.6}, \quad (1)$$

where F_c is the frequency in MHz, and d is the tree depth in meter. The environment parameters of Tel-U are then used to generate a set of instantaneous PDP on NYUSim. We generate 1000 instantaneous PDP with foliage and without foliage attenuation from each Rx locations as shown in Fig. 1 to observe more PDP for simulation accuracy.

B. Representative PDP Calculation

After a set of instantaneous PDP of Tel-U 5G channel model with foliage and without foliage attenuation were generated, the representative PDP are then calculated based on the following steps:

1. Convert PDP_i in dBm to numeric, where $i = \{1, 2, \cdots, K\}$ is an index number of PDP, with K being a total number of PDP trials.
2. Combine every α timeslot τ on each PDP_i and place into timeslot l. Symbol α represents the grouping index. We consider grouping index $\alpha = 40$ and $l = \{1, 2, \cdots, L\}$, with L being a total number of τ on PDP_i divided by α

$$\tau^{PDP_i}_{(l-1)\cdot\alpha+1} = \frac{1}{\alpha} \cdot \sum_{n=(l-1)\cdot\alpha+1}^{l\cdot\alpha} \tau^{PDP_i}_{n}. \quad (2)$$

3. Join each $\tau_{(l-1)\cdot\alpha+1}$ from all PDP_i and calculate the CDF.
4. Take the 90^{th} CDF percentile of each $\tau_{(l-1)\cdot\alpha+1}$ from all PDP_i as a representative PDP.
5. Take a threshold of -150 dBm to the $\tau_{(l-1)\cdot\alpha+1}$ from representative PDP.

Threshold of -150 dBm is assumed in this paper as the 5G device sensitivity in Indonesia. It means that the received signals having powers below than -150 dBm are assumed as a noise.

C. Capacity and Outage Performance Calculation

The obtained representative PDP of Tel-U 5G channel model with foliage and without foliage attenuation are then used to calculate the capacity and the outage performance. The capacity calculation on the broadband channel as a modification from Shannon theory is

$$C \approx \frac{B}{N} \cdot \sum_{n=1}^{N} \log_2 \left(1 + \left(m \cdot R \cdot |\psi_n|^2 \cdot \frac{E_b}{N_0} \cdot \frac{N}{N+Q}\right)\right), \quad (3)$$

where N is a block transmission length, m denotes the modulation index, R is a channel coding rate, Q is the CP length. The ψ_n represent the eigenvalue of parallel channel obtained from representative PDP expressed as

$$\psi = diag[\mathbf{F} \cdot \mathbf{H}_c \cdot \mathbf{F}^H], \quad (4)$$

where $\mathbf{F}$ is a Fast Fourier Transform (FFT) matrix and $\mathbf{H_c}$ is an equivalent matrix representing the channel matrix at the receiver after the CP removal. By following OFDM numerology zero [11], the CP length is

$$Q = \frac{4.69\mu s}{66.77\mu s} \cdot FFTSize. \quad (5)$$

We calculate the CDF to draw the outage performance curve of Tel-U 5G channel model without and with foliage attenuation based on the the outage probabilities. The outage probability is a probability that channel capacity C drops under channel coding rate R as

$$P(R > C). \quad (6)$$

By assuming that shannon capacity is achieved such that $R = C$, the theoretical outage performance of Tel-U 5G channel model without foliage and with foliage effects can be obtained.

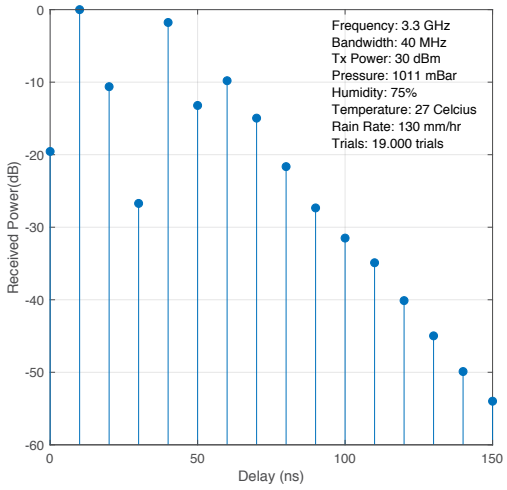

Fig. 4. Telkom University 5G channel model without foliage effect.

IV. Results and Validation

This section presents (i) the proposed representative PDP of Tel-U 5G channel models, (ii) the outage performance of the channel, and (iii) BLER and BER performance of CP-OFDM numerology zero with 5G NR C-BPSK and Polar codes to validate the outage performance. The outage performance of Tel-U 5G channel model will be valid if the outage curve is located in the left side of BLER curve and has a same gradient with BLER curve.

A. 5G Channel Model

We generated both 1000 instantaneous PDP without and with foliage attenuation from each Tx–Rx links in Fig. 1 to increase the number of PDP for simulation accuracy. We found that the instantaneous PDPs which were obtained from NYUSim are changing simulation-by-simulation.

Fig. 4 shows the Tel-U 5G channel model without foliage attenuation. The representative PDP of Tel-U 5G channel model without foliage attenuation have 16 paths. Mean excess delay and root mean square delay spread of representative PDP without foliage attenuation in Fig. 4 are 25.5960 ns and 18.1031 ns, respectively.

The representative PDP of Tel-U 5G channel model with foliage attenuation is shown in Fig. 5. We found that the foliage attenuation affects to the number of the path, where only 8 paths appear. Mean excess delay and root mean square delay spread of representative PDP with foliage attenuation in Fig. 5 are 12.7637 ns and 9.3653 ns, respectively.

The coherence bandwidth B_c of Tel-U 5G channel model without foliage and with foliage attenuation are 11.0478 MHz and 21.3554 MHz, respectively. Therefore, Tel-U 5G channel is classified into a frequency selective fading channel because the transmission bandwidth B_w (we consider bandwidth B_w of 40 MHz) is higher than the coherence bandwidth B_c, thus we need equalizer or OFDM to process the received signal.

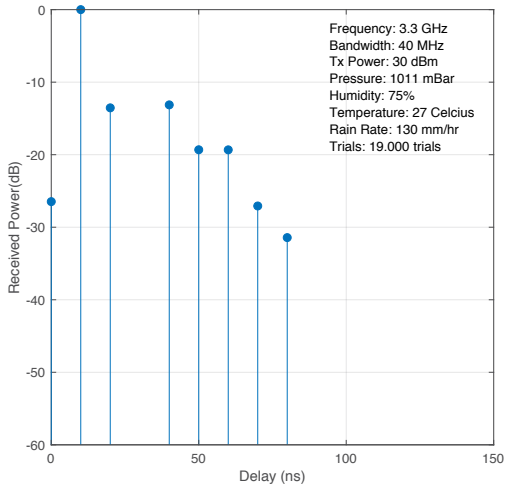

Fig. 5. Telkom University 5G channel model with foliage effect.

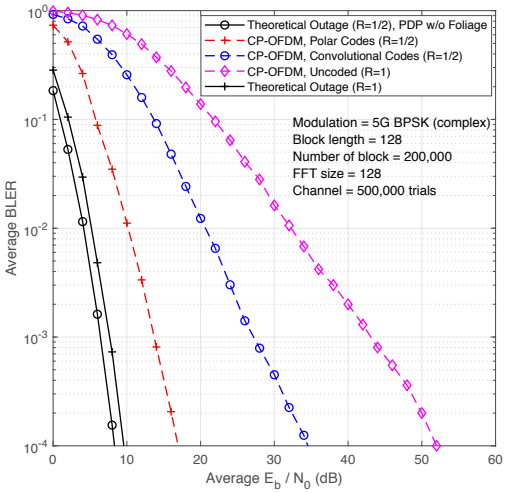

Fig. 7. BLER performances of Telkom University 5G channel model without foliage effect.

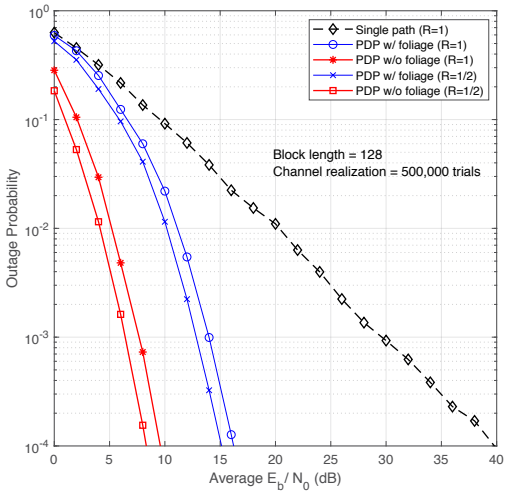

Fig. 6. Outage performances of Telkom University 5G channel model.

B. Outage Performance

The outage performance can be derived from the channel capacity by observing the probability of $P(R > C)$. This paper considers outage probability of Tel-U 5G channel model with channel coding rate $R = 1$ and $R = 1/2$ and then validate using CP-OFDM system with the same channel coding rate. The outage performances are shown in Fig. 6.

The outage performance curve of Tel-U 5G channel model without and with foliage attenuation have a better performance compared to the outage performance of single path, because Telkom University 5G channel model has 16 paths and 8 paths as a result of multipath. The outage probability of 10^{-4} in Tel-U 5G channel model without foliage attenuation can be achieved at E_b/N_0 of 9.7 dB with $R = 1$ and at E_b/N_0 of 8.5 dB with $R = 1/2$. On the other hand, the outage probability of 10^{-4} in Tel-U 5G channel model with foliage attenuation can be achieved at E_b/N_0 of 16.3 dB with $R = 1$ and at E_b/N_0 of 15 dB with $R = 1/2$. The E_b/N_0 of outage probability 10^{-4} with foliage and without foliage attenuation has a gap of 6.6 dB with $R = 1$ and 6.5 dB with $R = 1/2$.

C. Results Validation

To validate the outage performance of Tel-U 5G channel model in Fig. 6, we present the BLER and BER performance of CP-OFDM with channel coding rates of $R = 1$ and $R = 1/2$, where we found agreement on slopes of the curves between theoretical outage performance and practical performances obtained from simulations.[1]

Fig. 7 shows the CP-OFDM BLER of Tel-U 5G channel model without foliage attenuation. The BLER curve in Fig. 7 also confirmed the validation of outage performance of Tel-U 5G channel model without foliage effect.

Since we consider Shannon limit for the capacity calculation, the obtained outage performance can be used as a theoretical outage of 5G system implementation in Tel-U and Indonesia. The gap between the theoretical outage and BLER curve of CP-OFDM can be reduced by utilizing the strong capacity-achieving codes such that the diversity effect can be fully captured. Convolutional codes as a simple channel coding can give a performance improvement compared to the uncoded transmission, but not as much as Polar codes. The BLER of 10^{-4} in Tel-U 5G channel model system without foliage attenuation can be achieved at E_b/N_0 of 18.6 dB using Polar codes, at E_b/N_0 of 32.3 dB using convolutional codes, and at E_b/N_0 of 52 dB for uncoded case. The details of setting of simple convolutional codes with similar complexity is explained, e.g., in [15].

The validation of outage performance of Tel-U 5G channel model with foliage effect is shown in Fig. 8. The foliage attenuation leads to the performance degradation indicated

[1]It is important to note here that validation using, e.g., channel sounder for real-field experiment is still required to confirm the validity of PDP.

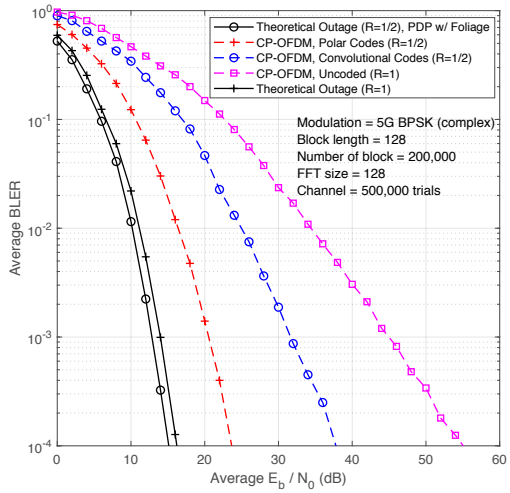

Fig. 8. BLER performances of Telkom University 5G channel model with foliage effect.

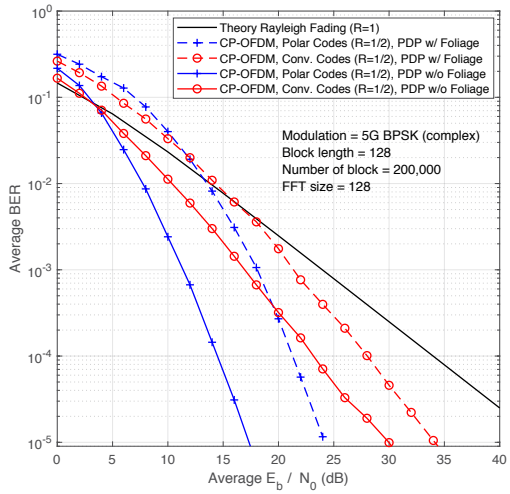

Fig. 9. Average BER of CP-OFDM under Telkom University 5G channel model.

by worse outage performance of Tel-U 5G channel model with foliage effect compared to the Tel-U 5G channel model without foliage effect in Fig. 7. The BLER of 10^{-4} in Tel-U 5G channel model system with foliage effect can be achieved at E_b/N_0 of 23.5 dB using polar codes, at E_b/N_0 of 37 dB using convolutional codes, and at E_b/N_0 of 54.3 dB for uncoded case.

Average BER performances of CP-OFDM with 5G NR C-BPSK and channel coding under Tel-U 5G channel model are shown in Fig. 9. We can see the diversity effect is exploited at the middle until high E_b/N_0, where Polar codes provide better performances compared to the convolutional codes. The BER of 10^{-5} in Tel-U 5G channel model with foliage attenuation can be achieved at E_b/N_0 of 22.2 dB using Polar codes, and at E_b/N_0 of 34 dB using convolutional codes. On the other hand, BER of 10^{-5} in Tel-U 5G channel model without foliage attenuation can be achieved at E_b/N_0 of 17 dB using Polar codes, and at E_b/N_0 of 30 dB using convolutional codes.

V. Conclusions

This paper has proposed Tel-U 5G channel model under foliage effect. We have produced a representative PDP of Tel-U 5G channel using the framework based on a series of computer simulations, where the parameters are taken from real-field environment of Tel-U. We found that foliage attenuation affects to the decreases of the number of paths, and worse outage performance. When foliage does not exist, the Tel-U 5G channel model has number of path, mean excess delay, and RMS delay spread of 16 paths, 25.60 ns, and 18.10 ns, respectively. When the foliage is taken into account, the Tel-U 5G channel model has number of path, mean excess delay, and RMS delay spread of 8 paths, 12.76 ns, and 9.37 ns, respectively. We expect that the obtained outage performances can be used as theoretical outage performances of 5G NR system implementation in Tel-U and in Indonesia. Similarly, the framework can be used to calculate 5G channel model in any locations in Indonesia such that the optimal 5G system implementation can be achieved.

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The Potential Use of High Altitude Platform Station in Rural Telecommunication Infrastructure

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***Abstract*— Many developing and less developed countries still need to develop its telecommunication infrastructures especially in rural area and remote area to enable the economic and social developments. Investment and operation costs are still major obstacles, due to the remoteness and lack of other infrastructures that support the telecommunication infrastructure deployment since solution are still rely on the terrestrial (cables and wireless) and satellite communication systems in term of cost, capacity and quality. In finding a compromise solution, the utilization of high altitude platform station (HAPS), a stratospheric airborne communication platform, as an alternative solution to the problems. In certain extents HAPS needs a lower investment and operation costs, while providing high quality and sufficient capacity. HAPS would be good alternative infrastructure solution for rural and remote area. This paper identifies the current problems in rural telecommunication: HAPS concept, current status of HAPS (technology and regulatory aspects), business model of HAPS and recommendation for HAPS implementation.**

Keywords—Rural telecommunication, HAPS, business model

I. INTRODUCTION

The importance of the information and communication technologies (ICT) for economic development has been widely acknowledged. Their positive impact on innovation, productivity, trade, employment, foreign investment, economic growth and, consequently, a country's competitiveness, has been widely proved and documented — not only in the case of developed countries, but also in developing countries and economies in transition [1].

Rural and remote area are integrated and important part of a country which cannot be differentiated from city. In many countries, rural and remote areas play important role e.g. preserving natural resources. Unfortunately, many people who live in those areas do not receive equal service in education, healthcare, financial services and other public services due to lack of telecommunication infrastructure. Common rural telecommunication infrastructure solutions are VSAT (satellite services) and microwave radio.

High Altitude Platform Station is a new approach of telecommunication infrastructure solution for rural and remote areas based on a stratospheric airborne platform. It has been discussed and studied for sometimes in many forums. HAPS has many advantages compares to other technologies. It seems to be good and fit to rural and remote conditions.

II. DISCUSSION

A. Rural and Remote Area

Typical condition of rural and remote areas is lack of road access and tend to be isolated. However, the existence of rural and remote areas particularly the people can not be neglected as they also play important role.

Developing the rural telecommunication infrastructure in many cases is not easy since most of the commercial telecommunication operators is not interested, unless some government initiatives are present. Common solution such as VSAT and microwave link incure high investment and operation cost such as site acquisition, access to site and cost of the technology, which in return are faced with low user density and low affordability.

B. HAPS

The stratospheric layer is one of layers surrounding Earth at the altitude 20 – 50km above the ground as shown in the following Fig.1 [2].

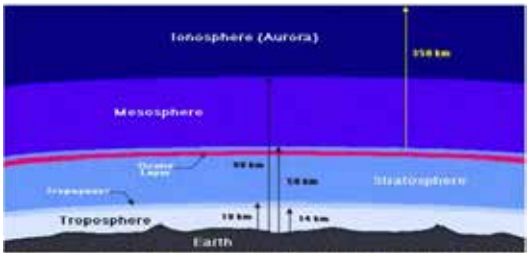

Fig. 1. Profile of Earth's Atmosphere [2]

That altitude also provides different distance to the horizon or radius as shown in the following Fig.2 where at 20-30km altitude gives a radius 500-600km [2].

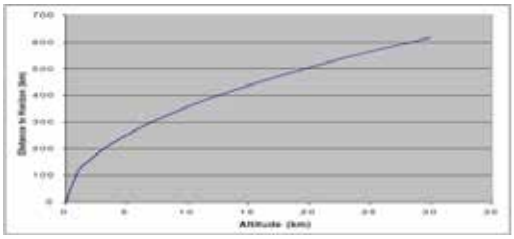

Fig. 2. Horizon Distance as Function of Altitude [2]

The mean annual wind speed profile (depending on the latitude) of the Stratosphere is around 5-10 m/sec or 18-36 kph [2].

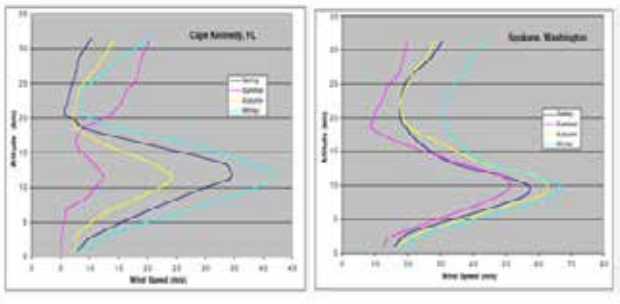

Fig. 3. Mean Annual wind speed in Florida and Washington USA [2]

Many airborne applications have been launched by utilizing the stratosphere environment e.g. atmospheric condition monitoring using gas balloon. In more advance man can also deploy a platform in stratosphere for long duration due to its mild condition. But in quasi stationary, a platform should be guided to provide broadband telecommunication services at different location.

HAPS is a technology that has been defined and elaborated by International Telecommunication Union (ITU) as stations located on an object at an altitude of 20 to 50 km and a specified, nominal, fixed point relative to the Earth [3]. HAPS radio spectrum allocations has also been provisioned in the ITU Radio Regulation (RR) document.

TABLE I. CURRENT HAPS SPECTRUM ALLOCATION

Frequency Band	Detail			
	Application	*Direction*	*BW*	*Coverage*
2 GHz	BTS IMT	UL/DL	145MHz-170MHz (x2)	R1, R2, R3
6 GHz	GW	UL/DL	80MHz(x2)	5 Admins (R1, R3)
28/31 GHz	GW, CPE	UL/DL	300MHz (x2)	23 Admins (R1, R3)
47/48 GHz	GW, CPE	UL/DL	300MHz (x2)	Global

Additional future HAPS spectrum allocation are being discussed and will be decided in the ITU WRC-19 (world radiocommunication conference) meeting in end of 2019.

TABLE II. ADDITIONAL HAPS FUTURE SPECTRUM ALLOCATION

Frequency Band	Detail			
	Application	*Direction*	*BW*	*Coverage*
21.4-22 GHz	GW, CPE	UL/DL	600MHz	R2
24.2–27.5 GHz	GW, CPE	UL/DL	3 250MHz	R2
38–39.5 GHz	GW, CPE	UL/DL	1 500MHz	Global

Where:
GW: Gateway
CPE: Customer Premises Equipment
UL: Uplink (GW/CPE to HAPS)
DL: Downlink (HAPS to GW/CPE)
R1: ITU Region 1 (Europe, Africa)
R2: ITU Region 2 (America)
R3: ITU Region 3 (Asia-Pacific, Australia)

HAPS implementation should be accordance in with the RR of Chapter III of Coordination, notification and recording of frequency assignments and Plan modifications on articles 11.9, 11.26, and 11.26A. The characteristics for HAPS frequency assignments in the terrestrial services is detailed in Table 2 of RR Appendix 4 [3].

The current status of HAPS is focusing on the platform (unmanned fix wing air vehicle and dirigible gas balloon) development. The ongoing HAPS projects are undertaken by e.g. Zephyr project of Airbus [5] and Stratobus project of Thales [6].

The following figure is the Zephyr platform as an unmanned air vehicle platform.

Fig. 4. Zephyr Platform of Airbus [5]

The following figure is the Stratobus platform (dirigible balloon) in a constellation formation.

Fig. 5. Stratobus Platform of Thales [6]

The objectives of those projects are: airborne duration and endurance, energy generation and conservation, payload capacity and telecommunication.

III. ANALYSIS

To understand on the system and cost impact of HAPS, an analysis by looking at the HAPS network model and comparison between the unmanned air vehicle or plane (fuel

and solar powered) versus the dirigible balloon is performed [7].

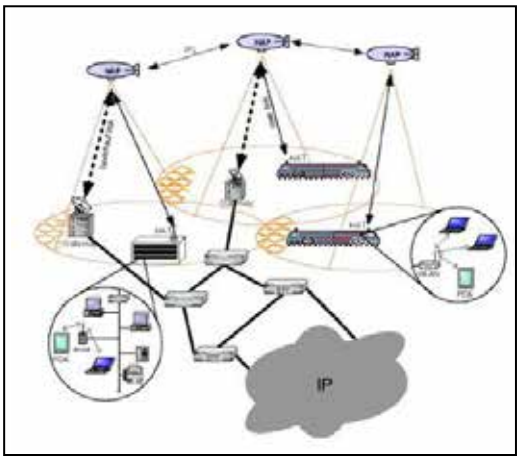

Fig. 6. HAPS Configuration Model [7]

The configuration is a basic model where HAPS are interconnected using Inter Platform Link (IPL) and each platform serves some HAPS Access Terminal (HAT). Some platforms are connected to gateways to further be connected to IP cloud.

Understanding the economic value, the following table provides comparison for HAPS business model adapted from [7] regardless of the frequency spectrum used.

TABLE III. COMPARISON OF HAPS SYSTEM AND COST

Item	Detail	
	Unmanned Air Vehicle	Dirigible Balloon
Fronthaul		
Max. cell capacity (Mbps)	120	
No. of cells	19	121
Total fronthaul capacity (Mbps)	2 280	14 520
Diameter per cell (km)	15	6
Diameter of coverage area (km)	59	60
Availability at minimm data rate (%)	99.9	
Redundency (%)	5	20
Backhaul		
Backhaul capacity per 50MHz	320	
No. of carriers per gateway	3	
Gateway capacity (Mbps)	960	
Redundency (%)	5	30
Cost		
Total development cost (M€)	50	225
CAPEX per unit (M€)	4	30
OPEX per annum non stop (M€)	1	4

Item	Detail	
	Unmanned Air Vehicle	Dirigible Balloon
Payload mass (kg)	150	1,000
Payload solar pwer generated (kW)	1	10
Flight duration	weeks	years
Operation human resource at launch	11	21
Platform lifetime (years)	5	
No. of platform for full operation per coverage area	1	
Spare factor	0.2	
Fleet/Reserve multiplier	0.2	

A qualitative comparison between HAPS vs GSO Fixed Satellite Services (FSS)/satelite vs Terrestrial (mobile cellular BTS) is presented just to show indicative differences among those 3 solutions for rural telecommunication infrastructure. A GSO FSS is at around 36,000 km from Earth with a national / regional footprint. The BTS is an average of 40 m tower of 2G/3G/4GLTE. The comparison is presented in the following table.

TABLE IV. COMPARISON OF TECHNOLOGY

Item	Technology		
	Satellite	HAPS	Terrestrial
Investment / CAPEX	High	Medium	Medium
OPEX	High	Medium	Medium
Access to User Terminal	Not direct	Direct	Direct
Geographical Coverage	National	Regional	Local
Signal propagation delay time	High	Low	Low
Upgradable	Hard	Easy	Easy

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Knowledge Management Readiness in Local Government of Archipelago: A Case of South Halmahera, Eastern Indonesia

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***Abstract*—Modern organizational resources are no longer based on economic capital, natural resources, or labor, but on knowledge as a major asset. Therefore, for an organization to have competitive advantages it is necessary to apply the concept of Knowledge Management (KM). By implementing KM in local government institutions, especially rural and island areas, it can successfully produce regional excellence by capturing, organizing, sharing and creating a new knowledge. The local governments are required to implement KM since the bureaucracy reform program was rolled out through Presidential Decree No. 81, 2010 concerning the Grand Design of Bureaucratic Reform and Ministerial Regulation on PAN and RB in 2011 concerning the application of KM in Government Organizations. In this study, the level of readiness of KM in the local government of South Halmahera is carried out using a qualitative approach. Direct interviews at the structural leadership level at the Department of Communication and Information in the District Government of South Halmahera, North Maluku were conducted, and validation tests were conducted through expert judgments (local academics) who interacted directly with a relevant government institution. The analysis results show that the level of readiness of the KM process in the Local Government of South Halmahera is 1.75 still in not ready level. The presentation of KM readiness is only 34% of the KMCSF factors from the assessment carried out, meaning that it still requires careful planning and a better strategy in the future.**

Keywords— Local Government, KM Readiness, KMCSF, South Halmahera.

I. INTRODUCTION

Modern organizational resources are no longer based on economic capital, natural resources, or labor, but on knowledge as a major asset [1],[2]. Therefore, for an organization to have competitive advantages it is necessary to apply the concept of Knowledge Management. By implementing KM in local government institutions, especially rural and island areas, it can successfully produce regional excellence by capturing, organizing, sharing and creating new knowledge process. The local governments are required to implement KM since the bureaucracy reform program was rolled out through Presidential Decree No. 81, 2010 concerning the Grand Design of Bureaucratic Reform and Ministerial Regulation on PAN & RB in 2011 concerning the Application of KM in Government Organizations[3].

Besides the lack of human resources and experts in local government institutions in Southern Halmahera, North Maluku, Eastern Indonesia also lacks the adequate and standardized infrastructures to simply apply the concept of electronic government (e-government). So, from the problem of lack of competent human resources and experts are required to implement a knowledge management (KM) implementation so that they get a healthy cycle of knowledge and information and can be reused of knowledge for the need to run the government task and improve the quality of services.

South Halmahera is one of the districts in the province of North Maluku, Indonesia. The capital of this district is located in Labuha City. This regency has an area of 8,892 km² and a population of 147,919 people. South Halmahera Regency at the beginning of its formation had nine sub-districts, but now it is 30 sub-districts. South Halmahera Regency was formed on February 25, 2003, based on Law No. 1 of 2003. In 2007 with the issuance of regulation No. 8 of 2007 the parent districts were divided into 30 sub-districts. The number of villages in South Halmahera is 250 definitive island villages and there are six Transmigration Settlement Units (UPT)[4]. Because it is classified as a new district and with a location in eastern Indonesia, the development of city and island infrastructure is still slack. Besides, the development of the village's economy and the potential of its natural local resources are abundant in this rural area.

This study aims to measure the readiness level of the local government in implementing the knowledge management process. Qualitative methods are used in preparing questionnaires and direct interviews with top managers in related units. The results of data analysis are then presented to get the expert judgment and agreement on the assessment data. As for the systematic writing of this paper that is, a chapter I we explained the background of the problem, why it is necessary to measure readiness in local government of the archipelago, chapter II conducted a literature review to obtain a theory of judgment, chapter III explained the stages and methodology used, chapter IV explain the results of the measurement and discussion for future recommendations and the chapter V contain conclusions and suggestions..

II. LITERATURE REVIEW

A. Knowledge Management

Knowledge management may simply be defined as doing what is needed to get the most out of knowledge resources. Although KM can be applied to individuals, it has recently attracted the attention of organizations. KM is set activities of discovering, capturing, sharing and applying knowledge for so as to enhance, in a cost-effective fashion, the impact of knowledge on the unit's goal achievement[5]–[7]. Knowledge as assets has crucial to managed in the government institution, according to this activity was very dependent on people work in, they work need knowledge where reside in every government employees. In addition, any government activity undertaken will be able to generate new knowledge and innovation[5], [7], [8]. These conditions require a knowledge management approach to be able to manage and maintain the knowledge that becomes a critical point in improving public services results. especially maintaining government task activities sustainability [9].

The knowledge management system is knowledge management mechanisms are organizational or structural means used to promote knowledge management. The use of leading-edge information technologies (e.g., web-based conferencing) to support KM mechanisms enables dramatic improvement in KM. knowledge management systems (KMS) is the synergy between the latest technologies and social/structural mechanisms[3].KM systems classification based on observations on the KM systems implementations are Knowledge Discovery Systems, Knowledge Capture Systems, Knowledge Sharing Systems and Knowledge Application Systems [2], [5].

The management process undertaken after creating Information systems is focused on the main business process. This study will be proposed KMS features that focus on the process of knowledge management that is critical for the organization. So that the required process KM process identification in the form of knowledge discovery, knowledge capture, knowledge sharing, and knowledge application[2]. Based on these aspects KM processes must be supported by KM System's proposed feature, KMS is supported by KM Mechanisms and Technologies supported by KM Infrastructure. These four KM processes are supported by KM systems and seven important types of KM sub-processes (e.g., exchange). KM processes are described and illustrated in fig. 1 below.

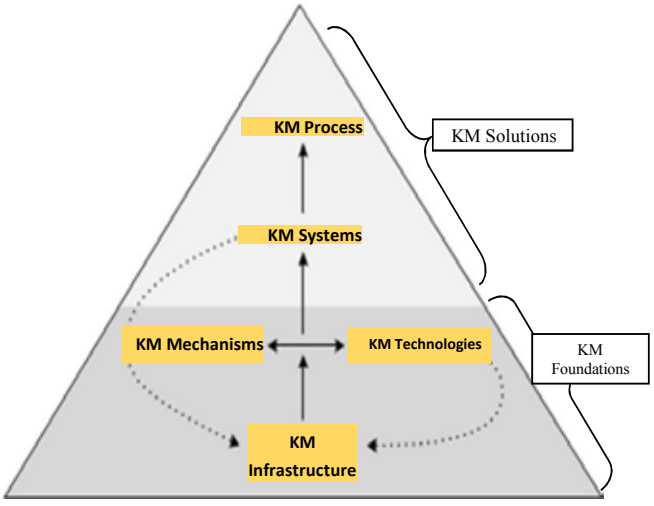

Fig. 1. KM Solutions dan Foundations Model[2].

B. Knowledge Management Readiness

Generally, readiness is preconditions required by a person or organization to succeed in making organizational changes[10]. Pertaining to KM, Mohammadi, Khanlari, and Sohrabi in [11]defines KM readiness as the ability of organizations, departments or workgroups in order to successfully use and gain the benefits of KM [12]. KM readiness as a receptive attitude or receive from members of the organization to be involved in the process of KM through sources available (KM enablers). This is in line with the statement Holt, Bartczak, Clark, and Trent in that the presence of enablers KM implies KM readiness[11].

Theoretically, considering what the key factors to success in the implementation of KM in organizations, in [13], [14] stated that the Knowledge Management Critical Success Factors (KMCSFs) are factors or activities that are needed to support the implementation of KM in organizations. The ability to understand and define the critical success factors is quite difficult. However, identifying KMCSF is important to understand how the system should be designed and implemented.

In [15] his book entitled "Knowledge Management Tools and Techniques" classifying the level of readiness of knowledge management into five levels, namely:

1. Not ready,
2. Preliminary (exploring knowledge management),
3. Ready (accepted),
4. Receptive (advocacy and measurement), and
5. Optimal (institutionalized knowledge management)

in[13] explained that the determination of KM Readiness level was seen from the average percentage of readiness of an organization in implementing knowledge management. The presentation of readiness of KM Readiness is calculated from the number or score of each indicator Knowledge Management Critical Success Factor (KMCSF) divided by the total overall maximum weight. Determination of these levels was analyzed using descriptive quantitative with the formula:

$$P = \frac{Sn}{Sm} X\ 100\% \qquad (1)$$

Description:

P : is a percentage of level

Sn : is the number of scores times weight obtained.

Sm : is the total score times the maximum weight.

The KM Readiness level can be shown in Fig. 2 below.

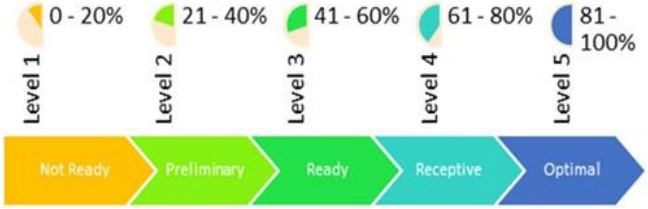

Fig. 2. KM Readiness Level.

The explanation from Fig.2 shows the characteristics of the KM readiness level as follows: level 1 (not ready) with 0-20% readiness, indicating that there is no understanding of the definition and benefits of KM, level 2 (preliminary) with readiness of 21-40% shows that there are individuals in the organization in carrying out KM processes, level 3 (ready) with 41-60% readiness, showing individuals in the organization have carried out activities that support KM regularly. Level 4 (receptive) with 61-80% readiness, shows that the KM process has provided benefits to the organization, level 5 (optimal) 81-100% readiness shows that the organization is well established in implementing KM in accordance with existing procedures.

III. Research Methods

This chapter discusses the methodology used in conducting research. The stages described are about research methodology and data collection techniques. The research carried out describes the measurement of the level of readiness of government agencies in implementing Knowledge Management. The study was conducted with a case study at the local government of South Halmahera, a qualitative approach with direct interviews with top managers in related departments (ICT department) and validated with 3 expert judgment. Stages in this research as shown in Fig.3 below.

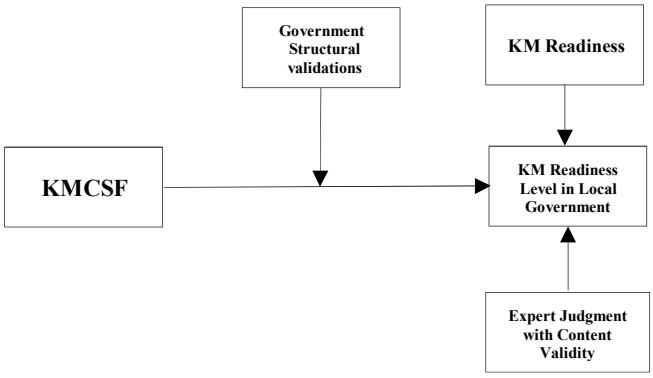

Fig. 3. Research Stages Methods

As the level of KM readiness in local government of the archipelago in South Halmahera will be measured based on KMCSF [13], [14], [16]. In addition, this KMCSF furthermore validated by direct interview of two top management in the structural department of ICT. Then these ratings will be weighted by a tree expert's judgment using the content validity index. To determine the readiness level, the authors use the KM Readiness. After the KM readiness level is ready, we showed a graph of the readiness level for improvements data to further assessment. Thus, the following theoretical framework of KMCSF used in this study can be shown in Table I. below.

TABLE I. Mapping Instrument of KMCSF Aspect

Aspect	KMCSF		KMCSF after Validations
	From Becerra-Fernandez[2]	*From Mamaghani, et al,*[17]	
Abstract	KM Understanding	KM Definition and Benefits	KM Understanding
	KM Initiative	KM Initiative	KM Initiative
Soft	Knowledge Strategy	Knowledge Strategy	Knowledge Strategy
	Management Support	Management Support	Management Support
	Performance Measurement	Performance Measurement	Performance Measurement
	Organizational Structure	Organizational Structure	Organizational Structure
	Organizational Learning	Organizational Learning	Organizational Learning
Aspect	**KMCSF**		**KMCSF after Validations**
	From Becerra-Fernandez [1]	***From Mamaghani, et al [17]***	
Soft	-	Financial Support	Financial Support
	Organizational Culture	Organizational Culture	Organizational Culture
	Motivational Encouragement	Motivational Encouragement	Motivational Encouragement
	Communication & Group Working	Communication & Group Working	Communication & Group Working
	-	Leadership	Leadership
Hard	Technology Infrastructure	Technical Infrastructure	Technical Infrastructure
	Physical Environment	Physical Environment	Physical Environment
	Knowledge Hub and Centers	-	Knowledge Hub and Centers

Based on expert judgment with a comment or rating quantitatively, the statistical approach used to measure the extent of items validity. In this research, we calculated the index following Aiken validity [18] that widely used in validating items rating of the KM Readiness level.

The agreement between experts indicated the significance of items, and it was calculated symbolized by V coefficient. V coefficient based on Aiken was formulated [18]–[20]:

$$V_j = \Sigma S_j / [n(c-1)] \quad (2)$$

Descriptions:

V_j : Validity Index
S_j : r-Lo (rating minus a low validity rating)
n : number of expertise
c : highest validity rating

The respondents profile interviewed directly both in the local government structure and academic expertise as shown in Fig.4. below. There were five respondents who had S1 educations 1 person (20%), S2 had 3 people (60%) and S3 had 1 person (20%), Which two respondents are the Head of ICT Department and Head of Employment Department in Local Government of South Halmahera. While three others are expert from local academics.

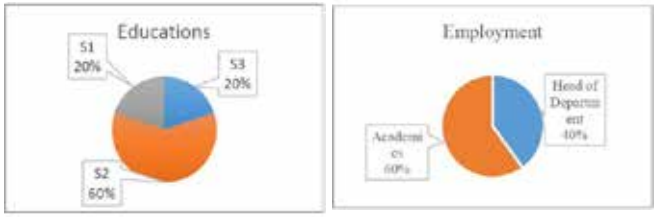

Fig. 4. Respondents profiles.

IV. Result and Discussions

After submitting a questionnaire with direct interviews with the heads of relevant local agencies in the Department of ICT (Dishubkominfo) and the Local Civil Service Agency (BKD) to get valid's KMCSF that has been confirmed directly by the local government structure. For the KM readiness level, we use the 3 academic lecturers, to get Expert Judgment on the results of the assessment conducted[21]. The validity results are shown by the value of the Validity Index> 0.7. the results are as shown in Table II. below.

TABLE II. The Validity Results of KMCSF Aspect

Aspect	KMCSF	Validity Index
Abstract	KM Understanding	0.70
	KM Initiative	0.70
Soft	Knowledge Strategy	0.75
	Management Support	0.95
	Performance Measurement	0.70
	Organizational Structure	0.70
	Organizational Learning	0.70
	Leadership	0.90
	Organizational Culture	0.70
	Motivational Encouragement	0.75
	Communication & Group Working	0.95
Hard	Technology Infrastructure	0.85
	Physical Environment	0.70
	Knowledge Hub and Centers	0.70

There is 14 critical success factor of Knowledge Management readiness to use in assessment in local government of South Halmahera. The result is shown in Table II, about validity index over 0.70 that using the formula (2)[21], [22]. The result of KM readiness level in local government in South Halmahera showed in Fig. 5 below.

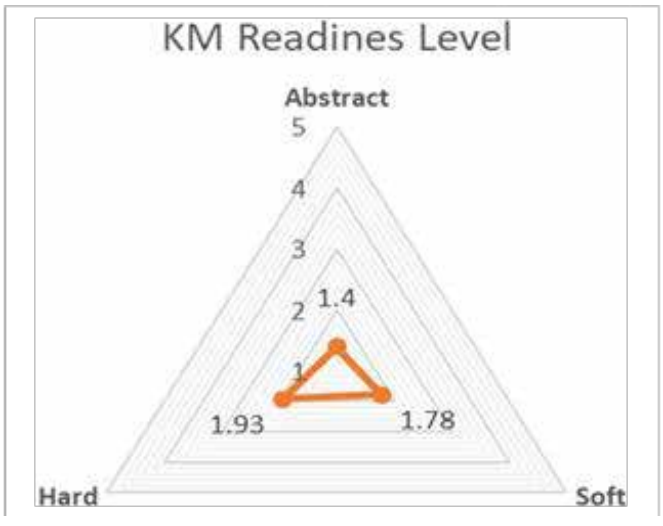

Fig. 5. The result of KM Readiness Level.

After validating the factors from KMCSF, both by the local government and expert judgment, we then used the KMCSF instrument to obtain the KM Readiness level in the local government by using a direct check of the interview results and requesting relevant evidence in the official location. The results of the readiness level KM measurement as shown in Fig. 5.

The study result of the measurement of KM Readiness level on local government in South Halmahera from the three aspects as shown in Fig. 5 shows the average readiness in the large group of Abstract aspects with a score of 1.4 or the percentage of KM Readiness is 28% meaning that it is still in level not ready, whereas in the aspect Soft is 1.78 which in percentage is 36% (that is not ready), while the last is in the Hard aspect with a score of 2.07 which is the percentage of around 41% is the highest, its meaning in level 2 (preliminary), so the total KM readiness level in the local government of the archipelago in South Halmahera is 1.75 or in the percentage of KM readiness for implementation in the institutions Government is 35% meaning that it is still 65% which has not been prepared.

V. Conclusions

Based on the results of the analysis and use of the method that is done by direct validation in the relevant department and requesting an expert judgment on the KMCSF factors presented in the form of a questionnaire, it can be concluded that from the three-aspect approach referred to, the measurement results show that the Readiness level KM on local government in Soult Halmahera is 1.75 or in percentage the readiness is still 34%, which means it is still in the not ready stage. Although in the Hard aspect, ICT infrastructures and physical environments have shown preliminary (level 2). So there is still another 66% to be prepared and planned carefully for the implementation of knowledge management in the future.

As a suggestion of this research to measure the maturity level, especially in rural areas in eastern Indonesia. That a standard cannot be applied to all cases of governments because based observes geographical, cultural, infrastructure and other factors are different in each region. The relevant contingency model must propose jointly between government business, citizen and academia local religion.

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The Revitalization of Warehouse Receipt System Through Business Process Improvement in Order to Support National Food Security

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***Abstract*—Warehouse Receipt System (WRS) is one of government programs that aims to increase farmers' income and support national food security. Based on data from Ministry of Trade, up to 2017 there are 121 public and 56 private warehouses which are spread out in 27 provinces and 124 regencies. In its implementation, the WRS has not been used optimally by farmers so that the purpose of its allocation has not been achieved significantly. Apart from the technical constraints of implementation in the field, this paper observed problems from the side of the implementation business process applied. Researchers make observations and interviews to stakeholders (farmers, warehouse manager, bank, local government) in warehouse best practice in Cianjur, to explore the existing implementation of WRS in Indonesia, and analyzes the weaknesses of the implementation business process. By doing literature review and benchmarking of the WRS implementation in some countries, this paper proposes improvement business process in order to strengthen the impact of WRS and reach the goals. The outcome of our proposed business plan is that farmer must deliver their harvest to WRS and further farmer doesn't have to take care their lending fund to lender because WRS manager will give the funds to farmer. Apart from it, farmer does not have to worries about how selling their harvest because WRS manager will help to distribute and sell and this entire process can be monitored by farmer through Mobile WRS app. The research also conducts Focus Group Discussion with expert and Bappepti (government body who responsible to WRS) to validate the proposed business process and provides some recommendations to implement the business process.**

Keywords— Warehouse Receipt System, Business Process Improvement, Food Security

I. INTRODUCTION

One of the main production commodities of the Indonesian is agricultural product, including rice, where the livelihoods of majority of people in the regions and villages are farming. Domestic rice needs are very high because it is a staple food. Based on data from the Ministry of Agriculture, in 2018 the target of national rice production is 80 million tons or 46.5 million tons equivalent to rice, while the estimated national rice consumption is only 33.47 million tons, so domestic production should meet national food needs, even surplus. But in fact, every year Indonesia still has to import rice. The government through the Ministry of Trade has opened a rice import tap in 2018. As many as 500,000 tons of rice will be imported from Vietnam and Thailand.

On the other hand, the level of welfare of Indonesian farmers is still largely poor. In 2014 the income level of farmers in Indonesia was around Rp. 9,032 /capita/day, ideally according to the World Bank the income poverty line was USD $ 2 /capita/day. Farmers often experience problems in terms of decreasing prices for selling agricultural products during the harvest, while they need money for their living needs and capital for replanting, but access to finance is difficult to obtain. So the choice that is often made is the transaction to the broker. Against these two problems, in order to realize national food security and to improve the welfare of farmers, the government has developed strategic programs, one of them is through the Warehouse Receipt System (WRS).

The implementation of the Warehouse Receipt System in Indonesia is carried out under the coordination of the Ministry of Trade and has a strong legal basis, which is regulated in Law No. 9 of 2006 concerning the Warehouse Receipt System as amended by Law No. 9 of 2011. There are many stakeholders involved in supporting the success of the Warehouse Receipt System, including warehouse managers, registration centers, guarantee institutions, conformity assessment institutions, financial institutions, and regulatory bodies as shown in Fig.1. The Warehouse Receipt System itself has been operated online using the Warehouse Receipt Information System / IS-WARE managed by PT. Kliring Berjangka Indonesia (KBI) as the registration center. So that the utilization of the Warehouse Receipt System in the regions is in line with efforts to provide information technology infrastructure networks to all regions of Indonesia carried out by the Ministry of Communication and Information through the Palapa Ring program. The benefits of the Warehouse Receipt System are expected to be experienced by many parties. For farmers, SRG is expected to improve the bargaining position of farmers, help get better prices (delaying sales time), certainty of quality and quantity of goods stored, and facilitate financing in a fast way. Meanwhile for the government, SRG is expected to be an instrument for making export/import policies, more efficient national stock control facilities, information price development tools, and controlling regional inflation [1].

Fig. 1. Stakeholders involved in Warehouse Receipt System [1]

According to data from the Ministry of Trade, up to 2017 there were 121 government warehouses and 56 private warehouses spread across 27 provinces and 124 districts [2]. However, there are some technical obstacles in its implementation, especially regarding limitations of prospective warehouse managers in regions that meet capital adequacy requirements and are able to carry out commodity management and marketing, limited access to non-food commodity marketing, and the lack of optimal support from local governments for the sustainability of WRS development policies. To overcome this, the Ministry of Trade through Bappepti has made several improvements. Among them is by integrating the Warehouse Receipt System with the Commodity Auction Market to facilitate the marketing of goods, and establish a multi-stakeholder working group to unite support for WRS success in the field [2].

However, these steps have not contributed to significant changes. The Warehouse Receipt System has not been able to function as an instrument to assist the government in maintaining the supply and prices of food commodities. Because the Warehouse Receipt System has not been used optimally by farmers, so its presence does not provide the maximum expected benefits, including increasing farmers' income. Apart from the technical constraints of implementation in the field, researchers observed problems from the side of the business process applied. Researchers conduct observations and interviews with stakeholders at WRS Cianjur which is the best practice, to find out the existing implementation of Warehouse Receipt System in Indonesia, and explore the weaknesses of the existing business process. This paper proposes business process improvement which has been validated through Focus Group Discussion with expert and Bappepti.

II. Basic Concept of Warehouse Receipt System

Basic concept of Warehouse Receipt System [3] shown in Fig.2 can be described as follows: (1) Producer entrusts the items in the Warehouse, (2) then the Warehouse will give receipt to Producer, (3) Producers can mortgage the receipt to Lenders, (4) and Lenders will provide the needed loan to Producers (5) Producer will sell the commodity to Buyer, and based on the agreement between Producer and Buyer, (6) Buyer can pay the loan directly to the Lender, (7) and will receive the receipt that has been pledged. (8) Buyer gives receipt to Warehouse, (9) and the Warehouse gives commodity to Buyer. To oversee the entire business process at the warehouse receipt system, there is a regulatory and oversight institution.

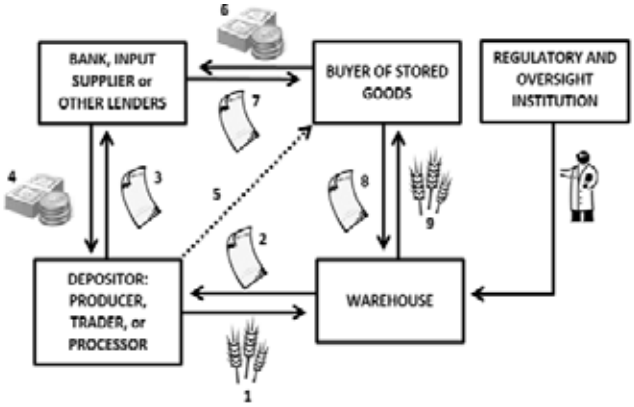

Fig. 2. Basic Concept of Warehouse Receipt System [3] [4]

III. WAREHOUSE RECEIPT SYSTEM IN UGANDA

Warehouse Receipt System has been implemented in several countries, such as in Uganda and the Philippines. Best practice in Uganda, farmer cooperatives collect commodities from small farmers to get large quantities of commodities and leave them to the warehouse. Warehouse operators accept the commodity and provide receipt. The receipt can be used to make loans to participating financial institutions. The trade in commodities that have been registered in WRS is supervised by the UCE, and all sellers and buyers involved in this trade must be registered in the commodity exchange or registered at UCE [5]. This process can be seen in Fig.3.

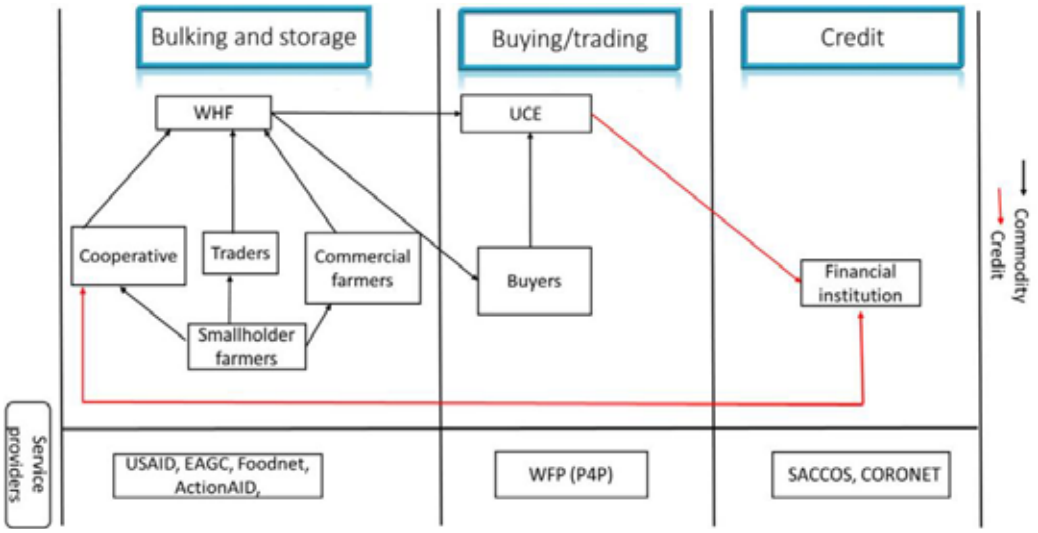

Fig. 3. Warehouse Receipt System in Uganda [5]

IV. EXISTING IMPLEMENTATION BUSINESS PROCESS OF WAREHOUSE RECEIPT SYSTEM IN INDONESIA AND BUSINESS PROCESS IMPROVEMENT

In Indonesia, the Warehouse Receipt System has been implemented since 2006. The business process of Warehouse Receipt System that has been running as described in Fig. 4 is as follows: Farmers come to the Warehouse to deposit their commodities, then the Warehouse manager will test the commodity quality, and register commodities to insurance. Then the warehouse manager will enter commodity data into the Registration Center to get a Receipt. Warehouse managers submit the receipt to farmers or commodity owners. Farmers have several choices after receiving the warehouse receipt, which is to deposit warehouse receipts to the bank and then sell them to consumers when commodity prices have increased, keep their warehouse receipts and sell them directly to consumers, or sell them through the auction market. In addition, BAPPEBTI has also built WRS mobile, one of which is to help farmers get information related to WRS, but until now the implementation has not run smoothly.

To find out the practice of implementing warehouse receipt systems in the field, researchers conducted data collection on WRS best practices in Indonesia, namely in WRS Cianjur. Researchers conducted interviews with relevant stakeholders in WRS, namely warehouse managers, banks, farmers, and local governments. From the results of the interviews, researchers found at least four weaknesses in the existing business process. First, the current government does not require farmers to entrust their commodities in the Warehouse, so the government does not have commodity data nationally. The advantage of having commodity data nationally is the ease of knowing which areas are excess of staple materials and which areas are lacking, so that they can meet national staple needs.

Second, most farmers usually want to get cash immediately after the harvest is over, and the obstacles that are often found in WRS existing business process are that farmers cannot get cash immediately when the harvest is complete or when their commodities are left at WRS. Although farmers can get loan funds from the Bank, the funds cannot be immediately disbursed because there is a bank administration process first. This is what often makes farmers reluctant to leave their commodities in the warehouse. Third, small farmers with a small number of commodities cannot entrust their commodities in the Warehouse, because this is constrained by the amount of costs used to entrust the commodity, starting from the cost of transportation and warehouse rental costs, which if not total in proportion to the sale value later. Last, the farmer who finally collects his receipt at the Bank, sometimes still experiencing confusion to sell the commodity. Whereas the maximum shelf life of the commodity is only 6 months.

To overcome the weaknesses of the existing WRS business process, the researchers proposed business process improvement. Then, the research held an FGD to validate the proposed model. The FGD was attended by experts in the field of information technology management and also Bappepti as the person in charge of the WRS program. The business process improvement that has been validated is shown in Fig.5 . Description of the proposed business process improvement is as follows:

Farmers must entrust their commodities to the nearest WRS. After the farmer put the commodity to the warehouse, the farmer will receive an electronic warehouse receipt and

receive the bailout provided by the warehouse. WRS manager works with the Bank to provide loans to farmers using commodity collateral deposited in the Warehouse.

Furthermore, the WRS manager manages the commodity, starting from commodity quality management, taking commodities to farmers, packing commodities so that they are ready for sale, commodity marketing to the sales process to consumers.

Through mobile WRS, farmers can monitor the status of the commodity, as well as the selling price of the commodity entrusted and decide for themselves when the right time is to sell the commodity. WRS managers will also give financial consideration to farmers about the best time to sell their commodities.

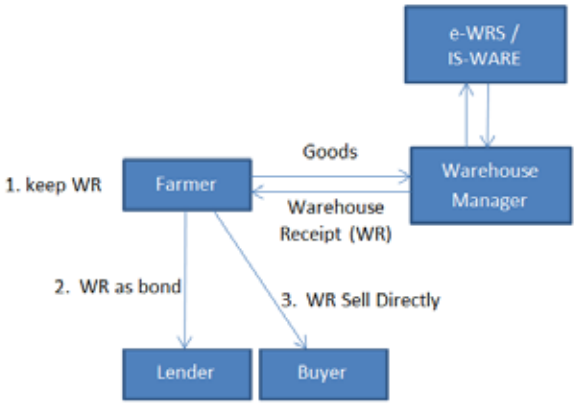

Fig. 4. Existing Business Process of Warehouse Receipt System in Indonesia [1]

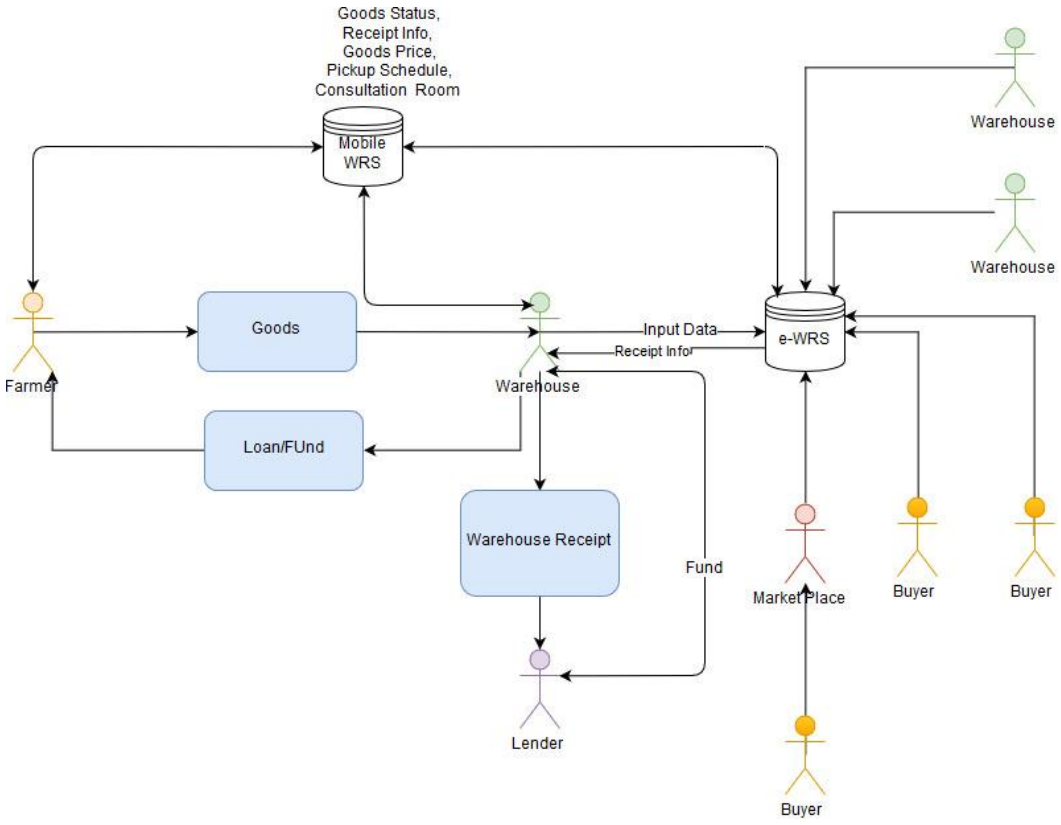

Fig. 5. Business Process Improvement of Warehouse Receipt System

WRS managers sell commodities stored in their warehouses through the national commodity exchange system. This national commodity exchange system connects the existing WRS throughout Indonesia with all potential buyers registered in the national commodity exchange system and also a market place to reach buyers who are not registered in the national commodity exchange system. In this national commodity exchange system, buyers can see the stock of goods in the entire WRS along with detailed information from the related commodities.

After the farmer has successfully sold the commodity, some portion of the funds will be used to pay off the Bank's loan and pay the WRS fee.

V. CONCLUSION

Revitalization is needed to strengthen the utilization and usefulness of warehouse receipt systems that have been built in Indonesia. The revitalization step can be done through technical improvement in field implementation, as well as business process improvement. The business process improvement of warehouse receipt system proposed in the research is expected to help realize national food security, because it is suggested that farmers are required to entrust their commodities in the WRS, and e-WRS has been established that connects one warehouse with another in Indonesia. So that it is expected to show the stock of staple food commodities in each region in real time, to fill the vacancy in food stocks in other regions, and there will be no more excess and shortage of staple food stocks in an area.

In order to optimally implement the proposed business process improvement of warehouse receipt systems, some recommendations are given. First, the government must first improve the condition of the warehouse receipt system in Indonesia and overcome the technical implementation constraints in the field, so that the warehouse receipt system is interesting enough for farmers. Second, the government can optimize the other warehouses in Indonesia, such as the warehouse owned by BULOG so that it can also be used as an WRS to overcome rice storage capacity nationally. Third, the government can socialize the warehouse receipt system to farmers widely by providing WRS mobile usage training, and placing a companion of at least 1 person who understands WRS mobile usage in each farmer group association. For the future research can focus on empowering farmers in the use of e-WRS, in addition it can also design the WRS and mobile WRS systems that do not yet exist in the existing e-WRS.

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Cloud Computing and E-commerce Adoption in Indonesia: Mind the Gaps

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***Abstract*— This study examines the e-commerce road map of Indonesia with its implementation and project plan to promote national development in Indonesia. The objective is to compare the eight aspects of the road map to academic literature that focuses on rural development strategy from the perspective of cloud computing and e-commerce adoption. The paper identifies areas of similarity and gaps in the road map to enable future research to best promote rural area development in Indonesia and reduce the digital divide.**

Keywords*— *e-commerce road map, cloud computing, e-commerce, adoption, rural area development, digital divide

I. INTRODUCTION

Cloud computing has been reported as the technology solution for e-commerce to leverage business coverage [1, 2], particularly for developing countries to improve business integration with information and communication technology (ICT) and national economic development [3]. Cloud computing adoption for e-commerce provides benefits such as cost reduction, less reliance on equipment needs, faster service and customer tracking [4, 5]. However, there are challenges for cloud computing adoption for e-commerce in developing countries, these include lack of infrastructure, lack of regulation and lack of stakeholders' support [6, 7]. In particular, the lack of infrastructure that contributes to limited connectivity in rural areas can increasingly inhibit adoption success [3].

The socio-culture and socio-economic challenges also hinder adoption in rural areas due to existence of digital divide, poverty and low awareness [6, 8]. The digital divide defined as "The gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard both to their opportunities to access ICT and to their use of the Internet for a wide variety of activities" [9].

In Indonesia, a developing country located in South East Asia, the digital divide mostly exists in eastern areas such as Papua Province due to low quality of infrastructure and low people IT skills [8]. The transaction valuation of e-commerce in Indonesia has been increasing since 2011, reaching more than US$ 3 billion in 2015 and predicted to reach US$ 16 billion in 2020 [10, 11]. With this potential, the government of Indonesia has attempted to optimize the development of E-commerce by declaring the E-commerce National Roadmap 2017-2019 [12].

The aim of this paper is to assess the effectiveness of Indonesian e-commerce road map in term of implementation based on existing literature in the information systems area and rural development strategy. The scientific contribution of this paper is to identify gaps between the road map implementation and rural area development strategy reviewed from the literature.

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II. BACKGROUND

A. Cloud Computing and E-commerce

Cloud computing is commonly described as the technology which offers virtualization of IT infrastructure resources (hardware, software and networks) in order to achieve cost reduction [13, 14]. Virtualization of IT infrastructure generated by cloud computing is based on its ability to provide "on-demand" infrastructure, platform and software for the service users [15]. The cost reduction obtained by cloud computing is its huge capability in supporting large data center and distributed hosting [16].

Cloud computing can be described using five essential characteristics, three service models and four deployment models [17, 18]. The essential characteristics include on-demand services [13], elastic computing [19], broad access [14], resource pooling [4], and measured service [18]. The service models consist of three main types, namely Infrastructure as a Service (IaaS), Platform as a Service (PaaS) and Software as a Service (SaaS) [3, 20]. The distinction between these service models lies on the purpose of services to achieve effective adoption [2, 17].

Cloud computing deployment model comprises of public cloud, private cloud, hybrid cloud, and community cloud. The differences among the deployment models include the intended service of deployment of cloud computing such as private vs public data centers as well as general vs specific purposes of the deployment [7, 20].

The main concept of e-commerce is the ability to process online transactions over the internet technology [5, 20]. The central idea of online transaction process is closely related to the availability and connectivity of internet technology facilities [6, 21]. The transaction process in e-commerce includes the exchange process between buyer and seller electronically [5, 22]. Here, the exchange process can include data and information, products, services and payments for commercial purposes using communication technology to facilitate business transaction [5, 18].

Furthermore, the digital transaction process in e-commerce can engage by several entities. From the business perspective, these includes customers, service enterprises, partners and employees at organisational or individual level [3, 17]. However, other perspective stakeholders such as suppliers and governments also contribute significant roles for effective online transaction process [23, 24].

Referring to the above concepts, it can be seen that e-commerce is the integration of business and ICT [3, 25]. This integration includes application of data exchange such as email, data provided such as website information, and automatic data capture such as barcode and Radio Frequency Identification-RFID [22].

B. Cloud Computing and E-commerce in Indonesia

The development of e-commerce in Indonesia began in the early 1990s, which was initiated by the introduction of Bhinneka.com in 1993. In 2012, the E-commerce Association of Indonesia (idEA) was founded by nine pioneer e-commerce enterprises in Indonesia, in response to increasing number of new e-commerce enterprises. Currently idEA has more than 320 registered members [26].

The e-commerce ecosystem in Indonesia is dominated by the business to customer (B2C) e-commerce platform, which comprises more than half of Indonesian e-commerce population [27]. These e-businesses mostly serve popular products and services such as fashion and apparel, home and living, electronic and gadgets, beauty, lifestyle and travel, women and baby, food and grocery [27]. A report from the Ministry of Communication and Information Technology (MCIT) of Indonesia in 2016, stated that fashion products have the largest sales from online shopping, followed by cosmetics and medicine, electronic device, transportation, and household [28].

The e-commerce valuation in Indonesia promoted by emerging internet and mobile technologies, reached 88.1 million mobile internet users in 2015 [29]. It is predicted to reach 215 million users and create potential e-commerce value of US$ 13 billion in 2020 [30, 31]. The increasing potential in online shopping value is recognized as an important aspect to the increased in national economic development of Indonesia [32].

The Association of Cloud Computing Indonesia (ACCI) was established in 2012, with the aim to synchronize cloud computing development in Indonesia as well as to improve the quality of human resource for industrial needs [33]. However, information of cloud computing development in Indonesia is still limited in terms of academic research. This makes it difficult to provide a complete history of the cloud computing development in Indonesia [34]. To date, there are reports that present case studies on how some e-commerce enterprises in Indonesia have implemented cloud computing technology to improve its competitiveness and market expansion [22]. This include the ability of cloud computing adoption to reduce the infrastructure needs that is beneficial to support the conditions in rural areas [25].

C. Challenges in Rural Areas

Current literature that reports on challenges encountered in rural areas in adopting the cloud computing and e-commerce in low middle-income countries include lack of telecommunication infrastructures, socio-cultural and socio-economical constrains [6, 7]. Infrastructure challenge is reported as the most relevant factor in rural areas [35].

The lack of infrastructure contributes to limited connectivity as well as socio-cultural and socio-economic hindrances such as low education and literacy levels, lack of awareness of e-commerce usage, limited language understanding provided by e-commerce website, and poverty that can result in low online shopping penetration in rural areas [6]. The lack of awareness in e-commerce usage resulting in lack of concern in security and trust issue such as buyers' deceptive activity and fraudulent behaviors [21]. This condition can be aggravated by low government regulatory support, particularly in low-middle countries [7, 18].

Other challenges faced by rural areas include the lack of stakeholders' support such as low market participation [21], lack of logistic vendors [36]. This can result in the difficulty to establish e-commerce ecosystem and disconnection between products and services delivery in rural areas [4].

In the context of Indonesia, factors that have the most implication to rural areas of Indonesia are infrastructure, security, regulatory framework, stakeholders' support and user acceptance [35]. A 2016 survey conducted by the E-commerce Association of Indonesia [37] reported a huge gap of e-commerce penetration between rural and urban areas. The survey reported only 11% of total rural area population, have had experience in online shopping, compared to 39% of total urban population. See Fig.1.

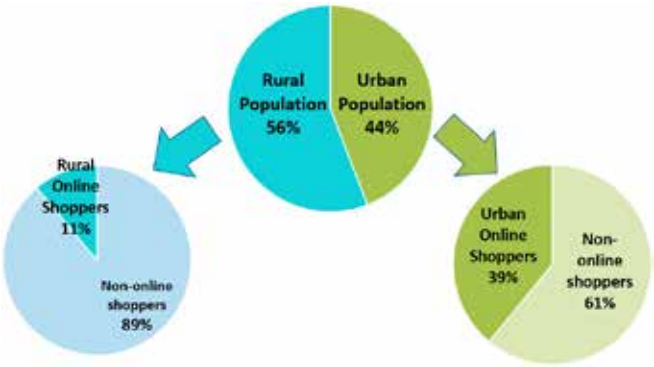

Fig. 1. Online Shopping Penetration in Indonesia in 2016 [37]

In 2017, a survey by Ministry of Communication and ICT similarly reported that internet usage in Indonesian rural areas was low, reaching only 32.5% of total population, which is half of the internet penetration rate in urban area (61.83% of total population) [38]. The internet penetration in eastern area of Indonesia such as Maluku and Papua Islands is only 20.65%, much lower than the penetration rate of internet in western Indonesia such as Java Island (61.35% of total population) [38]. This indicates the low infrastructure quality can affects the user acceptance in rural areas. It is also reported that more than 58% respondents have indicated that they are reluctant to participate in online shopping due to distrust of e-commerce security and uncertainty in relation to on-time delivery [37].

D. Government Effort

The Indonesian government has made several programs to develop rural areas. As indicated in Fig 2, the comprehensive national e-commerce development initiatives, stated in the presidential decree of E-commerce Road Map of Indonesia 2017-2019, covers eight aspects include funding, tax, consumer protection, education, committee, cyber security, logistic and infrastructure [12, 39].

Fig. 2. E-commerce Road Map of Indonesia [12, 39]

To follow up the road map, the government has formed a committee of e-commerce road map of Indonesia to coordinate, synchronize and monitor the implementation of the e-commerce road map, called the monitoring committee of electronic based national commerce system road map, which consists of several ministries, presidential office, and central bank [40].

From the infrastructure aspect, the government has developed the "Palapa Ring" national telecommunication infrastructure project since 2006 [41]. The project covers 34 provinces and more than 500 regencies in Indonesia. This project is expected to complete by the end of 2018 [42]. This project intend to reduce the lack of infrastructure in rural areas The goal is to overcome, the digital divide that still exists in rural areas [8]. The completion of the project will be a massive opportunity for the government of Indonesia to maximize adoption of cloud computing and e-commerce in rural areas [43].

In education aspect, the government has provided training to improve digital literacy for housewives and people with disabilities in the rural areas [44, 45]. For cyber security and consumer protection, the Law of Information and Electronic Transaction as well the Government Regulation on Electronic System and Transaction have been applied to reduce the fraudulent behavior and transaction protection in all area of Indonesia [46, 47].

The funding aspect has been followed up by the government, the MCIT, by providing financial support for a thousand of new digital startups in Indonesia to assist in starting their businesses [48]. For the tax aspect, the government provides easier process of tax administration for small medium enterprises (SME), equality treatment and easier procedures for new e-commerce registration [49].

III. Methodology

The method that was used to investigate consistencies and potential gaps between the e-commerce road map of Indonesia and the literature is one based on literature review use Webster and Watson strategy [50]. After distilling research themes based on key words, rural area development strategy, cloud computing and e-commerce keywords the literature was analysed. Using the eight parts of Indonesia e-commerce roadmap as an analytical framework the literature was analysed for areas of consistency, divergence and gaps.

IV. Rural Area Development Strategy

The academic literature devoted to the topic of rural development strategy provides a useful reference point from which to conduct an analysis of the E-commerce Road Map of Indonesia. A literature search was undertaken using the database Association for Information System Electronic Library (AISEL) and fourteen publications were selected for review (see Table I).

TABLE I. Rural Area Developmen Strategy

No	Authors	Strategy
1	Jansen [51]	Diffusion of Information Technology - Infrastructure and telematics development - Community teleservices centers establishment - IT-investments - User competence development
2	Leong et al. [52]	- Villagers' online purchasing assistance
3	Duan et al. [53]	- Infrastructure development - Human capacity investment - Service stimulation (internet, online public services, content and digital, agriculture extension) - Environment investment
4	Sabo et al. [54]	- Wireless network project for telemedicine, community information, and communication
5	Huang et al. [55]	- Building double e-markets - Integrating dual positive logistics - Constructing of agriculture supply chain traceability system - Construction online supermarket chain - Operating the construction of rural distribution center - Forming rural inventory pool - Building online community - ICT farmer training
6	Liu [56]	- National broadband plan
7	Shuai et al. [57]	Cost and profit sharing for rural business project
8	Bedekar & Peter [58]	Empowerment initiatives
9	Huang [59]	- Eco-innovations - Last-mile delivery program
10	Khairiansyah [60]	Telecenters for people community: - Organisation - Government support - Financial support - Social support - Operational support
11	Cazier et al. [61]	- Financial incentive - Social media encouragement - Interactive web interface for low literate people
12	Yenni et al. [62]	- Bridging digital competency gap - Strengthening digital and business capabilities - Creating sustainable ecosystem
13	Yue et al. [63]	Community empowerment
14	Xia [64]	Rural e-commerce framework

As indicated in Table I, the literature that reports rural area development strategy mostly focuses on human capacity empowerment and community development [53, 58, 60, 63]. The authors report that human capacity empowerment and community development can be delivered effectively using Telecenters for community [60].

Three authors reported telecommunication infrastructure development that include national broadband, and wireless network project [51, 54, 56]. Logistic development were also reported as the strategy for rural area development [55, 59]. It can be seen that several stakeholders' such as government, business players, logistic vendors and people are engaged in all these development areas.

Human capacity empowerment and community development area is related to government and business players endeavor to support increasing people understanding and usage of cloud computing and e-commerce. Since the digital divide is closely related to the socio-economic and socio-cultural level of the community, therefore, to reduce the digital divide, an effort should exist to increase the literacy levels in rural areas in order to engange more people to adopt cloud computing and e-commerce [63].

The government initiative to support people in rural areas to have access to ICT can be provided Telecenters for digital community The Telecenters can be used as a place to provide training of digital skill, service stimulation, and capital incentives [52, 53]. However, this effort needs to be supported by other stakeholders' such as educated people in rural areas and business players [55, 59]. For instance, the business players can provide user friendly e-commerce websites for users to facilitate easier usage, and also cost and profit sharing from larger business players to SME for business empowerment [57, 61]. The educated people in rural areas can also encourage community interaction with some ethical education in social media usage [61].

Infrastructure project is also reported as an important effort to reduce digital divide in rural areas. Good infrastructure can improve connectivity and access for people in rural areas [51, 56]. In the context of low- middle income countries such as Indonesia, infrastructure development such as broadband and wireless network are becoming a major agenda of national development [56]. This is evidence in the case of Indonesian government effort, in completing the "Palapa Ring Project" in 2018.

Logistic system development is essential for goods delivery process in rural areas to support agriculture products delivery. Literature review shows the logistic development using the dual positive logistic method and last-mile delivery program, as a potential solution [55, 59]. The supply chain system with decent distribution center and inventory are also critical for adequate supply of goods [55].

In addition to logistic system, the rural e-commerce framework is proposed by [64] to improve buying decision-making for people with low literacy in rural areas. This framework consists of big data, cloud computing, decision-making and Internet of Things (IoT). The rural e-commerce framework also intends to improve the agriculture products sales in rural areas by integrating the decision-making framework with smart agriculture system. The decision-making system can increase people e-commerce usage in future transaction [64].

A. Comparison of E-commerce Road Map of Indonesia with Rural Development Strategy

To assess whether the E-commerce Road Map of Indonesia 2017-2019 has accommodated the purpose of rural area development in Indonesia, it is worthy to compare the implementation program and project plan of e-commerce road map to rural development reported from literature. The comparison is summarized in Table II below.

TABLE II. COMPARISON BETWEEN E-COMMERCE ROAD MAP OF INDONESIA AND LITERATURE RURAL DEVELOPMENT STRATEGY

No	Aspect	E-Commerce Road Map Implementation and Project Plan	Literature Rural Development Strategy
1	Funding	- National Program 1000 New Digital Startup [48] - Soft loan for small enterprises [65] - Business incubator for startup [65]	- Financial incentive - IT investments - Cost and profit sharing
2	Tax	- Tax incentive [65] - Easy permission and procudere [49, 65] - Tax equality [65]	-
3	Consumer Protection	- Government Regulation of Implementation of Electronic Systems and Transaction [47] - Regulation harmonisation [65] - National payment gateway development [65] - Certification and accreditation [65] - Transaction protection [65]	-
4	Education and Human Resources	- Awareness campaign [65] - National incubator program [65] - E-commerce curriculum [65] - Education for consumer, business player, and law enforcer [65] - Digital literacy trainning for housewives [44] - Digital literacy trainning for disable people [45]	- Empowerement - Social media encouragement - Interactive web design - Farmer ICT training - Human capacity investment - Service stimulation - Online purchasing assistance - User competence development
5	Committee	Systematic committee from various government institutions [65]	-
6	Cyber Security	- Education for consumer, business player, and law enforcer [65] - National monitoring system model [65] - Improving cyber awareness - Storage, certification, and consumer data protection regulation [65]	-
7	Logistic	- National Logistic System (NLS) [65] - State Post company revitalisation [65] - E-commerce logistic facilities outsourcing development [65] - Logistic development in urban and rural areas [65]	- Integrating dual positive logistic - Agriculture supply chain traceability system - Online supermarket chain - Last-mile delivery program
8	Infrastruc-ture	National "Palapa Ring" Telecommunication Project [41]	- Telecommunication Infrastructure development - Broadband plan
9	Community	-	- Community telecenters/ teleservice centers - Onlince community - Community empowerement
10	Framework	-	Rural e-commerce framework

As indicated in Table II., four of the eight aspects of E-commerce Road Map of Indonesia 2017-2019 are consistent with literature on rural development strategy. These include funding, education and human resources, logistic and infrastructure. Tax, consumer protection, committee, and cyber security aspects, which are found in the road map have not been presented in the literature. The community and framework aspects, which are reported in the literature, have also not included in the E-commerce Road Map of Indonesia.

The funding as logistic and infrastructure aspects in E-commerce Road Map of Indonesia are consistent with rural development strategy. Although the education and human resource aspect in E-commerce Road Map of Indonesia is consistent with literature, this aspect has not included the training of digital literacy to improve farmer literacy level, particularly in rural areas.

The rural e-commerce framework as proposed by literature can also fill the gap as it integrates smart agriculture system with decision-making framework to improve agriculture products sales and people's e-commerce usage intention in rural areas. Moreover, providing Telecenters in community development aspect can enhance education and human resource development strategy.

V. Conclusions

Cloud computing and e-commerce adoption in Indonesia is addressed to increase the national economic development. The E-commerce Road Map of Indonesia 2017-2019 has been set up to support e-commerce development in Indonesia, which covers eight areas. However, the existing digital divide in rural areas, requires the road map to accommodate the rural area development.

The comparison of E-commerce Road Map of Indonesia 2017-2019 with academic literature supports four aspects of development areas include funding, education and human resource, logistic and infrastructure. Yet, education and human resource aspect in the road map needs to promote agricultural and farming factors in rural areas.

To improve people engagement in the road map implementation, community empowerment can be instigated by providing the Telecenters, a space for stakeholders' interaction. This can promote better collaboration between stakeholders in rural areas.

It is worthy for future research to investigate the rural area community development and the decision-making system in practical perspective, in order to identify the effectiveness of the strategy in the context of Indonesia.

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Forecasting The Number of Patients at RSUD Sukoharjo Using Double Exponential Smoothing Holt

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***Abstract*—There is a severe queues of the outpatients of the Sukoharjo public hospital (RSUD Sukoharjo) due to the limited resources to handling the increasing number of BPJS patients. Good decision-making is needed to solve this problem. Management of the hospital needs a tool to make a right decision. They need support like a predicting data particularly in predicting the number of the patients in the next period as a consideration to make a decision. For that reason, we develop an application for forecasting the number of patients and their attributes in the future using the Double Exponential Smoothing (DES) Holt method. In this method, an initial value of smoothing is determined through four different methods. This study aims to examine the accuracy of forecasting using DES Holt. The accuracy is measured using three methods namely MAE, MSE and MAPE. The result shows that the fourth method has the smallest error for MAE, MSE and also MAPE. Meanwhile, the prediction error which is measured using MAPE shows the lowest value when we use the second approach. Overall, the error value of the forecasting result using all approach of DES Holt are less than 10%. Therefore based on the standard, it can be stated that the forecasting result for the number of patients in various attribute using DES Holt is highly accurate.**

Keywords— ***Double Exponential Smoothing (DES), Forecasting , Time Series Data***

I. INTRODUCTION

In Indonesia, the hospital provides health services with outpatient, inpatient, and emergency care[1]. Therefore, a hospital has a significant role for people who need healthcare services. RSUD Sukoharjo is the only public hospital in Sukoharjo, one of district area in Central Java province, Indonesia. As a public hospital, RSUD Sukoharjo became a primary hospital referral of around 21 community level health seervices centres in the district[2]. One of the severe problems in RSUD Sukoharjo is a long queue at outpatient polyclinics due to limited medical staff and an increasing number of patients. For that reason, they need an application to forecast the number of their patients in the future. Hence they can prepare some resources to support their services. In this study, we use data patient at the pulmonary clinic as a case study. Forecasting is a process of compiling information about past events in sequence to predict future events [3]. When doing forecasting, we need the numbers of data in time series. Time series data is data which is collected from time to time to describe an event [4].

One of the methods to forecast on time series data is Double Exponential Smoothing (DES). DES method is more efficient to model data trend than other methods [5]. Previous research used DES method to forecast the number of housing demand in Malaysia [6]. It is also used for forecasting the production of dates [7]. The DES method provides high forecasting accuracy on data model by considering trends that occur [6-8]. DES shows better forecasting accuracy than Linear Trend, Quadratic Trend, Exponential Growth, Moving Average (MA), ARIMA, and Kalman filter [6, 7, 9] methods. Among the types of DES Holt and Brown, DES Holt gives better forecasting accuracy results [10-12].

This study aims to forecast patients with some its attribute for the near future using DES Holt. By considering the result of this research, the management of RSUD Sukoharjo could make better decisions to improve their health services.

II. LITERATURE REVIEW

A. Forecasting Using DES

Basically, forecasting is a process of compiling information about past sequence event to predict future events [3]. Forecasting is generally used to determine future circumstances to be a tool for decision making [13]. In other words, forecasting is done in a certain way for the purpose of obtaining value in the future [14].

The DES Holt method has been widely used in various forecasts. This forecasting method is smooths the actual data and trends with two different parameters [15], so this method is suitable for predicting data that has a specific trend of patterns. Forecasting by DES Holt method is obtained by using the following three equations [16].

$$L_t = \alpha X_t + (1-\alpha)(L_{t-1} + T_{t-1}) \quad (1)$$

$$T_t = \gamma(L_t - L_{t-1}) + (1-\gamma)T_{t-1} \quad (2)$$

$$F_{t+m} = L_t + T_t m \quad (3)$$

With,

L_t : actual data smoothing value in period *t*
L_{t-1} : the actual data smoothing value in the period (*t*-1)
X_t : the actual time series data of the *t* period
T_t : smoothing trend value of *t* period
T_{t-1} : the smoothing value of the period trend (*t*-1)
α, γ : smoothing parameters, $0 < \alpha < 1$ and $0 < \gamma < 1$

F_{t+m} : forecasting results for future periods m
m : many foreseeable future periods

In general, there are several ways of determining the values of L1 and T1. Using the actual value of X1 as the L1 value can be used three ways of determining T1, which are [5] [17]:

$$T_1 = X_2 - X_1 \quad (4)$$

$$T_1 = \frac{X_4 - X_1}{3} \quad (5)$$

$$T_1 = \frac{X_n - X_1}{n-1} \quad (6)$$

With,
X_t : the actual time series data of the *t* period
T_t : smoothing trend value of *t* period
n : total lots of data

In addition to these three ways, linear regression can be performed between the actual value of the time series data and the time period in which the intercept is determine as the value of L0 and its slope is used as the value of T0 [18]. The regression equation is shown in equation (7), whereas the determination of slope and intercept is shown in equations (8) and (9) as follows [5] :

$$Y = a + bX \quad (7)$$

$$b = \frac{\sum_{t=1}^{n}[(X_t - \bar{X})(Y_t - \bar{Y})]}{\sum_{t=1}^{n}(X_t - \bar{X})^2} \quad (8)$$

$$a = \bar{Y} - b\bar{X} \quad (9)$$

Where,
X_t : time period *t*
Y_t : data of many patients in the period *t*
$\bar{X}$: the average number of all X values
$\bar{Y}$: the average sum of all Y values
a : intercept
b : slope

B. Time Series Data

Planning and decision-making require a conjecture of what will happen in the future. A forecasting can be accurately done with past data [19]. Therefore, one type of data that can be used in a forecasting is time series data. The time series data is a collection of observations taken sequentially [20]. With the time series data then the pattern of data movement can be known. Time series data pattern can be divided into four types [21], which are :

a. *Horizontal*
The horizontal data type is the type of data that occurs when the observed data changes around the level or average constant. Example: monthly sales of a product do not increase or decrease consistently at a time.

b. *Seasonal*
The seasonal data type is the type of data that occurs when the observation is influenced by seasons, which is characterized by a pattern of repeated changes automatically from year to year. Example: the pattern of new book purchase data in the new school year.

c. *Trend*
Trend data type is the type of data that occurs when observation increases or decreases in the expansion period of time. Example: population data.

d. *Cyclical*
The cyclical data type is a data type characterized by fluctuations in data waves that occur around the trend line. Example: data on economic and business activities.

C. Accuracy

The forecast error gauge is used to evaluate the accuracy of a forecasting model [5]. The value obtained from a predictor error gauge shows the error rate of the model evaluated, so the smaller the value obtained will indicate a higher degree of accuracy. There are several measuring tools that can be used to measure the error rate of a forecasting model, among which the most commonly used are MAE (Mean Absolute Error), MSE (Mean Squared Error), and MAPE (Mean Absolute Percentage Error) [5, 17]. The process of calculating the values of MAE, MSE, and MAPE is shown sequentially in equations (10), (11), and (12) as follows [5]:

$$MAE = \frac{\sum_{t=1}^{n}|X_t - F_t|}{n} \quad (10)$$

$$MSE = \frac{\sum_{t=1}^{n}(X_t - F_t)^2}{n} \quad (11)$$

$$MAPE = \frac{\sum_{t=1}^{n}\left|\frac{X_t - F_t}{X_t} \times 100\%\right|}{n} \quad (12)$$

With,
X_t : actual data in period *t*
F_t : forecasting value in period *t*
n : number of data

III. METHODS

There are several steps to forecast by using DES Holt method. First of all, we were gathered data from the medical record during January 2012 until Agustus 2017. The attribute data consisted of Medical record number, Gender, Age, Address, Type of services, Type of Clinic, Date of check-in, Date of Check out, Diagnose and Funding.

Then, we processed data. On this stage, we refined some which were incomplete and unnecessary in the forecasting process. Then, the selected data were transformed to time series data form to get information about trend data in time series graphic.

Thirdly, we used DES Holt to forecast by using a computer program. Previously, we determined the most optimum value for alpha (α) and gamma (γ). Then, use formula (1) to get smoothing actual data, formula (2) to smoothing trend dan using formula (3) to obtain the forecasting value. We used six months of data for data testing and the rest data for data training. We evaluated the accuracy forecasting value using MAPE and standard accuracy [18] whereby, forecasting with MAPE highly accurate, good forecast and the reasonable forecast is worth to use. The accuracy scale can be seen in Table 1.

TABLE 1. FORECASTING ACCURACY SCALE

MAPE value	Accuracy Meaning
Less than 10%	Highly accurate
11% to 20%	Good forecast
21% to 50%	Reasonable forecast
More than 51%	Inaccurate forecast

IV. DISCUSSION

In the stage of preprocessing data, we selected some attributes from medical record which were used to forecast. Then, all the selected records from each attribute were transformed into time series data based on the occurrence frequency which represent the number of patients from the type of records.

A. Program Design And Implementation

As mentioned before in the literature review, we forecasting time series data using DES Holt through four steps using formula (1) to (3), then evaluate the accuracy of the result by MAPE using formula (4). The smaller MAPE values indicate the better accuracy.

Forecasting result using DES Holt is determined by the value of variable alpha and gamma. Therefore, it is crucial to find the most optimum value of alpha and gamma to obtain the smallest MAPE value or the best accurate result. The previous study mentioned that the best alpha and gamma value is in the range 0 (zero) to 1 [20]. We construct the computer program to find alpha and gamma value using an algorithm which is described in pseudocode as seen as follow.

```
/*function tampilkanData, receive 2 input parameter caranilaiawal, periode*/
FUNCTION forecast(INPUT.caranilaiawal,INPUT.periode)
   /*set values of data[] array by all records of all attributes in data
table*/
   SET data[] = READ ALL ATTRIBUTE FROM TABLE data
   /*set value of alpha and gamma variables by 0.01*/
   SET alpha=0.01
    SET gamma=0.01
   /*initialize variable mape,mae,mse, and array result[]*/
   INITIALIZE mape
   INITIALIZE result[]
   /*loop while value of alpha variable less than 1*/
   WHILE alpha LESS THAN 1
      /*loop while value of gamma variable less than 1*/
      WHILE gamma LESS THAN 1
         /*set value of des[] array by result of desholt function*/
         SET des[]=desholt(data[],INPUT.caranilaiawal,
INPUT.periode,alpha,gamma)
         /*if conditional,true if alpha and gamma equals 0.01*/
         IF alpha EQUALS 0.01 AND gamma EQUALS 0.01
            /*update mape value by value of index mape in array des*/
            mape=des[mape]
            /*update result array values by des array values*/
            result[]=des[]
         ELSE
    /*if conditional,true if value of index mape of
          array des is less than value of mape variable*/
          IF des[mape] LESS THAN mape
             /*update result array values by des array values*/
             result[]=des[]
          END IF
         END IF
         /*increment variable alpha by 0.01*/
         alpha+=0.01
         /*increment variable gamma by 0.01*/
         gamma+=0.01
      END WHILE
   END WHILE
   /*call tampilkanHasilRamalan function*/
   tampilkanHasilRamalan(result[])
END FUNCTION
```

At the implementation stage, there are four approaches (1, 2, 3,and 4) to determine the initial value of smoothing as seen in Table 2.

TABLE 2. FOUR APPROACH TO DETERMINE THE INITIAL SMOOTHING VALUE

Approaches	Explanations
First	It uses the actual value of the first period (X1) as the value of L1, and the value of T1 is determined by formula (4)
Second	It uses the actual value of the first period (X1) as the value of L1, and the value of T1 is determined based on formula (5)
Third	It uses the actual value of the first period (X1) as the value of L1, and the value of T1 is determined by formula (6)
Fourth	It is done by linear regression between the actual value of time series data with its time period then the intercept point is used as the data of the zero actual smoothing value (L0), and its slope is used as the data of the zero trend finishing value (T0). While the value of L1 is calculated based on formula (1), and the value of T1 is calculated based on formula (2)

Each approach to determines the initial value of smoothing which gives the different result of forecasting (see Table 2). Each methods also needs different parameter values of alpha and gamma to obtain the smallest error rate of forecasting. To obtain the smallest error forecasting result, We use the first method from Table 2 with parameter value α is 0.53 and parameter value β is 0.01. The results of forecasting for next 6 period is shown in Fig.1 as follow.

Fig. 1. Graph and forecast error rate of the way the initial smoothing value determines 1

Meanwhile, the second method of the smoothing initial value determination gives the smallest error rate of forecasting results by using the parameter value of α 0.46 and β 0.01. The results of forecasting for next semester is shown in Fig. 2.

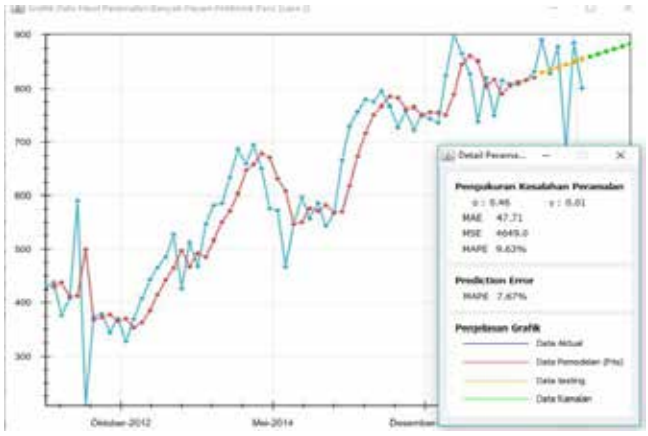

Fig. 2. Graph and forecast error rate from the way in which initial smoothing values are determined 2

Then, by using the third approach, we will get the smallest error rate when using 0.48 for parameter value α and 0.01 for parameter value β as shown in Fig. 3

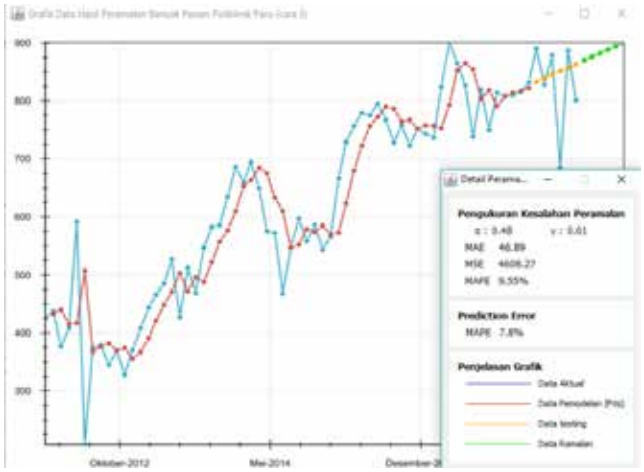

Fig. 3. Graph and forecast error rate from the way of initial smoothing values 3

Finally, by using 0.5 for the parameter value α and 0.01for parameter value β in the fourth method, we will get forecasting result with the smallest error rate as can be seen in Fig. 4.

B. *Accuracy*

We use MAE (Mean Absolute Error), MSE (Mean Squared Error), and MAPE (Mean Absolute Percentage Error) to evaluate the accuracy of forecasting result by using formula (10) for MAE, formula (11) for MSE and formula (12) for MAPE. The result of each method to evaluate the accuracy for four forecast approach shown in Table 3.

Fig. 4. Graph and forecast error rate from the way of initial smoothing value determination 4

TABLE 3. THE RATE OF FORECASTING PROCESS ERRORS OF EACH WAY OF DETERMINING THE INITIAL VALUE OF SMOOTHING

Methods	Forecasting model error rates			*Prediction error* (MAPE)
	MAE	MSE	MAPE	
1	45.87	4618.48	9.51%	8.04%
2	47.71	4649	9.63%	7.67%
3	46.89	4608.27	9.55%	7.8%
4	45.87	4574.56	9.4%	7.96%

It can be seen that there were just small difference error rate for each methods and the fourth method has the smallest error for MAE, MSE and also MAPE. Meanwhile, the second approach has the lowest value prediction error when measured by using MAPE. However, the smallest forecasting error rate is obtained by using the fourth method as shown in Table 2. Overall, the MAPE value is less than 10%, hence based on the standard in Table 1 we can say that the forecasting result for the number of patients in a various attribute using DES Holt is highly accurate. We can use the similar approach to predict other trend values of other attributes on the data patients of RSUD Sukoharjo.

V. CONCLUSION

An application for forecasting application the number of patients in various attributes has been developed using Double Exponential Smoothing Holt (DES Holt). By using four different approaches to determine the initial value of alpha and gamma using the level of accuracy 0,01 we obtain the high accuracy of forecasting result of the number patient with a various attribute in RSUD Sukoharjo.

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Bunda Cermat: Integrating Financial, Nutrition and ICT Literacy for Women in Indonesia

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***Abstract*— ICT applications such as mHealth have the potential to be an enabler in increasing the welfare and capacity of communities, such as the improvement of mother and child health. However, their implementation can often be hindered by many issues, including unfamiliarity with the technology. This is especially true in more resource-constrained settings such as rural areas in Indonesia. This paper describes a framework of a community education program that integrates ICT, health and financial literacy in order to increase mother and child health and nutrition for resource-constrained communities.**

Keywords—mHealth, mother and child health, ICT literacy, financial literacy, nutrition literacy

I. INTRODUCTION

Indonesia, like many other developing countries, faces a double burden of maternal and child malnutrition, with high rates of both under and over nutrition [1,2]. The causes of this issue are multifaceted, and include the intertwining between both outdated feeding practices with rapid socioeconomic and demographic changes that is not accompanied with associated capacity development [3]. In addition, rapid growth and socioeconomic changes also make both mothers and healthcare workers/volunteers time and resource constrained. This in turn limits the efficiency of existing interventions.

With the growth of mobile technology adoption in Indonesia, mHealth - the use of mobile technologies for health applications - becomes an attractive avenue to pursue to help alleviate these health issues [3]. However, actual implementation of mHealth programs are often faced with various hurdles, including in gaining participant engagement, operational and financial sustainability, as well as the lack of cumulative knowledge acquired from previous experiments/programs due to the difficulties in comparing pilot applications [4,5].

When one moves to more resource constrained settings, where ICT penetration is not yet very high, the hurdle also include unfamiliarity with technology, or simply, the lack of availability for the technology. This is especially the case in Indonesia moving from urban to rural implementation. Potential users often lack ICT literacy required for optimal uptake and impact of such ICT enabled applications.

This paper describes the development and initial stage of implementation for Bunda Cermat, a program that aims to combine financial, nutrition, and digital literacy for improving mother and child health, especially in terms of nutrition. The program utilizes a combination of digital and non digital toolkits to improve mothers' capacity in these three fields. The logic of this program is that each of the three capacities complement each other. Nutritional literacy may not be as effective when not supported by sufficient financial resources, which is influenced by financial literacy. Finally, ICT or digital literacy enables the development and growth of other capacities, including nutritional and financial literacy, as well as act on them, including the use of ICT-enabled application and opportunities.

II. OVERALL PROGRAM DESIGN

The program is developed by the Indonesian eHealth and Telemedicine Society with the support of Grand Challenges Canada. It leverages on prior experience, including Sahabat Bundaku, an mHealth application for mother and child health that links mothers, midwives and health offices.

Specifically, this experience highlighted the importance of complementary high-touch, low tech approach to technology, with more face-to-face or physical interaction easing the way in or complementing the way for technology. When moving from urban implementation areas to more rural areas where the mobile device penetration is still very low, the initial model of user training using their personal devices did not work. For that purpose, a paper based tool that simulates some of the function of the mobile application was developed.

Significantly,when the physical toolkit was introduced back to our mobile app users, the approach complementsed existing functions well, and even served as a good way to introduce some concepts and the mobile app program itself. Therefore, both digital and non digital tools are to be used in a complementary manner when possible.

Based on the lessons learned in these project, the Bunda Cermat program was developed on three main principles. The first principle is the integrated development of nutrition, financial and digital literacy. Nutritional and Financial literacy for women jointly drive the improvement of family

This project was made possible by funding from the Grand Challenge Canada Grant.

health and welfare, which fucntion as a base for growing family productive economy potential . Digital literacy serves as a catalyst to improving the other tyeps of capacity and opportunities. The second principle is to use creative learning tools such as the combination of both digital and non digital media and games for capacity building. Finally, the program combines top down and bottom up approach to engagement, leveraging the complementary nature between using economies of scale of top down implementation with more organic dissemination from the grass-root users.

The Bunda Cermat Program is designed to have strong synergy with existing governmental programs in multiple sectors such as health (e.g. mother and child health, stunting reduction). social and economy (financial literacy, saving culture, financial resilience, community productive economy potential), ICT (digital literacy), as well as gender (reducing the feminization of poverty)

The program is designed to consist of two main levels of literacy. In the first level, the aim is to develop basic nutritional, digital and financial literacy for the internal family domain, focusing on the internal family unit, namely creating a healthy family by improving family nutrition and resilience to financial shock. The second level builds on the first one, by focusing on skills that can help mothers and caretakers develop micro-businesses to improve their financial resilience as well as strengthen the community economy. The skills include basic market analysis and book keeping for the financial literacy, and nutrition-concious culinary skills that can serve as the content for the venture. Throughout, the ICT literacy will play a key role in facilitating the development of these related skills. Fig. 1 depicts the program framework as explained above.

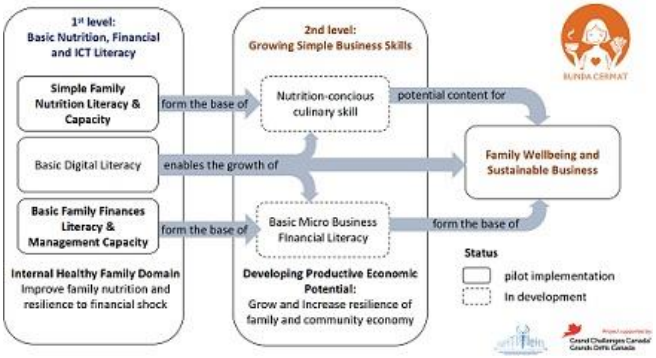

Fig. 1. General Program Framework

III. System Components

Based on the lessons learned from previous activities, the program utilizes a combination of physical and digital toolkits to facilitate capacity building. The toolkits are modular in nature and can be used in different configurations according to the needs of a particular community or event.

Some of the toolkits have only digital or physical versions due to their nature, while others may have both digital and physical versions or combine the use of both digital and physical mediums. In this section we present some of the first level modules that are being developed and implemented. The modules for the second level of the program are under development and are outside the scope of this paper

A. Bunda Cermat Application for Family Nutrition and Financial management

The main digital component of the program is the Bunda Cermat Application, an Android based mobile application which uses genetic algorithm implementation for meal recommendations. It is designed to have several functions, including (i) a simple healthy meal-planning tool, adjusted to locally based ingredients, which is (ii) integrated with weekly (groceries) budgeting tool, and equipped with (iii) additional simple financial planning/budgeting tools for pregnancy and child growth period, as well as (iv) a set of education modules on nutrition and budgeting.

B. Physical-digital-toolkit: Meal Planning, Portioning and recipes for Complementary foods

The second toolkit helps mother determine recipes and appropriate portions for their children's complementary foods. This toolkit has both a physical and digital version. In the simplified physical version of the toolkit, recipe ingredients are lined up on real size in a picture (as part of a picture recipe book, with appropriate sections for different stages of child's growth). These books are matched with transparent chopping boards or containers to help in food preparation portions.As highlighted in the previous section, the digital counterpart of this toolkit is a mobile application that will provide mothers with a simple healthy meal-planning and budgeting tool adjusted to locally based ingredients, and equip health workers/volunteers with a mobile app to assist in communication, education and patient management.

The two toolkits can be used either independently or together depending on the needs and available resources in the implementation settings. Fig. 2 depicts both the physical and digital version of the toolkit.

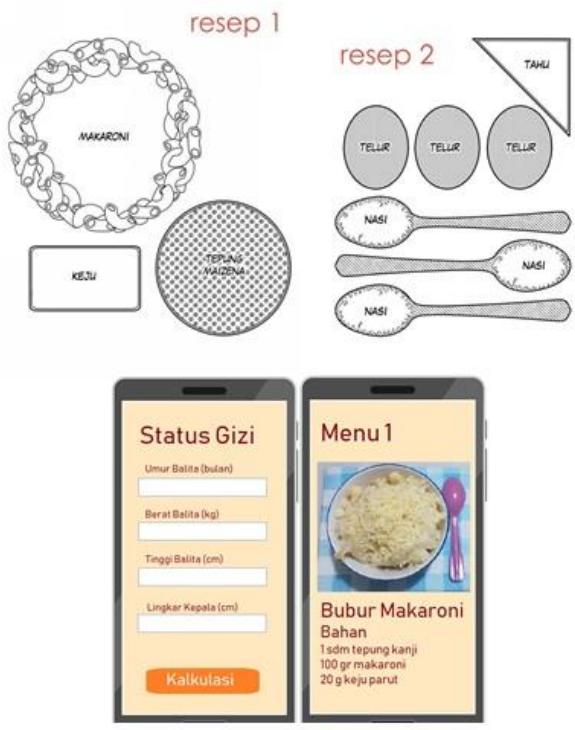

Fig. 2. The Meal Planning and Portion Physical and Digital Toolkit

C. *Physical-digital-Toolkit : "Kapan Ya Bu?" (When is it, Mom?) - Child Development milestones game*

The third toolkit is aimed as a refresher and learning tool for mother and child milestones, such as complementary feeding milestones, vaccination, and other developmental milestones. The game consists of a simple board with boxes denoting different stages of the mother and child's timeline, and a set of stickers representing the milestones. The game consists of taking turns in placing the milestones stickers on the correct "box", and the mother with the most correct answer wins.

In addition to being a refresher and learning tools for the milestones, the pilot workshop has revealed that the game is also a very useful conversation/discussion starter for mothers and volunteers/healthcare workers regarding children's development, as mothers would start talking about when different milestones are achieved by their own children, or when they thought the milestones should be. This also helps in detecting any systematic issues as well as an opening to a deeper discussion. Fig. 3 depicts the game board together with its matching set of milestones.

Board for the game:

Sticker set for milestones:

Fig. 3. The "Kapan ya bu" Board and its associated milestone stickers

D. *Physical toolkits: The Bunda Cermat Game - An Icebreaker for basic financial management*

The Bunda Cermat Game is a simple board game to learn simple day to day financial management for mothers. The game is intended to be played by a group of 3-5 mothers/players, ideally with at least one facilitator. The board simulates a calendar month, and the players proceed through the board in turns based on the dice thrown. The objective is to arrive at the end of the month with sufficient savings (10%,as recommended by the Indonesia Authority for Financial Services). Players gets points for arriving at the end of the month with more than 10% of savings, purchasing goods, and loses points if they run out of money before the end of the month.

The key learning points include basic numerical/financial literacy, balancing between needs and wants, the existence of unexpected events, the use of savings in unexpected events, as well as managing debt if necessary.

The players are given a "salary" (adjusted to local minimum wages) at the beginning of each month. Each day they pass on the board, regardless of whether the dice lands them on the date, players have to spend a small amount for daily shopping - this is in accordance with the daily (instead of weekly or monthly) shopping culture in Indonesia. Players also have to pay rent and utilities each month they play on a particular date. When they land on a "question mark", players have to take a card from the "Incidental" stack of cards. These cards represent non routine incidents, that can be either positive or negative shocks in the family finances, e.g. either having an accident or conversely getting a bonus from work. This set is currently in the process of being expanded with local variation.

Fig. 4 shows the board of Bunda Cermat, its associated "incidentals" card and a sample of a game ledger. When they land on a "star", players can choose to shop - players get 1 point for every 25.000 they spend. The point in giving some incentive for shopping is that there is the need to balance needs and wants. It's important to prioritize needs, but there is some value in fulfilling wants moderately. This is added to give players some agency, and encourage the perception that mothers may have personal needs and wants outside of the needs and wants of their children and family to maintain their mental health.

Fig. 4. The Bunda Cermat Board and accessories

E. Digital Literacy Program

The planned digital literacy training is also divided into several levels. The first level aims to develop basic competence in navigating digital media, including computers, mobile and smartphones, focusing on basic operations, the use of interned and social media for learning, as well as basic word processing. The second level goes into basic skills for small business purposes, including basic digital book keeping, online payment, and using online shopping platforms to open a business. In the future, more specialized courses may be developed to grow specific competence such as web design, graphic design, or other skills.

IV. Discussion

This program is currently at the later stage of its development and early stage of pilot testing. While there is not yet sufficient data regarding the efficacy of different elements of the program and the program as a whole, based on the initial pilot testing and development , we have several early lessons learned.

In order to iteratively improve our program, we conduct an evaluation session in the form of focus group discussions after each workshop. One lesson learned from the first pilot engagement sessions in different areas are the highly varied and specific practices between rural and urban areas, as well as between different regions, regarding financial and nutritional practices.

For example, in the more rural Karangasem area, there are specific expenditures that do not exist in other provinces such as a traditional/religious neighbourhood contribution. Similarly, the saving behaviour is also distinct. While almost all the mothers there do not have a bank account (due to both distance and habit), some have savings in the local co-op, or in the form of growing cattle as a means of saving for the birth of a child. The cattle will be cut/sold when the child is born.

Meanwhile, in the more urban Sukajadi district of Bandung, loan-sharks and consumptive behaviour are key issues. The consumptive behaviour impacts not only family finances, but also child health, for example in the habit of using disposable diapers (as opposed to fabric diapers) and ready made/instant food (as opposed to home-made food) which may not fit children's dietary needs. The local community health worker was very receptive to our program and we are in discussion of implementation in his jurisdiction and above. This kind of bottom up approach of adoption/uptake initiative from workers-on-the-ground is expected to complement a more top down approach of cooperation with municipal health offices.

To disseminate and continue to improve the program, partnerships are being developed. Currently, the implementation is done in cooperation with local health offices, and partnerships with relevant government bodies are being built. It is expected that this program can contribute to increase the health and welfare of mother and child in Indonesia.

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The eBario Story: ICTs for Rural Development

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***Abstract*—Malaysia's eBario project has had a seminal influence on policy and professional practice in ICT4D for rural development, especially for remote and isolated communities of indigenous minorities. Direct impacts have delivered benefits for improved skills, incomes, health, education, cultural preservation, agriculture and social communications for participating communities. Wider impacts include influence on national policy-making and the operation of development interventions as well as providing important insights into the conduct of ICT4D research that seeks to improve the lives of marginalised and underserved communities.**

Keywords—ICT4D, rural development, indigenous peoples

I. INTRODUCTION

eBario is the name given to an action research project by Universiti Malaysia Sarawak (UNIMAS) which began in 1998. Its objective was to demonstrate the opportunities for sustainable development in a remote and isolated rural community from the use of Information and Communication Technologies (ICTs), and to test how they could be applied to the problems and opportunities for development among communities of indigenous minorities. The project provided public telephones, computers and internet access for two schools and a community telecentre in the village of Bario. Access to the internet was via satellite and electrical power was provided with a combination of solar panels and a diesel-powered generator. The impacts of the project – both direct and indirect – have been considerable, delivering useful lessons at community, regional, national and international levels for the conduct of similar ICT interventions as well as for the means of using research to influence policy formulation and professional practice towards desirable outcomes for ICTs for development (ICT4D). In this article, we will outline the major activities, milestones, outcomes and lessons learned from the project. As each author has been directly involved from its outset, the article draws on a range of material, from formal research results to community workshop outputs and field observations.

Bario is an isolated and remote village in the Kelabit Highlands of northern Sarawak, one of the two East-Malaysian states on the island of Borneo. The area is the heartland of the Kelabit indigenous minority, one of Malaysia's smallest, and around 1,000 of the total 5,000 Kelabits live in the area. The lifestyle is typified by communal longhouses and wet-padi rice farming that is supplemented by hunting and gathering in the surrounding tropical rainforest. At the start of the eBario project, communications with the outside world were rudimentary. There were no roads connecting Bario to any other community. Access was by 20-seat Twin-Otter aircraft operated by the Malaysian Airlines Rural Air Service with around five flights per week. A cumbersome short-wave radio service was connected to the national telephone system. Being off-grid, all electrical power came from small-scale generators. The researchers soon discovered that the internet was unheard of and no-one had any knowledge of computers.

Simultaneously, the Government of Malaysia had proclaimed its Vision 2020 whereby the nation would achieve fully-developed status and it had established a Multi-Media Super Corridor that promised ICT-based development for all. Such initiatives sat in stark contrast to the daily experiences of many rural residents and particularly to the many isolated communities across the country who were starved of public services.

II. MILESTONES

The research study began by obtaining permission from the community leaders and this was followed by a household study that yielded base-line data for project guidance and outcome monitoring. Computers were initially introduced into the lower-secondary school, based on the widely-accepted notion that children would gain real benefits from them and against the background that the Ministry of Education was vigorously promoting e-learning. It also helped considerably that the school principal was strongly in favour of the research and supportive of having the technology in the school. Later, the facilities were replicated in the primary school and a community telecentre was established. This contained eight computers with internet access and printing facilities. Training in the use of the equipment was provided to anyone with interest.

In a short time, the benefits that internet connectivity provided quickly became apparent, mainly in terms of easy communication with family, friends and colleagues in the towns and cities of the rest of Malaysia. Another early impact was a boost to local community-based eco-tourism whereby the internet was used to promote local homestays and eco-tourism activities. Operators were no longer dependent on town-based agents to bring business as they were able to connect directly with any client having internet access. Additionally, the local clinic became a keen internet user; contacting the nearest hospitals on a variety of health-related matters.

As reports by the UNIMAS researchers began to emerge in global forums, various international bodies took notice of the project. The International Telecommunications Union (ITU) prepared a report in which eBario was proclaimed as "one of Malaysia's most significant Internet development projects" [1]. In 2006, UNESCAP published a Guidebook on Developing Community E-Centres in Rural Areas: Based on

the Malaysian Experience that was written by an eBario team member [2]. Additionally, the project began to receive awards, such as one of the Top Seven Intelligent Communities - 2001, by The World Teleport Association [3]. It went on to receive many more. Within Malaysia, the project instigator was commissioned by the Economic Planning Unit of the Government of Malaysia to prepare proposals for a National Strategy for Bridging the Digital Divide and this was written into the Nation's Ninth Malaysia Plan for 2006 to 2010 [4]. This provided for the establishment of telecentres in underserved areas across Malaysia.

As the UNIMAS researchers continued to present their findings at international forums, it became evident that whilst such events fulfil the imperative for academic advancement, they fall short of the requirement for influencing public policy and professional practice in the provision of ICTs to underserved communities that might stimulate local development. This is because policy-makers and development practitioners rarely attend such events. Neither do they read the academic journals in which researchers publish their findings. Moreover, conferences in which issues of poverty and rural development are addressed are rarely attended by poor people or residents of rural areas. In order to overcome these drawbacks, the eBario team devised the concept of a rural Knowledge Fair, and the first eBario Knowledge Fair was held in November 2007 [5]. This was formulated as an *unconference*[1] and was held in Bario so that participants received an immersive experience in the cultural and geographical context of the eBario project. In addition to the project research team, the event was attended by government officials and professional practitioners, most notably a delegation from the United Nations Development Programme (UNDP) Regional Centre in Bangkok who supported attendance by indigenous representatives from several countries around the world. The Knowledge Fair has been held every other year since then, upgrading to the eBorneo Knowledge Fair in 2015 and moving to another similarly isolated and remote indigenous community. This was in recognition of the expansion of the project to include more communities [5].

In 2009, the Government of Malaysia, who had provided the original funds for eBario, approached UNIMAS to implement the project in four other similar locations to demonstrate that the outcomes could be replicated elsewhere. At the same time, the eBario team was awarded funds by the International Fund for Agricultural Development (IFAD) to establish a community radio station in Bario. Radio Bario went on air in October 2010, becoming Malaysia's first community radio station. It broadcasts twice a day to a 15-25-kilometre radius from the eBario telecentre, in the local Kelabit language; disseminating local and national news as well as local announcements. The application for the broadcasting license for Radio Bario stimulated the government to liberalise its media policy, which had never before allowed community-based broadcasting. Following on from this success, IFAD provided funds for Bario to establish itself as an Innovation Village, under which a range of technology-based innovations were tested within the communities that UNIMAS and the Bario residents were supporting [6]. The project established Bario as a living laboratory for incubating innovative grass-roots applications of ICTs and renewable sources of energy capable of stimulating development within Malaysia's isolated rural and indigenous communities.

The project for Indigenous Technological Innovation in Malaysia aimed to organize further national dialogue between relevant stakeholders and the government to promote the concept of community radio among Malaysia's indigenous peoples and to consolidate the government's licensing policy stance. Additionally, under the new grant, eBario promoted the use of ICTs within Malaysia and among Asia's indigenous peoples by bringing together other Asian partners of the IFAD Indigenous Peoples Assistance Facility at the Third eBario Knowledge Fair 2011 [6]. Under this project, several initiatives were mounted that deployed technology innovatively towards community development that the participating communities had already prioritised during the Knowledge Fairs. These included low-cost aerial photography for community mapping, mobile technologies to record traditional botanical knowledge, and recording, cataloguing and archiving oral literature.

UNIMAS responded to the growth of the eBario project by establishing a Centre of Excellence for Rural Informatics (CoERI) which was later formalised as the Institute of Social Informatics and Technological Innovations (ISITI) in April 2011. The Institute aims to generate, disseminate, apply and preserve knowledge through an innovative and multi-disciplinary approach to empower society to sustainably address their developmental needs in a wider social and economic context.[2]

In 2011, the eBario team in UNIMAS was asked by the government's Economic Planning Unit to carry out a needs analysis in preparation for establishing telecentres at four indigenous Orang Asli[3] settlements in West Malaysia. The objective was to determine their ICT needs and uses and to provide training to all stakeholders, including community mobilisers attached to government and non-governmental agencies, on how to conduct community engagement activities when setting up telecentres for local development. Subsequently, the 2013 eBario Knowledge Fair included a delegation of representatives from these communities who were able to observe and learn from the ICT-based projects that were taking place in Sarawak.

Having partnered with several government agencies throughout the course of the eBario project, as well as stimulating national policy initiatives towards the provision of internet access for underserved communities, it was a logical development for UNIMAS to be asked to provide advisory services to the government agencies that were tasked with setting up the community centres that would make such access possible. Most notably, the government established a programme for community internet centres called *Pusat Internet 1 Malaysia* in which telecentres have been established in a wide variety of mostly non-urban locations. Since 2012, the role of UNIMAS has been to provide training to the staff of 29 of the centres that focuses

[1] A loosely structured conference emphasizing the informal exchange of information and ideas between participants, rather than following a conventionally structured programme of events. See https://en.wikipedia.org/wiki/Unconference

[2] See http://www.isiti.unimas.my/

[3] The indigenous people and the earlist inhabitants of Peninsular Malaysia.

on community engagement and mobilisation for initiating ICT-based development, on the basis that such initiatives will not emerge merely from the provision of access to the technology.

In a further collaboration, this time with researchers at Cambridge University, the Smart Villages Initiative aimed to better understand indigenous community preferences for electricity services and ensure that electrification schemes can be designed and implemented appropriately.[4] A joint research project was initiated focusing on a participatory approach that involved the identification of the choices that communities preferred for electricity services. The approach was undertaken through discussions with indigenous communities which took place at the eBorneo Knowledge Fair and which identified community preferences. Researchers noted that the eBKF created a space for dialogue in which indigenous community members felt comfortable for collaboratively developing their preferences and priorities. This resulted in far more authentic and relevant input than would have been attainable through, for example, a literature review or through discussions with academics or other experts.

Through their participation in international networks, UNIMAS academics met staff from Cornell University in the USA who were operating a programme of service learning for their students.[5] Service-learning is an educational approach that combines learning objectives with community service in order to provide a pragmatic, progressive learning experience while meeting societal needs. From the initial interactions it quickly became evident that the Cornell programme would benefit by sending students to the communities in Borneo with which UNIMAS were working in their ICT4D projects. Additionally, after consultations at the eBKF, the proposed participating communities were also able to recognise the potential benefits of receiving the students and their academic advisor to examine problems and solutions related to their resilience and sustainability. The first cohort of Cornell students arrived in Sarawak in January 2016 and were joined by two UNIMAS students to spend three weeks in Long Lamai, a remote and isolated village in the northern highlands. The exercise was judged a success by all participants and a second cohort of students repeated the experience in January 2018. Each of the problem/solution scenarios that the students and residents jointly examined during the service learning encounters involved the use of technology to some degree.

Parallel to the growth of the eBario project to include more villages, several indigenous communities in the same area formed an association called FORMADAT as a trans-boundary, grassroots initiative that aims to increase awareness and understanding of the communities in the highlands of Sarawak, to maintain their cultural traditions, build local capacity, and encourage sustainable development in the Heart of Borneo without risking the degradation of the quality of the social and natural environment.[6] The initiative was facilitated by WWF through their involvement with the proclamation of the Heart of Borneo as a government-led and NGO-supported programme that was initiated by a joint Declaration by the governments of Brunei, Indonesia and Malaysia in 2007. Its purpose is to conserve the biodiversity of the 220,000 km² forested region on Borneo island that is known as Asia's last great rainforest.[7] Given that two of the inaugural villages were already participating in the expanded eBario project, it wasn't long before the others learned about it and expressed an interest in sharing in the same benefits. Accordingly, in 2011, WWF, with guidance from eBario staff, facilitated the opening of the E-Krayan telecentre in Long Bawan, East Kalimantan, Indonesia – a short distance from the border with Sarawak.[8] Given the close correspondence between the aims of FORMADAT and UNIMAS-ISITI, the two organisations signed an agreement to jointly conduct research on community development, environmental protection and cultural preservation.[9]

By 2016, it became obvious that the eBario project had fulfilled all its objectives. The entire population of Bario were now aware of the internet and enjoying its benefits. Moreover, the device of choice had become the smartphone and the community expected ubiquitous access to the network. However, although the original model of a telecentre for shared access to internet-connected computers is now redundant for Bario, there remains an opportunity to re-brand the concept in response to its evolving role in a rapidly changing world. In addition to continuing to stimulate local development, eBario's role will now focus on managing the knowledge that this technology makes increasingly accessible. The telecentre is transforming into a knowledge centre for the community and a research centre under UNIMAS to promote the location as a destination for further research into topics related to community development and the environment. A key focus will be the facilitation of research that is relevant and useful to the residents of the highlands

III. OUTCOMES

The outcome results of eBario have been considerable and far-reaching and are well documented in the literature.[10] Within the Bario community, direct development improvements have occurred in many areas, relating to; improved skills, incomes, health, education, cultural preservation, agriculture and social communications. Furthermore, it can be argued that the indirect impacts of the project have been at least as profound as the direct impacts. Bario today is a very different place from that which confronted the first members of the team to approach the community with the idea of the project. In 1998, the population was dwindling; communications with the outside world were rudimentary; mobile phones were not available; no-one in Bario knew anything of the internet; nobody

[4] Funded by the Malaysian Commonwealth Education and Development Trust

[5] Cornell Public Service Center; https://psc.cornell.edu/students/service-learning-courses

[6] Forum Masyarakat Adat Dataran Tinggi Borneo (Alliance of the Indigenous Peoples of the Highlands of Borneo). Made up of the Lundayeh, Lun Bawang, Kelabit, and Sa'ban Indigenous Peoples of Bario, Ba'Kelalan, Long Semadoh (Sarawak), Ulu Padas (Sabah), Krayan and Krayan Selatan (Indonesia).

[7] http://wwf.panda.org/knowledge_hub/where_we_work/borneo_forests/

[8] http://wwf.panda.org/wwf_news/?unewsid=201070

[9] https://ir.unimas.my/14587/1/53.pdf

[10] See the Appendix Bibliography

regularly used computers; households had to generate their own electricity; agriculture depended on imported labour; there was no road access and less than one flight per day from the nearest major city of Miri.

By 2018, ex-residents are returning to live in Bario; everyone knows and uses the internet; computers are well-known and mobile phones are near ubiquitous; Radio Bario operates as Malaysia's first ever community radio station; a government-sponsored solar-farm provides 24-hour electricity; agriculture is mechanized; the highlands road network has greatly expanded, including access to Miri, from which there are upwards of three daily flights to Bario. Concurrent with these changes, the socio-cultural-economic and demographic profile of Bario has also changed. With easier access, tourism is now a major source of incomes; once-scarce goods are now commonplace; households boast a wide range of electrical appliances and there are even occasional problems with road traffic. Bario has been elevated to a sub-district, with a new administrative centre. High-level dignitaries frequently visit, including the Prime and Deputy-Prime Ministers. Local cultural events have become fixed features on Sarawak's event calendar.[11] The eBario project can rightly claim some influence in bringing about these development, as one resident succinctly put it "eBario put us on the map".

Moreover, the project has had not only a positive impact on the local community, it also influenced national policy and projects in Malaysia and abroad [7]. In Malaysia, the eBario experience advised national policy-making and implementations for bridging the digital divide and it was instrumental in liberalising the national broadcasting policy. Overseas, through the consulting activities of the instigator, the project's knowledge has been adopted by major international aid agencies and governments in 15 Asian countries.

IV. LESSONS

The first lesson concerns the conduct of ICT4D implementations and relates to its participatory approach to community engagement [8]. The researchers recognised at the outset that they were engaged in a development project that used technology rather than a technology project that did development. The key to desirable outcomes was seen to embed technology in local realities to ensure that it remains relevant to the needs and aspirations of the residents. Too many interventions take a techno-deterministic approach, assuming that it is the technology that will make the difference rather than the way it is used. The eBario experience underscores findings from elsewhere that paying insufficient attention to the context of implementation invariably leads to sub-optimal results. For example, de Goye, [9] found that the wellbeing impact of ICT4D interventions is primarily determined by whether they are introduced to address locally defined needs and the extent to which beneficiary communities are involved in their design, implementation and evaluation.

Next, the value of smart partnerships became apparent, not the least through the initiative of community members who leveraged on the project implementations to secure benefits of their own devising. The observation among the researchers is that true success emerges when community members appropriate the technology for themselves and put it to good use for functions that the researchers did not anticipate. An example of this is the annual Bario Food Festival that celebrates the unique food, farming, forest and cultural heritage of the Bario Highlands - as one of the last surviving intact traditionally farmed and forested highland watersheds in East Malaysia. The event was first organised by the management team of the eBario telecentre who made extensive use of the computing facilities to achieve their aims, admitting that without the centre, it would have been impossible to do so. The event is now a fixture on the annual Sarawak tourism calendar [10]. Further implementations have been accomplished by the eBario staff and project researchers working collaboratively with a wide range of government, private sector, educational and civil society organisations. One important lesson here is that technology appropriation become a highly desirable outcome from projects of this nature, yet because of its vagueness in terms of tangible and quantifiable benefits, it is unlikely to be found in successful bids for funding. In particular, technology appropriation does not lend itself to the logical framework approach to project definition that pervades many institutional methodologies for project definition and funding.

Another significant component of the project outcome relates to the imperative for innovating; abandoning cookie-cutter solutions that have been devised elsewhere and designing custom-made implementations that exploit technologies in a fashion that targets local problems and opportunities. It involves examining local problems and development challenges against a background of the known capabilities of the technology; then blending the two through brainstorming and creative thinking to devise innovative applications. Examples of this include the use of low-cost technologies for aerial photography – helium balloons and drones – in support of making maps that can be used to substantiate claims for land rights. Also, the project deployed mobile technologies to record traditional botanical knowledge and sign language of rainforest dwellers which was being lost but which encouraged the youths to learn using contemporary technologies [11].

Throughout its duration, the eBario project and its associated interventions have been based on the action-research paradigm, with the intention of not only testing interventions in real-life situations but also of demonstrating how similar results could be achieved elsewhere. The approach accords with the participatory principle of community-based development whereby residents are regarded as equal partners. It also ensured that solutions were devised through a bottom-up process that targeted genuine needs and opportunities in which local participants held a meaningful stake, something that contributes significantly to the likelihood of achieving desirable outcomes. Close engagement with community members was a key feature at all levels of project identification, design, implementation, operation and evaluation and this was extended to its ultimate expression through the eBorneo Knowledge Fair. As a mechanism for researchers to engage with their audiences, the Knowledge Fair overcomes much of the criticism that is levelled against academic research; that it is isolated from

[11] https://sarawaktourism.com/event/pesta-nukenen-bario-food-cultural-festival/

real-world situations within an ivory tower and has little or no influence on policy formulations or professional practice that might deliver improvements in the lives of underserved and marginalised communities. Research by Harris [12] revealed that while ICT4D researchers are interested in influencing policy and practice they are unlikely to adopt the behaviours that are thought to bring this about. One of the shortcomings is the absence of meaningful engagement with research users; something that the Knowledge Fair overcomes.

The final lesson for inclusion here is that through its work with indigenous minorities, the researchers have come to understand the distinctive relationship between indigenous peoples and development. Indigenous peoples have unique cultures and ways of relating to the environment that are distinct from the dominant societies in which they live. Orthodox state-sponsored development often inadvertently damages the cultures and lifestyles of indigenous peoples, as well as plundering their natural resources, despoiling their environment and sometimes moving them into new forms of poverty where none previously existed. Opposition to such initiatives can be misinterpreted as opposition to development, which indigenous representatives counter with calls for development that is indigenised – addressing their needs as they express them and fulfilling their aspirations rather than those of outsiders. The eBario project has convincingly demonstrated that ICTs offer opportunities for indigenised development when introduced within processes that take full account of the local socio-economic context. The outcome is to empower indigenous communities to devise and implement development activities of their own design. Furthermore, many of the core characteristics of ICTs have been seen to be conducive to the promotion and implementation of indigenised development. For example, the "death of distance" brings isolated communities into public debates around issues that affect them, and the democratisation of communications gives voice to previously unheard peoples [13].

V. CONCLUSION

The eBario project offers important lessons for ICT4D interventions, especially in rural communities. For practitioners and policy-makers, ICT4D interventions will maximise their chances for desirable outcomes when they are operated in a participatory bottom-up fashion; addressing needs that have been identified and prioritised by the community; involve smart partnerships with a range of stakeholders and which promote appropriation of the technology by the community. For researchers, action-research and close engagement with research users are effective methods for developing working solutions to local problems and promoting such methods to wider audience. These lessons have already been applied to national initiatives and are capable of replication elsewhere.

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The Design and Implementation of Data Visualization for Integrated Referral and Service System

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Abstract— **Integrated Referral and Service System (IRS/SLRT) propose to overcome possible fragmentation and lack of coordination of national and local social protection and anti-poverty programs. It also aims to update poverty database infrequently and the regular way by providing local government with tools to encourage better coordination of programs implementation at the local level and to make the programs more responsive and relevant to local needs.**

In its implementation, IRS built a comprehensive Management Information System (MIS) consisting of several modules, i.e., web-based modules, mobile application module, and dashboards. The dashboard is an essential component in IRS applications since it is one of the tools for monitoring program implementation.

This paper describes the design and implementation of the IRS dashboard module that summarizes implementation data from 78 regions until the first quarter of 2018, where authors involved in the design and development of the dashboard of IRS. This paper presents a data visualization approach by utilizing business intelligence and data analytic tools, Tableau, that allows dashboard created and presented effectively with simplifying the staging and ETL process that generally needed in dashboard generation.

Keywords—dashboard, data visualization, business intelligence, Tableau

I. INTRODUCTION

The Government of Indonesia, under the leadership of Indonesian National Development Planning Agency (Bappenas) and the Ministry of Social Affairs, is creating a program, Integrated Referral and Service System (IRS/SLRT) with the aim of improving coordination and integration of social protection and anti-poverty initiatives at the local level. IRS proposes to address possible fragmentation and lack of coordination of national and local social protection and anti-poverty programs. It also aims to update poverty database infrequently and the regular way by providing local government with tools to encourage better coordination of programs implementation at the local level and to make the programs more responsive and relevant to local needs.

In the 2015-2019 National Medium-Term Development Plan (RPJMN), the Integrated Service and Referral System (SLRT) has been established as one of the targets in the Field of Poverty and Equalization [1]. This IRS implementation is expected to help achieve the goals of sustainable development. Referring to the RPJMN, IRS is part of 2016, 2017 and 2018 Government Work Plans (RKP) which are the responsibility of the Ministry of Social Affairs in its implementation. The Ministry of Social Affairs in its Strategic Plan will develop IRS in at least 150 districts by the end of 2019, which currently has been implemented in 78 districts (including IRS which is fully funded by local government budget/APBD) and currently being expanded to 60 new districts.

IRS is a system to help identify the needs of the poor & vulnerable and direct them to the most suitable national and local programs to meet their needs. IRS also facilitate implementer in identifying complaints of the poor and vulnerable, make a referral, and keep track of the complaints to ensure that the complaints were adequately addressed. It manifested in its four main functions :
(1) Integration of information, data, and services;
(2) Identification, referrals, and handling of complaints;
(3) Identification of program participation and needs
(4) Dynamic data updating by local government

IRS develop internally a comprehensive Management Information System consisting of several modules, i.e., web-based modules, mobile application module, and dashboards. The dashboard is a crucial component in IRS applications since it is one of the tools for monitoring program implementation and the data visualization generated in an almost real-time manner, by a daily update, although technically possible to do a more frequent update or real-time.

Data dashboards are increasingly being used in the social sector to monitor the performance of projects, programs, teams, and organizations. Dashboards allow effective tracking of organization performance in an attractive manner and support timely intervention if appropriately designed and implemented [2]. The dashboard provides a brief overview of a system and facilitates easy decisions making. The dashboard, as the name implies, also serves to provide a quick overview of the contents of the organization data. This feature makes the dashboard powerful monitoring tools for Program Monitoring and Evaluation (ME) function.

II. THEORETICAL FOUNDATION

Data visualization is the process of interacting with clients to understand patterns, trends, and insights by transforming data into a visual context [3]. Data visualization helps users of data understand the data, and data visualization software enables the user to see and

understand the data in ways that could only previously be done through the use of complex queries and time-consuming manipulation. It can be in any form like tables, graphs, charts, map, images, patterns, movies, etc.

Data visualization often mentioned together with related concepts such as business intelligence (BI), dashboard, online analytical processing (OLAP), data warehouse, and many more. The selected definitions for concepts related to data visualization are as follows :

- **A dashboard (or data dashboard)** is a consolidated visual display of the most critical information needed to achieve one or more objectives; it usually arranged on a single screen so the information can be monitored at a glance [4].
- **Business Intelligence (BI)** is a process of discovering the meaning of (aggregated) data. Business Intelligence defines a set of tools and methods aims to transform raw data into a meaningful pattern for actionable insight to improve business processes. This BI usually involves data preparation, data analytics, and data visualization [5].
- **Online Analytical Processing (OLAP).** OLAP carry out a multi-dimensional analysis of business data and provides the capability for complex calculations, trend analysis, and other sophisticated data modeling. OLAP is the core technology behind many Business Intelligence (BI) applications. OLAP is a powerful technology for data discovery, including capabilities for numerous report viewing, complex analytical calculations, and predictive "what if" scenario planning [6].
- **A data warehouse** is a pool of organization/corporate information derived from the operating system and external data sources. Data Warehouse may be described as a system that consolidates data from multiple sources that is designed to support strategic and tactical decision making for organizations [5].

To summarize the above concepts, a business or organization may have a data warehouse as a collection of their operational data and external data. The organization, then, perform business intelligence to transform the operational data into a meaningful pattern. In doing so, the organization may use software, a BI and data analytics tool that support the generation of the dashboard that visually displays essential information about the organization and performs data visualization by enabling the user to see and understand the data. Based on the data and available software, the process may need some complex data preprocessing or merely using the integrated facilities inside the software.

III. Related Works

Various systems that process population and poverty data with data units at the household, family and individual levels have been developed. They publish data tables and data visualization that can be accessed by the public, for example, in TNP2K [7]. Some information systems that are implemented at the village level also include an analysis data module or OLAP module. Among them is the analysis module in the Village Information System (SID) [8] and Village Information System and Rural Areas (SIDeKA) that utilizes OLAP modules as one of system main feature [9].

These programs use the same data units, i.e., individuals, families or households that are associated with their specific business processes. The system manages data transactions on population administration and village potential and assets (SID, SIDeKA) or manages participation in social assistance programs, and complaint handling (IRS/SLRT). Those systems develop and provide data visualization, dashboard, or OLAP BI (to mentions various chosen system terms that portray similar meaning) as the development progress monitoring tools.

In developing the same objective, to display dashboard to monitor development progress to facilitate easier decision making, authors with team develop the dashboard for IRS using Tableau. Tableau is a BI and data analytic tools product that produces interactive data visualization enabling the development of dashboards using an intuitive drag and drop interface with a powerful data engine. Tableau initially originated to commercialize research result had been conducted at Stanford University's Department of Computer Science between 1999 and 2002.

IV. Methodology

This research is carried out with a methodology that cannot be separated from the overall development of the IRS MIS system. After the pilot phase completed, the dashboard module is then redesigned and rebuilt because sufficient numbers of data have already been collected and the data visualization process is more easily exercised. The stages of research are illustrated in Fig. 1.

Correctly, the redesign and rebuild stage of the dashboard module is performed using an agile development approach where the development and revision are carried out iteratively, and the system is immediately deployed progressively. After going through several iterations, the dashboard is considered complete without closing the possibility of changes and improvements, due to possible changes in user needs or change in the business processes itself.

Fig. 2. show that IRS Management Information System consists of several application modules as follows: (a) Android application for *Facilitators* users at the village level;

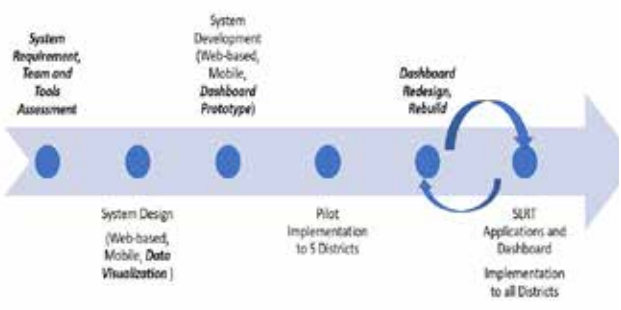

Fig. 1. Research Activity within IRS MIS Development

(b) Web-Based applications where the users are *Manager* at the district Secretariat Office, *Supervisor* at the sub-district level, and *Front-Office, Back-office officer* at Social Welfare Center (Puskesos) in village level; and (c) Dashboard module with the user at the national, provincial, district and village level.

Data managed in IRS is based on individual, family and household data of unified data PPFM (Program Penanganan Fakir Miskin) from Central Bureau of Statistics (BPS) 2015 which also contains participation of national social assistance programs (PKH, Rastra/BPNT, JKN/BPJS, PIP, etc.). This is then used by Facilitators, to reach household, update the data for any changes, update social assistance program participation data (and propose participation need for eligible one), and record local program participation, i.e. program that funded by provincial or local APBD, local agency, or CSR. The facilitator also records complaints related to program participation (exclusion error) and program service quality. This data will then be reviewed by Supervisor and Manager before being followed up (verified, validated, and supported).

There are many considerations in selecting data visualization tools. The availability of the tools in the market makes it challenging for the IT team to decide the right BI tool for the organization. The considerations vary from support on the existing infrastructure (including hardware and software), scalability, usability, financial commitment and other parameters [10]. The selection of tools is an important factor in increasing the productivity of the IT Team. Tableau was chosen because it is an effective tool that can be used for prototyping to produce the data visualization with minimal effort.

V. Requirement and Design of Data Visualization

A. System Requirement

IRS that targeted to be implemented in up to 150 districts until 2019 and involved thousands of users in various levels from village, sub-district, district, to national level. In the process, the IRS dashboard is expected to be able to help to answer program monitoring questions, including, but not limited to:

a) *Inform decision makers at the national and provincial levels:* how is the general performance of implementation in an area or province, and to compare the performance of regions that are close or similar (geographical, socioeconomic conditions, etc.)

b) *Provide quick feedback for the local implementer to improve program implementation:* what is the performance of the program implementation team at the district, sub-district and village levels, including individual performance?

c) *Answer some strategic questions at the policy-making level:* how many deciles 1 resident (the poorest) have received assistance from all four major national social assistance programs (PKH, Rastra/BPNT, BPJS, PIP)?

Fig. 2. IRS Application Modules

The design of the IRS dashboard also allows social assistance program managers, as one of IRS counterpart, to get an overview of complaint profile submitted through a facilitator, beside complaints coming from their own channel. They can further explore the data visually in the dashboard using available filters: type of social program, complaint type, region, time, etc.

B. Selection of Tools for Developing the Dashboard

Tools for developing dashboards are varied: using programming (scripting) approach, using embedded charting facility in programming languages, or using a BI and analytic tool. BI and analytic tools have data preparation capabilities, facility to choose the type of visualization, and compose data visualization as a dashboard. At the pilot stage in five districts (Sukabumi, Bantaeng, Sleman, Bangka Belitung, and Sragen), IRS dashboard was built with programming (PHP) and embedded in the application module. But in the module-rebuild phase, to accommodate area expansion with a greater amount of data and the need for more diverse types of visualization, more sophisticated and tools that easier to use is needed.

Tableau is chosen as Analytics and Business Intelligence Platforms for IRS based on several considerations, i.e. the feature and functionality, available skills, and experience in using it. Tableau is still one of the most reviewed tools with a good rating (4.3 out of 5) [11]. The tools can be categorized as a modern analytics and BI platform supports IT-enabled analytic content development. It is an integrated architecture that enables nontechnical users to perform full-spectrum analytic workflows from data access, data breakdown, and preparation for interactive analysis and the collaborative sharing of insights. Tableau has also data blending capability, which gives users the ability to produces data visualization combination from structured, heterogeneous data sources dynamically without any previous integration effort [12].

C. System Design

Based on the consideration of the type of user, their information need, and the types of decisions they made, the dashboard is separated into several sub-modules. This also to eases the load of execution/query on data. Dashboards are grouped both thematically (by the type of data managed), by aggregation level (district, province, national), and by user

type (external, internal). Because the district level requires inquiry to household and individual levels, the district dashboard is designed to drill-down to that level of detail. The dashboard also able to monitor the performance of IRS individual implementers (facilitator, supervisor, manager, front-office/back office officer) in implementing the program.

The IRS dashboard was then developed in a modular manner by grouping them into submodules as (a) the National Dashboard which summarizes the implementation of the four main IRS functions in districts and can be displayed regionally (province or island); (b) Regional Dashboards that present data in more detail and has additional capability to shows the performance of officers. This dashboard shows IRS services at the district level and Puskesos at the village or sub-district level; (c) Complaints Handling Dashboard that presents data on complaints regarding the participation of the national social assistance program (exclusion error) and the quality of program services and handling.

VI. The Implementation of Data Visualization

The work produced consist of several dashboards to monitor the IRS implementation result. They are:

1. Summary of IRS Implementation, showing the summarization of implementation progress for each IRS function
2. The Number of Poor and Near-Poor at IRS Locations, showing the summary numbers of 40% poorest citizen in a location.
3. Implementation Progress by IRS Implementers, showing the summary of the implementation progress by each implementer types (manager, supervisor, facilitators)
4. Proposed Addition of New Beneficiaries, showing the summary of new proposed social program participation function
5. Verification of Beneficiary Profile, showing the summary of the beneficiary administrative profile verification function
6. Program Participation Summary, showing the summary of the social programs participation verification function
7. Program Participation Intersection, showing the intersection of four main social programs participation (PKH, Rastra, PIP, and PIS)
8. Proposed Program Needs Summary, showing the social program's participation need/demand recording function
9. Complaint Registration, showing the management of complaint on social program implementation function
10. Beneficiaries with Disabilities, showing the summary of the IRS functions for beneficiaries with disabilities

Two of the dashboards from the above list are shown as samples of data visualization produced in the process. They represent two of IRS main functions, showing the program participation intersection in a district in Fig. 3. and program complaint handling in Fig. 4. The data sources are from the PostgreSQL database. The front end is built interactive to display filters based on location, time, and other measures to ease data interpretation. Tableau also allows users to export data in the form of CSV or Excel for further use, for example by combining it with external data that has the same representation unit to produce output that fit with local needs, e.g. producing more charts using a spreadsheet (Excel).

VII. Discussion

The development of the dashboard showing the descriptive part of the IRS program using Tableau is relatively easy because the tools supporting the development of the dashboard without complicated data preprocessing. The main factor that determined how complicated the process are the database design and the visualization design. With a comprehensive understanding of the how data visualization tools work in the first place, the database design can be prepared to support the tools, while, by their design, the tools itself already supporting the database if it modeled in a standard way.

The dashboard produced has shown that it effective as a monitoring and management tools. It gives the end user the capability to monitor the progress of program implementation from time-to-time and it also gives quick rapport on implementers performance. The tools also supporting the effort of producing the data visualization quickly without using data staging or ETL process, although more data preprocessing may improve the dashboard update and access performance.

The challenge is in the full utilization of the tools, as Tableau can also be used using a what-if scenario and has predictive capability. Not only it needs more exploration on the design of the necessary prediction model, such as to predict how successful is the implementation of IRS in a location, but also how to teach end user on how to use the tools to fulfill their specific needs. In a program that its end user has low to moderate IT or analytic skills, the utilization of the tool to its maximum capability need better capacity building plan.

VIII. Conclusion and Future Works

Data visualization for IRS program has been developed and implemented in the dashboard module and already used in the IRS implementation areas. The system has effectively been able to answer the needs of users for monitoring the implementation of the program. For program managers at the central level (National Secretariat), the dashboard has also become the main monitoring tool to see district performance through the visualization of transaction data progress summary. The dashboard was developed using proprietary

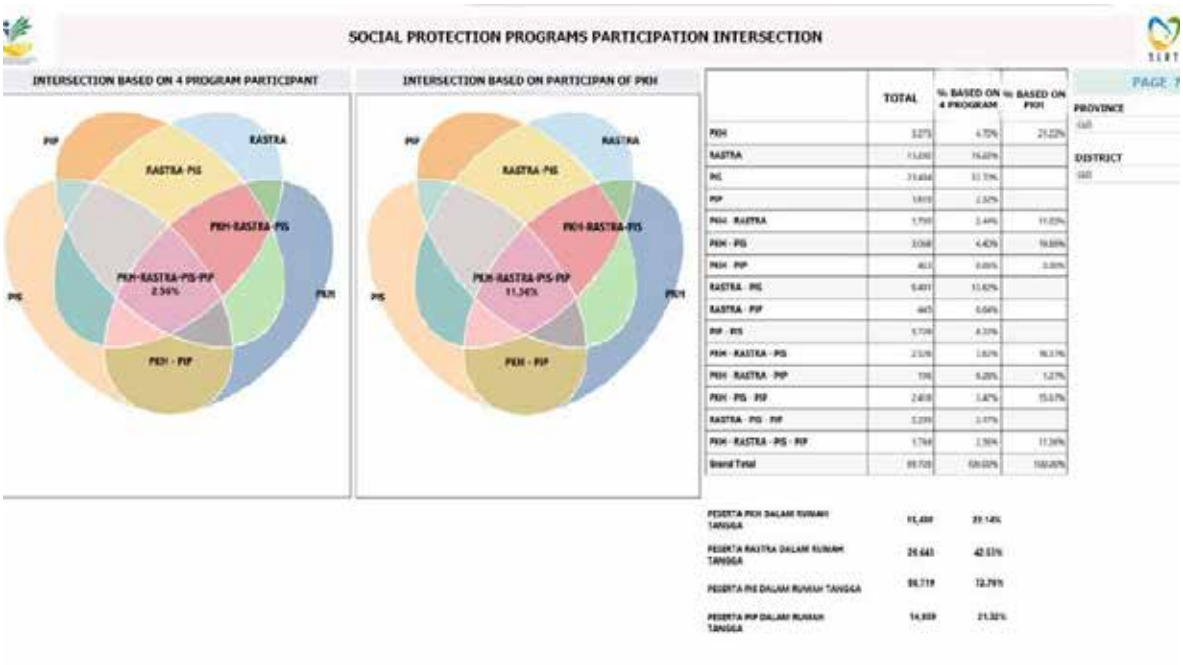

Fig. 3. Screenshot of Social Protection Program Participation Intersection Dashboard

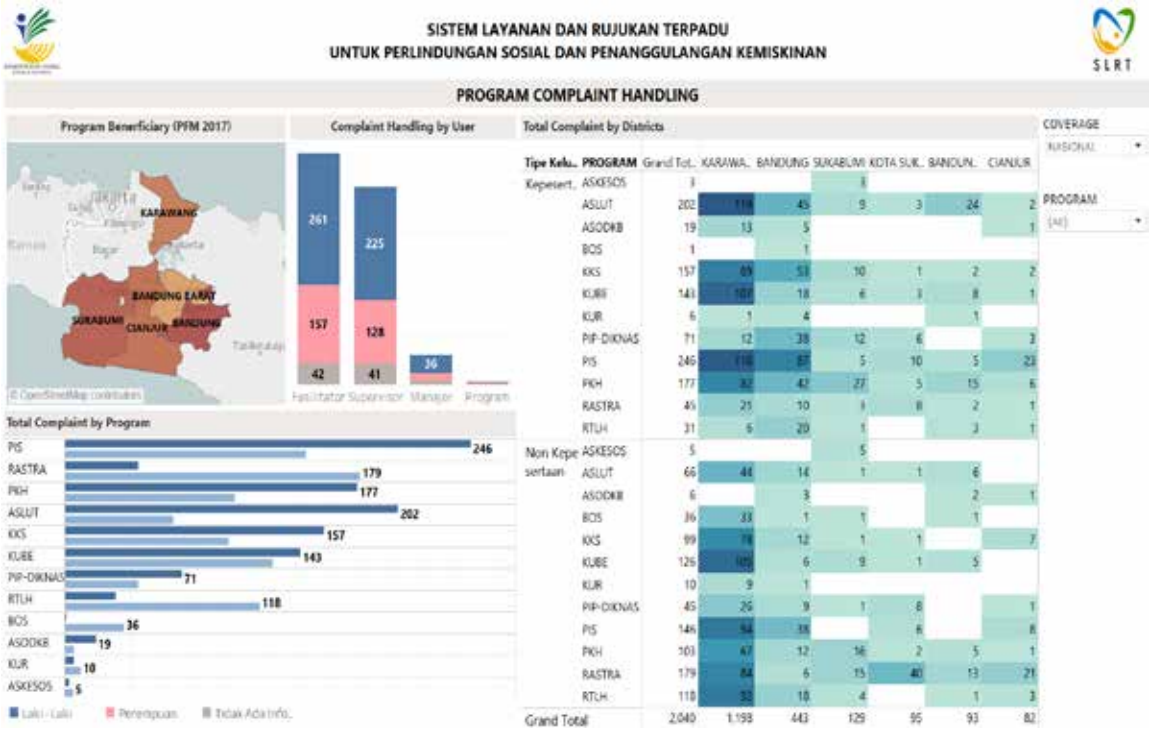

Fig. 4. Screenshot of Program Complaint Handling Dashboard

tools, Tableau, that is selected based on some criteria and proofed to be a suitable tool for the dashboard development.

With the existing database design and dashboard, it is quite easy to make modifications and improvement if needed. For well-trained users, tools also allow end users to take advantage of business analytic features by modifying queries or the appearance of predefined dashboards that have developed. In the future, the challenge is how to improve the performance of the dashboard by modifying its staging for faster access, for example, considering the twice data size produced by areas expansion that may affect the access speed. The rich of household data can also be further explored and presented because this area has not been a priority during the current implementation.

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Telemedicine Design for Rural Areas as a Framework of e-Health Implementation

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***Abstract*—Access to high quality health services is needed to maintain the health of the community to be better. Urban health services are relatively easy to access, which is unlikely to happen in rural areas. This does not apply to rural areas. Besides mobilization location factors, only a small amount of health workers are willing to work in remote areas. Health services provided there are mostly conventional. This is partly affected by the lagging of technology infrastructure in rural areas compared to urban areas. The level of ICT adoption in rural communities is still far behind compared to urban communities. Telemedicine is a form of e-health implementation to improve health services for the community. Telemedicine provides solutions in health services for patients in remote areas which has difficulty accessing referral health facilities with adequate equipment. Telemedicine is a health service carried out remotely by transferring electronic medical data from one location to another. Thus, it will facilitate rural communities in accessing health services. This study aims to design telemedicine for rural areas as a framework for the implementation of e-health. The methodology used in this study is system planning cycle method for the implementation of electronic health systems. The results of this study are recommendations from the telemedicine framework for the implementation of e-health for rural areas.**

Keywords—telemedicine, e-health, rural area

I. BACKGROUND

Telemedicine is essentially a remote doctor-patient interaction. This is why many believe telemedicine may save small hospitals that are struggling, and provide quality care to patients, right in their homes. Telemedicine has great potential to expand the access and improve the quality of rural healthcare. It hypothetically reduce burdens for patients, such as travelling to receive specialty care, and improves monitoring, timeliness, and communications within the healthcare system.

The Health Resources and Services Administration (HRSA) of the U.S. Department of Health and Human Services defines telemedicine as the use of electronic information and telecommunications technologies to support and promote long-distance clinical health care, patient and professional health-related education, public health, and health administration [1].

In the health sector, Indonesia has limited number of health workers. Based on data from the Ministry of Health of the Republic of Indonesia strategic plan 2015-2019 [2], it is mentioned that the ratio of general practitioners per 100,000 population in Indonesia only reaches 30.98, which is below the ideal doctor ratio according to Health Indicator 2010 indicator of 40 per 100,000 population. For specialists, Indonesia's ratio is only at the level of 8.14. This is in contrast to the conditions in Malaysia that have reached a ratio of > 60, and the Philippines with a ratio of 120. While the production rate of doctors is low and the need for health services continues to increase, tools are needed to improve the efficiency and effectiveness of services. In addition to the need for health workers and equipment, information and communication technology (ICT) may also play a significant role to improve efficiency and expand access to services.

Solution offered to solve these problems is by implementing ICT technology to support health services for the community, especially in rural areas. The form of solution to the use of ICT in the health sector to help people who have difficulty accessing health services is Telemedicine. In Indonesia, the use of information technology for the health sector has been regulated in Law number 36 year 2009 on Health, which states that to organize effective and efficient health efforts required health information is done through information systems and through cross-sector [3]. Telemedicine as a form of e-health implementation in Indonesia just has been implemented, with cooperation among hospitals, government, universities, private, and telecommunication service providers.

The term e-health itself began to emerge when telecommunications technology was being used as an analog communication medium between patients and doctors as well as for patients to access hospital services. In further developments, telecommunication technology was used as a medium of data exchange of electrodiagram [4]. Currently, the development of these technologies is known as telemedicine. In general, e-health is a service in the form of Information and Communication Technology applications which are connected with the overall elements of functional elements supporting the health sector [5].

Recent developments in e-heatlh technology include: electronic health records, telemedicine, consumer health informatics, healthcare information systems, mobile health, virtual healthcare teams, and health knowledge management [6]. Nevertheless, in Indonesia, the application of the technology is still limited in the limitations of the broadband band, so there are rooms for improvement regarding various aspects. In line with the development of telecommunication and internet infrastructure, the technological aspects and governance of e-health services, especially telemedicine are crucial to note in this application.

This research aims to find Telemedicine Implementation Plan which fits to rural areas in Indonesia. This research project uses existing Internet communication technology to develop a prototype telemedicine system that can be easily

moved from one place to another. The telemedicine application is focused on diagnostics, consultation, recording, and reporting patient's information. The system can also be used for other health care service applications and is considered to be particularly useful in many remote areas in Indonesia.

II. Theoretical Framework

A. Telemedicine and Electronic Health (E-Health)

Telemedicine is the use of telecommunication and information technology to provide clinical health care from a distance. It has been used to overcome distance barriers and to improve access to medical services which is not consistently available in distant rural communities. It is also used to save lives in critical care and emergency situations [7].

Telemedicine can be beneficial to patients in isolated communities and/or remote areas, by receiving care from doctors or specialists far away without the patient having to travel to visit them [8]. Recent developments in mobile technology and also internet of things (IoT) allow health workers in multiple locations to share information and discuss patient issues as if they were in the same place [9]. Remote patient monitoring through mobile technology may reduce the need for outpatient visits and enable remote prescription verification and drug administration oversight, potentially significantly reducing the overall cost of medical care [10]. Telemedicine also facilitates medical education by allowing health workers to observe experts in their fields and share best practices more easily [11]. Fig. 1 Show the simple diagram of telemedicine system

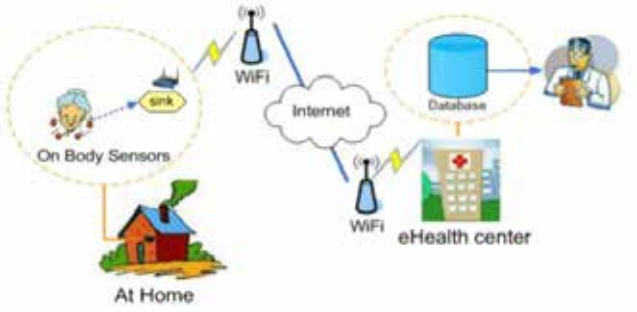

Fig. 1. Simple Diagram of Telemedicine System

While, e-Health is a relatively recent healthcare practice supported by electronic processes and communication [12]. Furthermore, e-health is defined as "the ability to seek, find, understand and appraise health information from electronic sources and apply knowledge gained to addressing or solving a health problem [13]. Simply put, the e-Health system consists of a number of "Medical Stations" connected to each other on a network. A medical station itself may consist of :

1. Units of computer with support application software,
2. A patient interface device,
3. A number of biomedical instruments (depending on the need),
4. A user interface device (following the input device used), and
5. Available telecommunication networks and equipment.

Basically, any medical station is able to deal with other medical stations on a regular basis :

1. Real-time (synchronously), for example teleconsultation between a General Practitioners and a specialist regarding a patient's emergency.
2. Store and forward, the delivery of information and its readings are not at the same time, for example short recapitulation of patients at a community health center during the month along with important information.

In e-health distance is not a factor because all activities are done through data connection and in real-time. Thus telemedicine is an implementation of e-health. In telemedicine information and communication technologies including electronics, telecommunications, computers and informatics are used to process various types of medical information, to carry out clinical services (diagnosis or therapy) and even to the administrative process.

B. Related Works

Nowadays a lot of research has been done related to e-health and its implementation. Relevant researches were conducted by the Center for Research and Development of Post and Information Devices Resource [14], Human Resources Research and Development Agency, Ministry of Communications and Informatics. The research was about the implementation of the Internet of Things for the health sector. In the research, IoT framework for health sector was based on ITU cover application layer, service support and application layer, network layer and device layer.

Research conducted by Rahmani et. al [15] concerning the Smart e-Health Gateway resulted that in most IoT-based patient monitoring systems, particularly in smart homes or hospitals, there are connecting points, i.e. gateways, between sensor networks and the internet that perform only basic functions such as translating between protocols which is used on the internet and sensor networks. This gateway has all the data to be transmitted over the internet. The results also state that the IoT-based health monitoring system improves overall system, energy efficiency, performance, interoperability, security and reliability.

Another study conducted by Samir V. Zanjala [16] resulted in an IoT system model for the health sector which is used in health care health care such as drug scheduling, monitoring and updating of patient data, and patient drug management conducted by prescription through the website. In this research indicated that, through the cloud IoT performs the sensor data storage effectively. The advantage of digital storage is to simplify data retrieving quickly in an emergency.

III. Methodology

A. Overview of System Design

The aim of this research is to design and to implement a working tested model of a telemedicine system based on ICT. The system is expected to be used for community health care in rural area.

Fig. 2 shows the platform of the proposed e-health in Indonesia which will be used as a basis for designing telemedicine in Indonesia. Telemedicine directs medical data, health services, and emergency team mobility. The system is based on the deployment of IoT based computer, and also diagnostic devices and processes, which are set up

to acquire the patient's medical information. The system can be operated in both on-line and indirect (store and forward) modes. This Fig. 2 below describe the proposed platform of e-Health implementation in Indonesia.

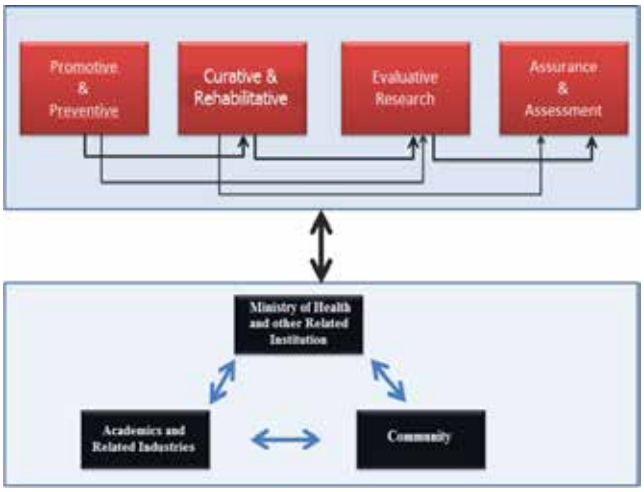

Fig. 2. Proposed Platform of e-Health in Indonesia

Direct or indirect interaction with other health care providers (for a second or expert opinion), ill patients, or citizens. An example would be teleconsultation and social media. Whereas the term telemedicine is restricted to direct health care, telehealth has a broader definition.

B. *Preliminary Project Requirements*

Operational Community Health Centers (Puskesmas) in rural areas that are always crowded every day have not been supported by a proper information system. The distance between patients' house and the Puskesmas is quite far, even far away, Furthermore, there are chances that doctors are not available during working hours or that patients' cases has to be escalated and therefore must be referred to another health center. Not to mention frequent queues during busy hours in the Puskesmas. This queue process should be made more effective and patients' health information can be obtained without having to come directly to the health center. The core problem that needs to be solved is the Effectiveness and Efficiency of access to health services for the community by highlighting the service function of the Puskesmas. Therefore, in this study, we proposed to design a Telemedicine plan by using these frameworks :

1. Infrastructure needs, actual business, and schedules will be completed after identification of needs.
2. The scope of this project is done by considering the functional health center according to the system design document.
3. Details of need documents will be prepared after data analysis is carried out with all stakeholders' agreement.
4. Changes to the approval of the requirements document will be applied such as changes in requests and modifications that will be considered as additional bills to the client.
5. Performance issues are intended for the availability of infrastructure desired by the client.
6. Commitment from all levels of management and project workers.
7. Puskesmas operational activities are carried out manually (no information system has been used).
8. Conditions for developing applications are safe and conducive.

C. *Research Framework*

This study will describe the implementation of telemedicine for rural areas in Indonesia. Key activities of the research of Telemedicine Design for Rural Areas as a Framework of e-Health Implementation comprise methods such as fieldwork by implementing the system, literature reviewing, development and testing, and user activities such as workshops and evaluation through user acceptance test. The following diagram shows the research framework of telemedicine implementation for rural areas in Indonesia. Fig. 3 below describe the framework of telemedicine system implementation.

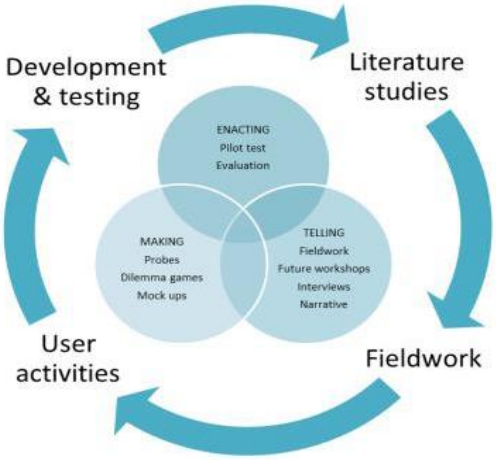

Fig. 3. Framework Implementation

Methods that support telling, making, enacting. For instance telling activities as drivers for participation, where practitioners are given a chance to share their knowledge or the making of things can be a means of designing the system, where tools allow the ability to create and describe future objects. As well as acting out and testing scenarios, technologies can increase participation as people explore how new designs could affect their practice.

Based on the framework, the following are steps taken in implementing the system:

1. Identification of problems; The process of defining research problems and can include initial concept involving research object.
2. Intervention; The process of planning, development and taking action to create a construction, models, methods, prototypes (prototype) or other resources.
3. Evaluation; The process of observing and measuring the level of suitability and appropriateness of outputs generated in support of solutions to problems mentioned above. This process is a validation of the model or design produced by expert judgment.

IV. System Design

In the context of the effect of telemedicine on the process of innovation and generation of results in rural area health care organizations, we would like to introduce the model that addresses the implementation of a telemedicine service. In

order to obtain the best system performance, an overview of the current trends and an existing telemedicine system is carried out. Hence, the different requirements will be taken into account for designing the IoT based Telemedicine system.

Telemedicine services are also based on video conferencing to provide medical consultation remotely in the areas of specialization needed in the framework of diagnostic, treatment and patient care, between medical and satellite health facilities where there are limitations of Specialist Doctors and / or Sub-Specialist Doctors. Data may be transmitted to a base unit within a reference hospital or Puskesmas which enables the doctor or medical staffs to diagnose or monitor the patient's condition in real time. The data interchange is conducted using TCP/IP network protocol.

A. Business Objective

A Information Technology plays an important role in improving the quality of an institution. Its use is not only a process of automation of access to information, but also creates accuracy, speed, and completeness of an integrated system so that the organizational processes that occur will be efficient, measurable and flexible. Even nowadays the development of Information Technology is starting to get a positive response from the public. Its development was not only welcomed and enjoyed by business and government circles, but also began to expand in the world of education.

Telemedicine is regarded as one of the major innovations in health services, not only from the technological aspect, but also from the cultural and social perspectives since it benefits accessibility to health care services and improves the quality of medical care and organizational efficiency. Telemedicine has a role in providing solutions to the challenges posed by socioeconomic changes in health care systems in the 21st century, all in an environment of limited budgets and restrictions on spending. Nevertheless, there are significant barriers to standardize telemedicine and to its full consolidation and expansion [17].

Since the availability of integrated information is increasingly important in supporting efforts to create a competitive future generation. Information technology becomes a non-negotiable need, due to the availability of integrated information is increasingly important in supporting efforts to create an efficient and competitive system. Almost health centers in rural area do not have good management. Numerous Puskesmas still use manual recording systems which work less effective.. There are difficulties which are open for improvement opportunities for computerized applications.

B. Implementation

The plan to implement telemedicine for rural areas is based on a healthy Indonesia program with a family approach. The proposed concept of telemedicine is carried out with a tiered telemedicine level that refers to the level of health facilities referred to. The services available at each level also vary in terms of the level of service complexity.

Health facilities, namely the place that becomes the center of acceptance and service to patients as well as the source / sender of telemedicine data both in the form of audio, video, graphics, and combinations with standard criteria as follows:

1. Get 24 hours of electricity with a voltage of 220 volts,
2. Have a Fixed Phone connection (from PT Telkom Indonesia) for IndieHome internet connection, and
3. Reached by GSM / CDMA network services with 3G or 4G services.

Fig. 4 shows a plan for implementing telemedicine in Indonesia.

Fig. 4. Telemedicine Implementation Plan

Application users, namely implementing subjects in the form of health workers who run, use, and utilize telemedicine (software-hardware) functions both as senders and consul data. For Application users, namely implementing subjects in the form of health workers who run, use, and utilize telemedicine (software-hardware the implementation of telemedicine to be realized optimally, application users (users) must meet the minimum requirements in the form of:

1. Permanent health personnel assigned to health facilities, and
2. Has undergone training in the use of applications and telemedicine devices according to the type of examination.

For Telemedicine software, is a software that consists of a number of commands or source code to activate, run, and function the telemedicine system or subsystem so that it can be used as desired. The software includes:

1. Electrocardiography Module (tele-EKG),
2. Ultrasonography Abdomen Module (tele-USG),
3. Spirometry Module (tele-Spirometry),
4. Thorax Photo Module (Tele-X Ray), and
5. Laboratory Module (Tele-lab).

All of these devices are used to support a service system at a community health center (Puskesmas). However, its use is in accordance with the level of reference at health facilities. Fig. 5 below shows the flow of telemedicine service model in community health center with reference from Ministry of Health, Indonesia.

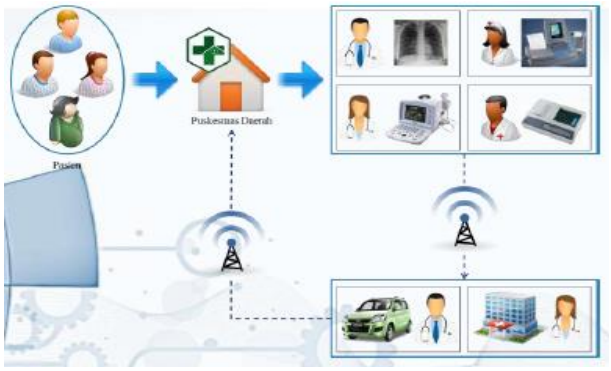

Fig. 5. The Flow of Telemedicine Service Model in Puskesmas

Other modules according to the needs and developments of telemedicine. Telemedicine is carried out to provide access to services from a specialist and to consult remotely from diagnostic or examination results from a Specialist in the health care facilities of the provider, to satellite health center that do not / have a Specialist Doctor.

Video-based telemedicine is carried out to provide medical consultation remotely in the areas of specialization needed in the framework of diagnostic, treatment and patient care, between medical and satellite health facilities where there are limitations of Specialist Doctors and / or Sub-Specialist Doctors. During the proposal and scheduling of teleconsultation, patient data and supporting examinations are included so that the supporting hospital can determine the specialist doctor or specialist needed during the consultation. The Fig. 6 shows the flow of Teleconsultation service model according to Ministry of Health

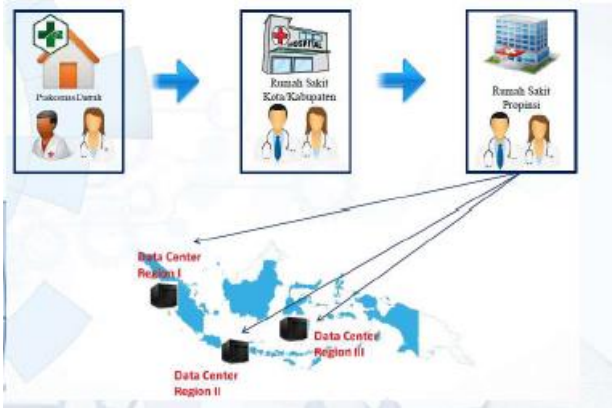

Fig. 6. The Flow of Teleconsultation Service Model

The mechanism for sending patient and supporting data in the form of ECG, LAB and radiology results can be done by application or manually. In certain circumstances, the proposed teleconsultation is an emergency, so transmitting patient data is sent astray before or during teleconsultation.

C. *Constraints and Solutions*

Telemedicine is a health care solution for rural communities because it provides benefits for people who have difficulties in accessing health services. However, there are several obstacles in telemedicine implementation, including:

1. The high cost of infrastructure procurement and maintenance,
2. The high operational costs of carrying out telemedicine,
3. Complicated acts for operating telemedicine,
4. Conventional mindset: The doctor must be in the same room as the patient to interpret the results of the examination, and
5. Specific use of service in clinical aspect only.

As a solution to these problems, for financing and operational problems, it needs a strong commitment from the local government and the local health department responsible for the operation of telemedicine. Meanwhile, for operational constraints in the use and mindset of local communities, both as patients and for implementers, conducting socialization and training to accelerate understanding and adoption and penetration of technology in the surrounding community. Telemedicine implementation in rural areas would be better if collaborated with the Broadband Village Program of the Ministry of Communication and Information Technology.

V. Conclusion

Health devices (IoT) such as USG, ECG, Rontgen, etc. should be able to be connected to the bias system by using the API in the form of a webservice especially when saving the recording results by pressing the save button, the action performed by the machine sends data to the address certain webservice. If the device does not support API with webservice then the thing to do is to build an application to retrieve data to the device by utilizing the SDK from the device. This Telemedicine implementation project, named Nusantara Telemedicine System Development, is expected to help health services in Puskesmas operations. This is the technical document of the archipelago telemedicine development; hopefully it can be the beginning of good cooperation.

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E-Complaining "SiKesal" Implementation Analysis for Developing Electronic Based Public Services at Jambi City

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***Abstract*— This study aims to analyze an e-complaining system implemented by the Government of Jambi City called SiKesal. The reason is that since it was launched from December 2017 to May 2018 the result of implementation is considered not optimal. This study is conducted in qualitative approach, and the data is collected through FGD. The SWOT analysis results in strategies including disseminating the applications to schools, universities, communities, and other youth gathering centers in the city of Jambi. It is expected that after they get the information about the SiKesal, they will be willingly to use it and inform others around them about it. SiKesal should be developed like a social media application model where there will be interactions between users, and also it would be better if it is integrated with SMS gateway. The ICT competencies of government officials should be mapped in relation with their positions, so that in each Local Government Work Unit (Organisasi Perangkat Daerah / OPD) there would be an administrator who becomes the operator and transmits the knowledge about how to use SiKesal in government side.**

Keywords—SiKesal application, ICT Development, eGovernment, SWOT

I. INTRODUCTION

When Indonesia enters the reformation era, sovereignty of the people is placed into the highest position and its political commitment is emerged by legalizing the act that ensures the public's political rights, such as: freedom of speech, freedom of association, and public expression without fear, including the rights to communicate and obtain information. The rights are not only in political environment but also in every area of life such as public services like the opportunity to complain about public services when they are not good. Moreover, society also has rights to receive the response for their complaints., which is regulated in Act No. 25/2009 on Public Services article 18 section C [1].

Nowadays, many governments in Indonesia use Information Communication and Technology (ICT) and also the internet to create public space for communication, empowering public participation, including receiving the society's complaints about public service by using SMS Center, website, and also social media. By using the complaint services, the community's problems can be known in real time and handled as soon as possible [2]. One of them is called SiKesal (Sistem Informasi Keluhan Masyarakat Online) an e-complaining application developed by the Government of Jambi City.

Jambi City is the most populous city compared to cities and regencies in Jambi Province, with an area of around 205,38 km² and population of about 576.067in 2015. Although Jambi City is the capital city of Jambi Province, the sub-districts are not only consisted of urban classification. Some, of them are village (rural) areas. They are: Kelurahan Penyengat Rendah, Kelurahan Teluk Kenali and Kelurahan Sijinjang. Therefore, SiKesal becomes the electronic complaint system that support the government of Jambi City to reach out every complaint from urban and rural society. SiKesal feature is not only to make complaint, but also to encourage the society to participate in developing the Jambi City by giving suggestion and aspiration from their Android smartphone.

In other words, SiKesal becomes part of the Jambi City eGovernment which utilizes ICT especially internet to improve the delivery of government public services to society, business, and another agency. EGovernment enables society to communicate and receive public services from local, province, and also central government in 24 hours a day, 7 days a week [3]. In addition, with the development of ICT, a concept called information society is emerged. According to William Martin, information society is a society in which their quality of life, prospects for social change and economic development depend on the improvements of information and its utilization. Their patterns of life are always in contact with information and knowledge which are shown by the increased production of information and communication services through the media, mostly with electronic media [4]. Putu L. Pendit [5] mentions that the information society's main mission is to create a society that is aware of the importance of information, science and technology, creates the integrated, coordinated and to document information service and to disseminate information to the public in a fast, precise and useful way.

Implementation of e-Government and support for the development of information society is a result from the efforts of developing ICT by the Government of Jambi City. In Indonesia there is a general guidance of information governance which is used as guidance for every government institution in doing governance and utilization of ICT, especially in implementing good governance related to the field of ICT. The guideline is described in the government policy through Permenkominfo No. 41/2007. But not all development activities of ICT conducted by the local government can run as expected. The development activities which are arranged in the long term or medium term may not be suitable because of the changes that occur in society [6]. The implementation and utilization of SiKesal is also considered not optimal. These conditions stimulate to analyze the implementation of SiKesal to provide recommendations to optimize the utilization of SiKesal.

SWOT analysis is one of the most basic technique to analyze the object's condition. It provides every condition from the internal to the external (surrounding) of the object. The general result from SWOT analysis is strategies that: build on objects strengths, remedy the weakness around it, take advantage of the opportunities, and protect the object from the threats [7].

II. METHODS

This study is an analytic study with qualitative approach because in this study does not measure the relationship between variables statistically. Through this approach it is expected to obtain information more deeply, and also to understand the phenomena that actually occurred in detail. This research was carried out as an initial study of SiKesal implementation as an e-complaint application for the community of Jambi City. The data was collected through Focus Group Discussion (FGD) by presenting speakers from representatives of Smart City Council of Jambi City, representatives of Smart City implementation team of Jambi City, SiKesal application developers, representatives of admin from Local Government Work Unit, and representatives from society who are users of SiKesal. In this study, SWOT method was used to analyse the qualitative data. SWOT analysis is a classic strategic planning tool that uses frameworks from internal strengths and weaknesses and external opportunities and threats. According to Start and Hovland, this instrument provides a simple way to assess how the best strategy can be implemented [8]. In this research SWOT analysis is used to identify strategies by taking into account internal and external weaknesses and strengths of the application conditions SiKesal since it was launched from December 2017 until May 2018 which is described in the SWOT analysis.

III. RESULT AND ANALYSIS

Development of SiKesal application is initiated by the urge of Diskominfo Jambi City to create an application that can handle complaints from the public. There are several things that are important in the development of SiKesal such as: the user interface must be user-friendly, able to capture GPS position and is also supported with photo uploads related to the things that are complained to avoid fake complaints. SiKesal has been integrated with 112 call center by using Panic Button feature. Currently, the operating system is only based on Android, because based on the general public perspectives the most owned smartphone by the people of Jambi City is mostly based on Android. The privileges of SiKesal's administrator are such follows: they can access the incoming complaint report and can provide guidance from complaints that are in process of completion, and then provide report from the complaint that has been handled. If the complaint is not resolved until the specified time limit, SiKesal will notify to the account of the relevant Head of Local Government Working Unit. Then, the Head of Working Unit will ask his staff to resolve the complaint immediately. But, if it still cannot be resolved within a certain time limit, then the application will give notification to the accounts which belong to the Assistant Mayor, Regional Secretary, and also Mayor's account directly. So that the Assistant Mayor, Regional Secretary, and Mayor can give instructions directly to the Head of Local Government Working Unit and his staff to resolve the complaint.

Based on the results of data collection that has been mapped by using SWOT analysis, it is obtained 4 groups of SiKesal's implementation strategies which aim to encourage the use of SiKesal as a part of e-Government and information supporting media that can be used as an evaluation for the implementation of ICT by the Jambi City Government.

A. Strengths (S)

Based on the data, there are identified five strengths in SiKesal:

- SiKesal is legally supported by the Jambi Mayor Regulation Number 40/2017 about the Online Complaints Information System of Jambi City.
- Regional Leaders of Jambi City give great attention about the development of ICT.
- Some Government Working Unit of Jambi City get benefits from SiKesal application.
- Development of Fiber Optic networks is in process.
- SiKesal is already disseminated through advertisements on local television, social media, and also banners which are placed in the village (Kelurahan) office.

B. Weakness (W)

Based on the data, there are identified about seven weaknesses in SiKesal:

- The society are not used to making the complaints electronically yet.
- Internet speed is slow in some areas of Jambi City.
- ICT devices and infrastructures are still inadequate for the community.
- Some problems were still found when using SiKesal application.
- There are still no studies about SiKesal public acceptance.
- The number of human resources in the ICT field among Jambi City Government officials is limited.
- The society feels lack of socialization about SiKesal.

C. Opportunities (O)

Based on the data, there are identified about four opportunities in SiKesal:

- The development in the field of ICT encourage the improvement in every City / Regency in Indonesia.
- Can be easily downloaded through Android device which is mostly used by society
- Supported by academics sector in preparing the legality, studies related to SiKesal and development of SiKesal.
- There is no online public complaint service in Jambi City.

D. Threats (T)

Based on the data, there are identified about six threats in SiKesal:

- There are still government officials who are reluctant to use the Sikesal application because they expect that the devices and networks used to access SiKesal applications are provided by the Jambi City Government.
- There are still government officials and staffs who have not socialized SiKesal's application to the society.
- Until May 2018, there have been many hack attacks to the system of SiKesal.
- There are people and government officials who are reluctant to use it because they find it difficult to use.
- There are several people in the government such as Village Heads (Lurah) who feel that they have not get a role in SiKesal.
- Changes in the way of thinking and workings of government officials by utilizing applications in their daily activities or in public services have not yet occurred optimally.

E. Strategy Strengths – Opportunities (SO)

- Conduct a study about ICT development budgeting to obtain financing strategies that can be realized to the implementation of e-Government in the Jambi City, and build its society into an information society.
- Conduct a study to obtain a database about the condition of ICTs in Jambi City. The database will describe the condition of the society related with online-based public services.
- There should be a socialization about SiKesal to schools, campuses, communities, and other youth gathering spaces in Jambi City. It is expected that after they get information about SiKesal, they use it and spread it to other people around them.

F. Strategy Weakness – Opportunities (WO)

- Conduct a study or review regarding the use of SiKesal.
- Provide assistance to the society in using SiKesal.
- Collaborate with the private sector to carry out CSR activities, as well as communicate with the central government, to support the infrastructure development, human resource development, and society readiness.
- The socialization of the SiKesal application should be prioritized to Gen Z (ages 8-23 years). Generations who are considered familiar with technology and familiar with sophisticated devices.
- SiKesal application model should be developed like a social media, where interaction between users will be quicker and also could be integrated with SMS gateaway.

G. Strategy Strengths – Threats (ST)

- The Scoring system needs to be made to assess user activities and also give appreciation for their activities. This, will encourage users to be more active using SiKesal.
- Government officials who have already known about SiKesal, socialize it to other officials who do not understand and also disseminate the information to the public.
- SiKesal feature could display activities carried out by the society and government such as: Posyandu, religious activities, cultural activities and others.
- SiKesal should be improved to be smarter, easier for administrators and management in making reports, and also easier for users to use applications.
- Make an effort towards a service paradigm shift and electronic-based performance among government officials.

H. Strategy Weakness – Threats (WT)

- The Monitoring and Evaluation process must be carried out periodically.
- The number of administrator in the Government Working Unit must be equal to the number of complaints.
- Government officials who have competence in ICT field need to map their abilities and positions, so that in each Working Unit there is an admin who becomes the operator and spreads his knowledge about using SiKesal.
- Conduct training or technical guidance related to ICT that is carried out continuously.
- Apply several layers of network security and there are competent officers in handling cyber-attacks that can occur anytime and anywhere.

Based on the research conducted by Dini et al., it also shows that "the introduction of the custom-made social media platform has a positive influence on citizen participation and political discourse by connecting citizens and government institutions and encouraging interpersonal civic engagement. In this sense, the system has impacted the way in which the government delivers public services and the way citizens contribute to shape policy" [9]. Therefore, various strategies from this analysis are recommendations that can be implemented to achieve the objectives of SiKesal. In addition, the development of SiKesal needs to be carried out continuously because by using it the society can directly participate to submit suggestions and complaints to the Jambi City Government.

IV. CONCLUSION

The SWOT analysis shows that internal weaknesses are more than internal strengths. In addition, external threats are also more than external opportunities. The realization of public participation will increase the transparency and trust of citizens to the government. The development of information technology creates opportunities for government to be closer to their society. The use of information technology in facilitating public participation could increase the level of community participation and actualize the participatory, inclusive, collaborative and deliberative in decision making. And then, it is expected that the decisions taken by the government are appropriate government policies, and also helps to create transparent and accountable governance [2]. Further study is also needed to obtain

information about public acceptance both in urban and rural areas of SiKesal application.

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Towards Development of Academic Information System –as-a-Services

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***Abstract*—As in many other fields, the technological progress has had a significant impact on the improvement of Higher Educational Institutions (HEIs). The academic information system is believed can provide the competitive advantages in HEIs. In facts, some HEIs are unable to afford the high resources of an academic information system. Cloud computing has the capability to help eradicate this problem by providing HEIs with needed software and applications at affordable effort. Aim of this study is to develop the academic information system for small-medium sized HEIs that can fulfill users' needs and satisfy the users. This paper focus to develop academic information system as a service toward Model Template Controller(MTC) that adapted from Model View Controller. This paper provides a contribution that academic information system developed through MTC approach is proven to fulfill and satisfy user needs that are shown by survey results.**

Keywords— academic information system, higher educational institution, cloud computing, Model Template Controller

I. INTRODUCTION

As in many other fields, the technological progress has had a big impact on the improvement of Higher educational institutions (HEIs)[1]. The management of students, activities, and services is one of the biggest challenges for modern HEIs, which requires the improvement of systems, tools and processes to be faced[2]. HEIs are encountered with the need to be innovative in order for them to remain competitive[3].

Small-medium HEIs has a limited budget, resources, and the number of students enrolled.[1] However, those campuses have the challenge to maintain the quality of education management better to provide great service for the stakeholder. One of the solution is to apply academic information system that can provide the competitive edge for those campuses. Academic information system will help the university to manage its activities from student admission to student graduation. Due its limitations, some HEIs are unable to implement the academic information system. These HEIs are therefore seeking alternative ways to procure this software and applications at reasonable valuation[4].

So is the case with that experienced by STIE Kesatuan Bogor. As a small HEI, STIE Kesatuan wants to improve the quality of its institutions by providing services to the academic community more effectively and efficiently. Therefore, STIE Kesatuan wants to implement Academic Information System to help manage the business process of education service activities.

Cloud computing technology is growing rapidly, attracting great attention to educational institutions[5][6]. The National Institute of Standards and Technology described cloud computing as "a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction"[7]. Cloud Computing has the capability to help eradicate this problem by providing HEIs with needed software and applications at reasonable effort[3]. Cloud Computing will also provide HEIs with the opportunity to focus more on other activities like research and teaching because issues with the software and applications will be taken care of by the service providers[2][4].

Based on the type of resource that is offered, cloud computing has three main service models namely Software-as-a-Service (SaaS), Infrastructure-as-a-Service (IaaS) and Platform-as-a-Service (PaaS)[3]. SaaS is a cloud computing service in which information technology resources, including computing power, data storage, software applications, and technical infrastructure, are delivered to users through a network. SaaS can be implemented with MTC (Model Template Controller) adapted from MVC(Model-View-Controller) framework.

According to Wardana[8], a framework is a set of commands or basic functions that have certain rules and can interact with each other. Meanwhile, according to Basuki[9], a framework is a collection of program pieces that are organized, to facilitate in making the application intact without having to make all the code from scratch. The concept of MVC itself was originally invented by Smalltalk programmer, Tryge Reenskaug[10], [11]. MVC is a software development approach that separates application logic from presentation[12]. MVC is a framework for thinking about programming and for organizing developer's program files. MVC gives developers a starting place to translate their ideas into code and help them to identify which code does what and make other developers easy to understand the code. The users get stable software quickly, the company saves money,

[1] To our knowledge, there is no exact definition about the size of HEI in Indonesia. In the case of that, we adapt definition from https://www.collegedata.com/cs/content/content_choosearticle_tmpl.jhtml?articleId=10006

and the developers don't go insane[13]–[15]. Model-Template-Controller (MTC) framework is created by applying OOP, where the Model section is a class model, the Controller is a class controller, and the Template section is a derivative of the class view.

Based on the background and motivation, the aim of this study is to develop an academic information system for small-medium sized HEIs that can fulfil users' needs and satisfy the users. This paper focuses on presents the implementation of MTC as a promising extended approach of MVC in develop the academic information system through WISDM.

The rest of this paper is organized as follows. The section on "Concept Overview" introduces the definition of the framework and object-oriented programming. The section on "Methodology" describes our steps to conduct this study. The section on "Proposed Approach" discusses MTC framework approach and its implementation through the use case, class diagram, and user interface. The section on "Result and Discussion" discussed our evaluation survey results and its implication for small HEIs. The last section on "Conclusion" discussed summary of findings and future work of the study.

II. Concept Overview

A. Academic Information System

The academic information system or student information system is a core system of any university and cover many functionalities[16], [17], include: being a repository of an institution's products(courses, subjects, etc) and their availability in any specified period; providing record management of past, present and future students covering aspects of enquiry, application, enrolment, academic performance and history; allowing for billing and fees management; processing major events such as graduations and examinations; scheduling classes; processing results; student progression and completion; operational and management reporting, and feeding data into various other specialist systems.

Related work we found at Enterprise University Information System (EUIS) project[18]. EUIS is an Academic Information System developed by venture unit under the University of Indonesia. This application is used by universities to manage and solve complex academic problems, such as managing data on new student admissions, payment administration, class schedules and so on. When the author is carrying out this study, EUIS has just been released in July 2018. Therefore, further investigations need to be carried out to see the results of the implementation of EUIS in universities.

B. Framework

A framework is a set of commands or basic functions that have certain rules and can interact with each other[8]. Another definition, a framework is a collection of program pieces that are organized, to facilitate in making the application intact without having to make all the code from scratch[9]. Framework application will benefit developers from time-side and organize the source to be more standardized, so it can be used by other application development teams with the same standard code-writing style. So also in terms of maintenance will be easier, because developers do not need to examine all components of the application code, simply by focusing on code that seems to be a problem. By using the framework in application development, developers will also be more focus on business process applications such as features that will be made and the application.

C. Object-Oriented Programming

Object-oriented programming (OOP) is a programming method that group the codes that are made into an object[10]. The created object can have properties and methods. Property is data owned by the object, while the method is a function that can be used to manipulate property owned. Programming with the concept of OOP has several advantages[11] including:

- Reusability, classes or objects that have been created can be used again for projects that other applications.
- Extensibility, because the class that has been created can be extended or derived in the class that will be created.
- Maintainability, the source code that has been made becomes more manageable because the source code is grouped into classes that have properties and methods that are separate between classes.

Frames that are built with Object Oriented Programming oriented will apply a class or object to create parts of the source code block[12]. Model-View-Controller (MVC) framework is created by applying OOP, where the Model section is a class model, the Controller is a class controller, and the View section is a derivative of the class view[13]–[15].

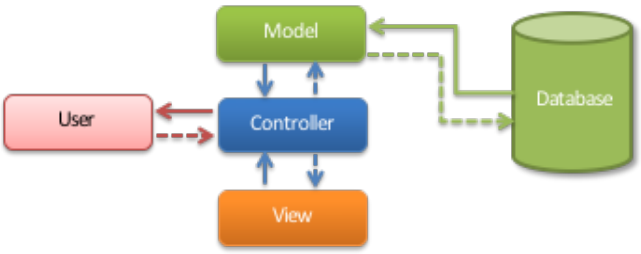

Fig. 1. MVC Concept[13]–[15]

III. Methodology

This study guided by Web IS Development Methods (WISDM)[19] as a system development methods that aims to make a program quickly and gradually so that it can be evaluated by the user. In addition, WISDM also makes the process of developing information systems to be faster and easier, especially in the circumstances of user needs difficult to identify[20].

The Web IS development methods (WISDM) matrix as seen in Fig. 1 categorizes methods in two dimensions: socio (the organization and individuals) and technical (things), analysis ('what' is required) and design ('how' it will be achieved). Engineering-based approaches to IS development concentrate on the right-hand side of the matrix: the

generation of a requirements specification and its stepwise refinement into a software model.

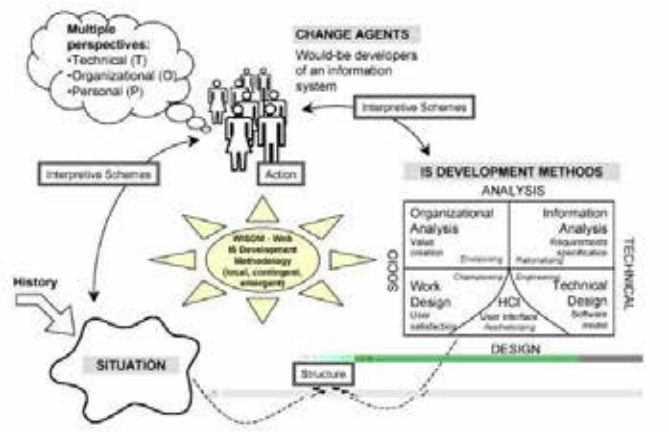

Fig. 2. WISDM Matrix[19]

Each of the aspects of the methods matrix has been annotated to highlight the different emphases that IS development projects are subject to as the developers move around the matrix. The organizational analysis is stereotyped a s*envisioning* and creative thinking, information modeling with *rationalizing* and a 'rage for order', work design with *championing* and representing stakeholder interests, technical design with *engineering* and problem solving, and Human-Computer Interaction (HCI) with *aestheticizing* and a notion of design as style[19].

A. Organizational Analysis

Authors conducted observations and interviews with stakeholders to find out the main problems in the current academic management process. From these activities it is known:

1) Students fill out the form manually to choose the course to be taken, then the form is validated by academic counselor. After that, students pay directly to the cashier, so there is a long queue just to fill the Study Registration Card (KRS).
2) Recapitulation of payment data is done manually, so finance staff is difficult to monitor payment status of the students.
3) Students and lecturers find it difficult to know the status of their presence and their studies activities.
4) Admission process of new student candidates is still done manually up to the exam card printing so it feels ineffective because there are six admission periods in a year.

Based on the that, the stakeholder need of automation process for admission, courses to graduate system to create value in improving quality of business process. Moreover, related to limitation resources that faced, authors, offer a solution: academic information system-as-a-services, called 'SIAK Cloud'.

B. Information Analysis

From previous step then information analysis modeled with use case and class diagram as seen in Fig.5 and Fig. 6. Unified Modeling Language (UML), is a standardized modeling language consisting of an integrated set of diagrams, developed to help system and software developers for specifying, visualizing, constructing, and documenting the artifacts of software systems[21], as well as for business modeling and other non-software systems. The UML represents a collection of best engineering practices that have proven successful in the modeling of large and complex systems[22]. The UML is a very important part of developing object-oriented software and the software development process. The UML uses mostly graphical notations to express the design of software projects. Using the UML helps project teams communicate, explore potential designs, and validate the architectural design of the software.

C. Technical Design

In the development of web-based applications that work based on Software as a Services (SaaS) require a different display for each institution that uses the SaaS. MTC concept framework was created to address the problem. As discussed above, in MVC concept, MTC also has Model and Controller, as seen in Fig. 3. View dimension developed into Template dimension. In general, Controller work as part of business process, Model work as part of the data manager, and Template as part of multi-company display generator.

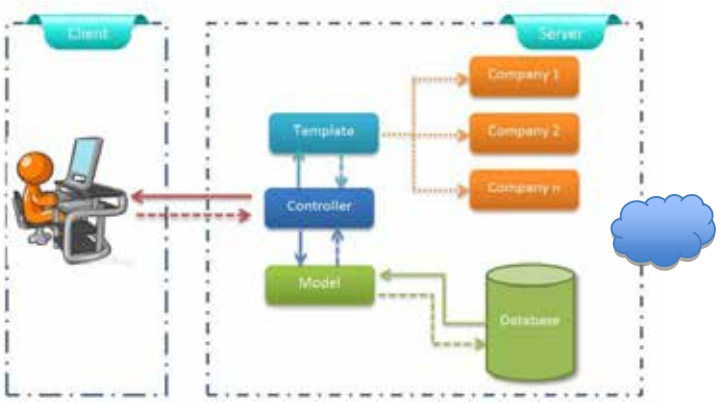

Fig. 3. MTC Work Flow

A request comes from stakeholder through internet browser that used (i.e. Mozilla Firefox or Google Chrome). The request will be processed by the Controller section. If the request requires data from the database, then the Controller will make requests to the Models section and this section will interact with the database. Interaction results with this database will be provided by the Model to the Controller section. Next to the Controller will be given to the Templates section to be a view that matches the look of the company who access the application. The view will be given to the Client as the response to the request made by the Client.

A library or code library that can be used in a framework is located in a library sub-folder, as seen in Fig. 4. As for setting the database connection and other configurations are placed in the *config* folder.

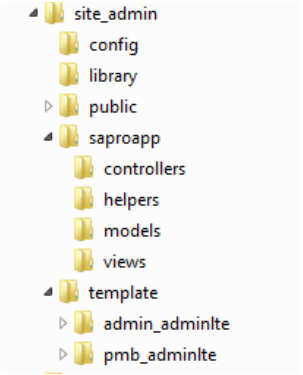

Fig. 4. MTC Folder Structure

To sum up about approach that we use in this study, Table 1 list the perspective about MVC and MTC approaches.

TABLE I. PERSPECTIVES OF MVC AND MTC APPROACH

Framework Approach	Data	Business Process	Display	Description
MVC	Model	Controller	View	The display is created for a company Need a further action to adapted in SaaS development
MTC	Model	Controller	Template	The display is created for multi-company Fit well for SaaS implementation

D. Human-Computer Interface

As the main part of the system, interface play an important element for system and user interaction. Here are examples of interfaces in SIAK-Cloud as seen in Fig. 7 to Fig. 10.

E. Work Design

Previous studies have established the fact that the power to retain the users also lies in managing users satisfaction. In this study, SIAK-Cloud is a critical component and also play a significant role in processing transaction of business and providing information. Measuring the satisfaction of users towards SIAK-Cloud can be useful for predicting their perception towards the system, quality of online services and tendency to reuse of system. The present study uses web service quality model called WebQual 4.0 to measure user satisfaction.

WebQual 4.0 came from many resources that have the strong foundation in Service Quality, Web and Information System assessment studies such as SERVQUAL developed by Parasuraman and user satisfaction model by Bailey and Pearson[23]. The key dimensions of the measurement are *Usability* (Includes quality attributes associated with human-machine interaction, site design and usability measures like appearance, ease of use and navigation); *Information quality* (This dimension deals with the quality of the website content and suitability of the information for the user's purposes, e.g. accuracy, format, and relevancy; and *Service interaction quality* (It concerns with the features associated with reliability, trust, and empathy. It includes measures for issues in transaction and information security, product delivery, personalization, and communication)[24].

An instrument developed in 5 point Likert scale (see APPENDIX). The validity and reliability test of the instrument of satisfaction measurement were performed using PSPP software to ensure that the result of the survey is valid and reliable.

IV. RESULTS AND DISCUSSION

A. Interface of SIAK-Cloud

1) Use Case

The use case diagram design is used as the standard language of UML model to describe the business process requirement and illustrate the interaction between system and environment. It starts with defining the actor and its activity with what the system (functionality) does. A use case represents discrete activity performed by the user and presents the main part of the system function. Between actor and use-case is connected by a line that describes a relationship that is usually an Association relationship, Include Relationship, Extend Relationship or Generalization Relationship.

In the academic information system (SIAK-Cloud), we define five actors: two actors as users (student and lecture) and two actors as admin in the department (i.e. Head of the study program and Operator) and an actor as super admin. The main function of the system is to conduct the recovery process from the beginning of the course offer to see the results (grade).

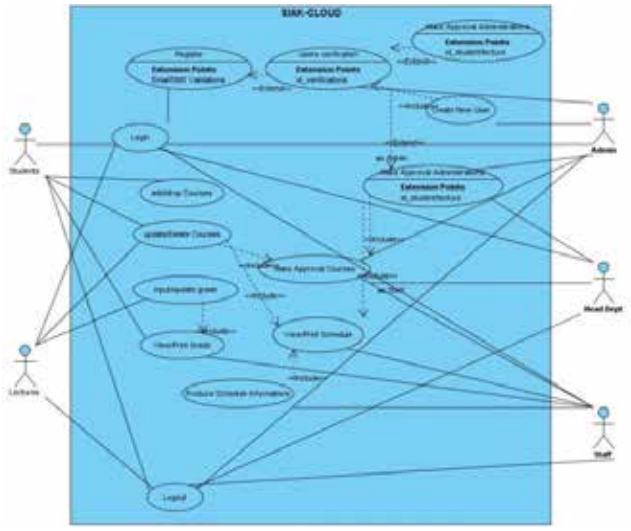

Fig. 5. Use Case Diagram of SIAK Cloud

2) Class Diagram

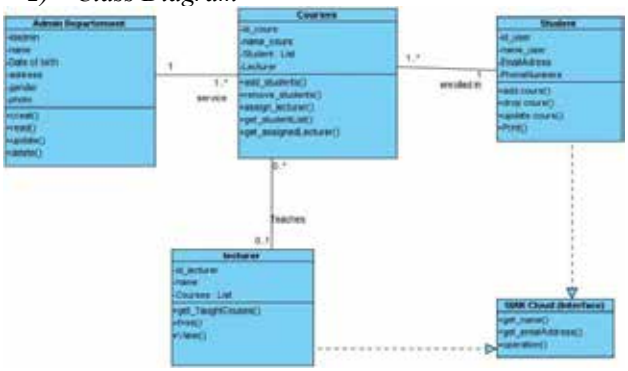

Fig. 6. Class Diagram

The class diagram shows the object in the system. All class objects have the same structure and behavior, but they contain different attributes. In the system proposed in this study, we defined there are five classes: admin department, courses, students, lecturers and interface. As shown in Fig. 6, that the objects consist of student, lecture and admin realize the relationship by using the interface, in this case SIAK-Cloud system, in the process of recovery (courses). The relationship between classes is association whereas from user lecture and students to interface is realizations.

3) User Interface

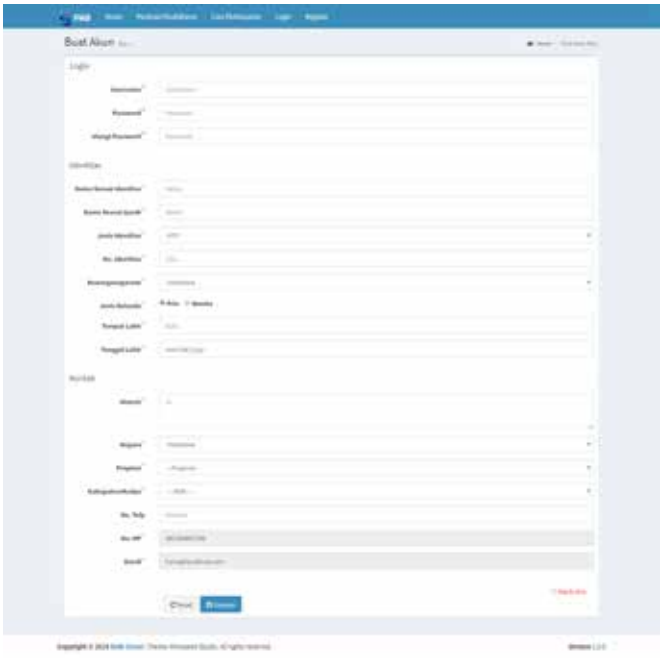

Fig. 7. An Interface of "Register New Account"

Based on the form in Fig. 7, to create an account required data for login such as username and password. It also required identity and contact data. All of the asterisks (*) are required to be filled in the specified format. After the form is filled, visitors can click the Save button to save the data already filled in.

Fig. 8. An Interface of "Preview of Exam Card"

Fig. 8 showing the interface of exam card preview, download and print the test card. A photo and QR-Code are included in the card so that can be used by the exam supervisor to check the similarity of people who took the exam with the data in the exam card, thus reducing the practice execution test.

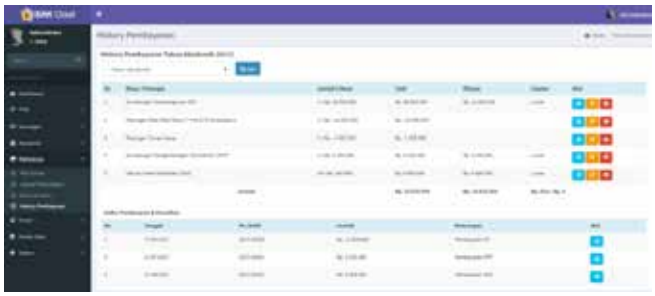

Fig. 9. An Interface of "Payment History"

Fig. 9 show the payment history to view student payment data i.e. payment tuition, credits cost, and so forth. It is useful for the administration of campus finance to monitor payments already paid and who are still in arrears.

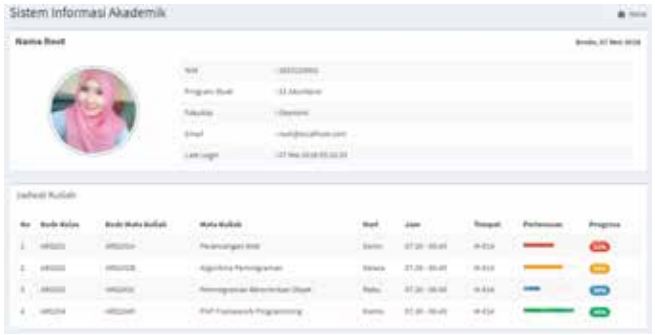

Fig. 10. An Interface of "Student Study Control"

Fig. 10 shown the Student Dashboard page. Interface presented is the academic data of students and the schedule of lectures are also equipped with class data both place and time of course of each course followed in the current semester. In addition, students can also see the graph of the number of classes have been attended during the lectures. It is useful for students to get a warning if there is a number of meeting subjects that are followed are not yet eligible for mid-exam or final exam.

B. Validity and Reliability Test

Validity test using Pearson Bivariate Formula (Pearson Product Moment Correlation) done with PSPP Software that has supported the use of this formula. From the result of analysis using PSPP got r-value result of item questionnaire item with the total score. This value is then compared with the r- value of the table sought on a significant 5% with 2-sided test[25] and N (number of respondents) = 121.

TABLE II. THE RESULT OF VALIDITY TEST

Question Item	r-value	r-table	Result
Use1	0.41	0.1786	Valid
Use2	0.34	0.1786	Valid
Use3	0.48	0.1786	Valid
Use4	0.48	0.1786	Valid
Use5	0.59	0.1786	Valid
Use6	0.65	0.1786	Valid
Infoqual1	0.57	0.1786	Valid
Infoqual2	0.46	0.1786	Valid
Infoqual3	0.62	0.1786	Valid
Infoqual4	0.58	0.1786	Valid
Infoqual5	0.55	0.1786	Valid
Servqual1	0.54	0.1786	Valid
Servqual2	0.55	0.1786	Valid
Servqual3	0.40	0.1786	Valid
Servqual4	0.44	0.1786	Valid

The next step is to test the reliability that aims to determine the level of consistency questionnaire. The statement item that has been declared valid then tested the reliability by using Alpha method (Cronbach's) on PSPP Software. The Alpha method is suitable for use in scale questionnaires[26]. The basis of decision-making in Reliability Test is if the value of Alpha is greater than r table then the questionnaire items used are declared reliable or consistent[27].

In the result of reliability test using PSPP it is known that Alpha value is 0.79 (see Cronbach's Alpha column) and then this value is compared with r table value with value N = 121 sought on distribution r value table significance 5% (same as on the validity test) obtained r table value DF = N-2 of 0.1786. The conclusion is Alpha = 0.79> r table = 0.1786 means the items in the questionnaire of SIAK-Cloud Service can be said as reliable as a data gathering tool in this study.

C. Survey Results

Measuring the satisfaction of users towards SIAK-Cloud can be useful for predicting their perception towards the system, quality of online services and tendency to reuse of the system, as shown by prior studies in online system[28], [29]. User satisfaction score of SIAK-Cloud services that captured from survey summarized in Fig.11.

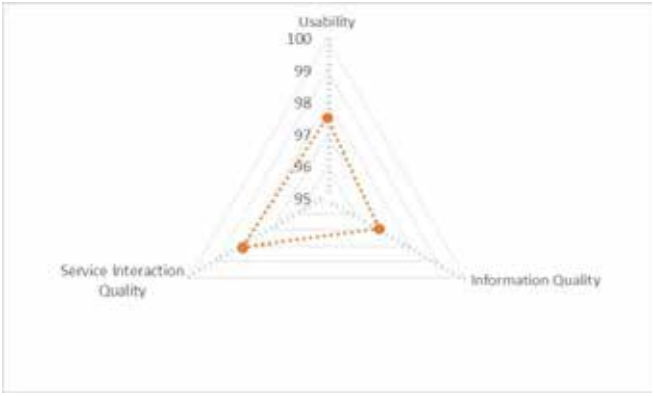

Fig. 11. The score of users satisfaction on SIAK-Cloud Service

In today's competitive environment, retaining a satisfied user is a requirement. Delivery of high service quality in an online environment has also been treated as the basic business strategy. This study makes an attempt to measure the users' satisfaction for SIAK Cloud services.

The questionnaire was carried out in an online survey and distributed to students, lecture and academic staff of STIE Kesatuan as the actual user. From 121 respondents, the score of Usability, Service Interaction Quality and Information Quality dimensions are 97.52, 98.07 and 96.88, respectively.

The results reveal that users are highly satisfied with the system that is easy to navigate, operate and have an attractive appearance. Regarding information quality dimension, users find that SIAK-Cloud content is informative, accurate and relevant. Moreover, attributed to service quality dimension, users' feels reliable and safe using SIAK. Overall, it can be said that users feel satisfied with the service of SIAK-Cloud.

From the survey result, we can assume that using MTC approach for the development of academic information systems in small-medium HEIs will provide the competitive advantage to present value for users. Even this approach is more efficient than building a new one from scratch, users feel satisfied with the service of SIAK-Cloud.

V. CONCLUSION

In this study, we have proposed and implemented MTC framework approach for development of academic information systems in small medium HEIs, guided through WISDM. The steps consist of organizational analysis, information analysis, technical design, human-computer interaction design and work design that performed evaluation to measure user satisfaction.

Through the survey toward actual users, the findings show that most users are satisfied with the service of SIAK-Cloud in all dimensions: Usability, Service Interaction Quality and Information Quality. This paper provides a contribution that academic information system developed through MTC approach is proven to fulfil and satisfy user needs that is shown by survey results.

However, we realizes that this study may have limitation. Many studies found there are various challenges that surround cloud computing in terms of security, privacy and, trust. Even we asked about trust and security in general to users, however, these challenges are not our focus on this paper. To extend this study, we recommend to consider

about trust and security aspects. Moreover, regarding the achievement of user satisfaction in SIAK-Cloud, MTC framework approach are considered to develop for another e-service in education field, i.e. online distance learning.

Also, this approach need more consideration regarding implementation in location that might not have sufficient infrastructure for reliable internet connection, such as in rural area. Another issues that need to be considered is about capability of human resources in rural area. It will have potential area to study for explore the implementation of academic information system-as-a-services in rural area.

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APPENDIX. QUESTIONNAIRE

No.	Measurement (Strongly Agree to Strongly Disagree)
1.	SIAK is easy to learn to operate
2.	The interaction with SIAK is clear and easy to understand
3.	SIAK is easy to use
4.	SIAK' interface is interesting
5.	SIAK looks convincing and competent
6.	SIAK provides a positive experience for me
7.	The information available in SIAK is accurate
8.	The information presented in SIAK can be trusted
9.	The information presented in SIAK is relevant
10.	The information provided in SIAK is easy to understand
11.	The information provided in SIAK is detailed
12.	SIAK has good reliability
13.	SIAK has been paying attention to my safety
14.	SIAK service is as expected
15.	Overall, SIAK service is satisfactory

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Village Library and Social Media: Communicating "Puro Village Library" to Consumers through Facebook Account

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***Abstract*— Libraries play a crucial role in the development of society. In this era, where the Internet dominates many fields of human life, libraries needs to optimize internet technology either in terms of the management or the communication to the stakeholders. Indonesia's infrastructure for Internet connection has been improving until now, yet many villages already have privilege to it. The purpose of this research is to study the usage of social media as channel of communication for village library in Sragen, Central Java, Indonesia, namely "Puro Village Library" based on its Facebook content. This research focuses on seven themes: engagement, listening, relationships, trust, authenticity, visibility, and branding. Using document and literature study, this research analyzes the posts of "Perpustakaan Bukuku Guruku" Facebook account during the first semester of 2018 using content analysis. This research found that "Puro Village Library" has utilized social media (Facebook) for communicating with the customers. However, the usage was not optimum because the seven themes used in this research did not appear optimally based on the posts in the organization's Facebook account. This result implies a need for communication management literacy among village libraries, especially in terms of broadening costumers so that social media utilization can be optimal.**

Keywords—village library, social media, Facebook, organization communication

I. INTRODUCTION

Communication is a process that is inseparable from everyday human life, both in personal life and in the context of organizations or institutions. It is reinforced by Maslow's theory, namely the Hierarchy of Human Needs theory. Maslow in Wood [1] said that although the term 'communication' does not appear specifically as one of the human needs, communication is needed to fulfill all human needs. This even applies to basic human needs, which are in the form of human physical needs in order to survive, such as food. Before humans were born to earth, the babies have communicated with the mother and other family members while they were still in the womb. Shortly after he was born, his cry was a form of communication with other people and had various meanings.

The various meanings that arise in a communication process allow the elements of reference and field of experience for important things. This is in line with the communication theory formulated by Wilbur Schramm in Buttle [2] which involved both elements in the delivery of messages as a communication process. Although a message can be interpreted with a variety of meanings, both elements make the diversity of meanings interpreted by the participants in the communication process smaller. This will be able to support mutual understanding between the source and receiver. In this mutual understanding, the message that the sender wants to convey will be received exactly same as the receiver's interpretation.

In a broader context such as organizations, institutions, and companies, mutual understanding in communication is also very necessary, both in the context of communication within the organization and communication between the organization and the outsiders. Public communication is a level of communication believed to involve outsiders from a particular organization as participants in the communication process that occurs. Macnamara [3] even conducted studies related to websites 2.0 and 3.0, which since 2010 have been optimized as a channel for public communication of a company; public communication is believed to have links with public sphere, journalism, advertising, and public relations.

A village library is an organization located in a village or rural area that is able to provide benefits for the people in the village and its surroundings. The management of a village library is important, but establishing relationships with stakeholders, especially potential consumers, is equally important. One of the village libraries in Indonesia is the "Puro Village Library", which is located in Sragen Regency, Central Java Province. This village library won the Perpuseru Award in the category of the best village library in 2018 [4]. Perpuseru is a collaboration program between the Coca Cola Foundation Indonesia (CCFI) and the Bill & Melinda Gates Foundation which aims to transform library information to central information, learning and activities based on technology, information, and communication. CCFI has successfully transformed 102 district libraries and 580 village libraries in 18 Indonesian provinces (Kumparan 2018) [5]. As a partner of Perpuseru, "Puro Village Library" was transformed into a center of learning and activity in community based on information and communication technology (ICT). This library has been using social media, Facebook, with "Perpustakaan Bukuku Guruku" as the user name.

This study explores public communication of "Puro Village Library" to the stakeholders which eventually will become loyal customers through Facebook. The research model adopts the Anderson model in Voss and Kumar [6] which involves seven themes: engagement, listening, relationships, trust, authenticity, visibility, and branding.

II. LITERATURE REVIEW

A. Village Library as An Organization that Needs to Communicate to The Public

The types of public libraries can be distinguished based on the type of collection and diversity of library users.

According to Yusuf [7], village libraries are classified as public libraries. Based on the reference book about management of village libraries [8], the purpose of a village library is to support compulsory education programs, support lifelong education programs for the community, and provide knowledge books. Because of the importance of a library, the management must think about how to optimize its service to the community. The explanation shows that the library is an organization that is very important and has a big role in improving the intelligence of the nation. In the future, it will be able to improve the quality of society.

However, one of the efforts to support the embodiment of the village library goals in the era of ICT is by utilizing social media, for example Facebook. In addition to improving its management, internal and external public communication is very important because it will bring an attachment between the organization and the public, which in turn can form trust among the public regarding the library.

In the modern era, libraries have new role, since there is a change of perspective in the library to a web-based information model. It causes some differences from the old library, such as the development of the sources, the management of the library which is considered as more democratic, the more flexible communication system and organization, and also quality and user-oriented service development. Modern libraries must increase their collection in various forms while maintaining easy access. There will be a need for digitizing the sources for online users [9].

Libraries need to be managed internally and externally. For the management, it is crucial to keep improving internal management of a library, from the circulation to the standard of excellent service. On the other hand, external aspects must be given the same attention. It can be done by communicating the library to the public. Does 'communicating' here hold the same description as the definition of 'communication'? The answer is yes. Just like the mutual understanding that needs to be reached in communication, communicating an organization also means to disseminate the message from the sender to the receiver, or in this context, having a communication process from a library to the public, internally, and externally to gain trust, and to form a great database of consumers that is believed to increase.

B. Social Media as the Channel of Public Communication of An Organization

There are several reasons why people use social media. As a channel in communicating something, where it can be classified both in computer mediated communication and mass communication, it is not such an exaggeration to understand social media use personally and institutionally.

For personal users, social media was highly believed as a media to connect to others, either with new people or with someone familiar [10]. Social media is also used as a means to get information and to disseminate it to others [11]. Another form of social media, academic social networking sites, has also become popular among academicians. There are several reasons for academician to use academic social networking sites: self-promotion and egobolstering, acquisition of professional knowledge, belonging to peer community, and interaction with peers [12].

In business, social media also plays an important role. Universities, for example, use social media to show their image. Instagram, a popular social media platform, can be considered as the representation of the universities in Indonesia to tell the world that they have an international vision, which can be seen from the posts [13]. In Poland, social media is also crucial for the image of a university, particularly in terms of visual content [14]. To reach a wider range of customers, social media can also be considered as an effective tool, particularly in marketing communication and promotion [15].

Specifically, as a social media platform (or social networking sites), Facebook has a huge number of users in Indonesia. Based on Hootsuite data published on the online news portal beritasatu.com, it is known that internet users using mobile phones were up to 177.9 million, and 120 million of them were social media users. The number of active social media users in Indonesia in one year increased by 23% or 24 million users compared to the same figure in January 2017. Based on the data as of January 2018, active social media users can be divided into the most commonly used platforms, which are YouTube and Facebook [16].

Facebook has some features that support interaction: friends list, timeline, pokes, status, events, photos, video, messages, chat, groups, etc [17]. The timeline is a feature that functions as a bulletin board and allows other users to post personal messages directed toward the end user. The poke feature enables users to provide initial greetings to other users. The status feature allows users to inform their friends of their whereabouts and activity. The events feature enables users to plan meetings or events that they can extend invitations for.

Several studies about Facebook range from the usage of Facebook [18], motivation of using Facebook [19], to Facebook as a channel of corporate communication and branding [20]. In terms of Facebook use in libraries, Purwani [21] found the use of Facebook in college libraries were to inform collections, promote services and to inform activities that have been held. Moreover, according to Aharony [22], although there are some differences in Facebook use in public and academic libraries (amount of posts, photos and content), using Facebook enables both kinds of libraries to market activities, events, services, and so forth. He added that public and academic libraries should use Facebook not just as a dissemination or marketing tool, but rather as a venue for a real interactive dialog with their patrons.

Facebook has become a topic of research in Library and Information Science scholars since 2007 [23]. However, the research that specifically studies about the use of social media in the village library are still rare. Researches related to village libraries in Indonesia mostly discussed the benefits of village libraries for village development through education by utilizing collections in village libraries. Rohman & Sukaesih [24] found that through education, people are more easily empowered.

However, study about the usage of Facebook as a communication channel for institutions such as a village library, for instance, are still rare.

C. *Audience Engagement in Communication Using Social Media*

Basically, communication is about transmitting message to the receiver, either directly or through a particular channel. Since its appearance, social media has played an important role in transmitting the message from the source to the receiver. Engaging the receiver in a communication process is also crucial, particularly in the context of external organizational communication. Engaging the audience may cause a positive impact for the organization itself.

Zheng et.al. in [25] defined audience engagement as a process that leads to the loyalty, a behavioral manifestation, and a state which involves vigour, dedication, absorption, and interaction. Therefore, engagement is a crucial part in gaining a wider scope of audience which also leads to the customer. In the context of an organization, audience engagement will also establish a broader customer base.

Social media engagement focuses on the role of technology as the underlying platform needed to support social interactions among global users. It is clear that the appearance of social media is a part of technology evolution that enables a user to experience to be connected in new ways that never existed before [26].

There are several ways to study audience engagement. One of the studies that researched audience engagement is Voss and Kumar [6]. They studied audience engagement in 7 (seven) themes: engagement, listening, relationships, trust, authenticity, visibility, and branding. However, this research only uses four of them: visibility, engagement, trust, and branding.

III. METHODS

This research uses content analysis to explore and understand the usage of social media, especially Facebook, in Puro Village Library as a communication channel for the audience. Krippendorff in [15] said that the purpose of content analysis is providing knowledge, new insights, a representation of facts, and a practical guide to action.

The method of collecting data in this research is document study, or literature study. In this research, the documents being analyzed are the posts of the Facebook account of "Puro Village Library", namely "Perpustakaan Bukuku Guruku". The process of data collection was done by accessing the "Perpustakaan Bukuku Guruku" account in Facebook manually and gaining all of the posts from the first semester of 2018. There were 28 posts along the period. In addition, literature study is also done on journals and text books related to the research topic, which are libraries, communication, and social media.

The analysis units of this research are the photos, captions, likes, comments, and replies in "Perpustakaan Bukuku Guruku" Facebook account along the period. After collecting data, the next phase is data coding. The coding sheet consists of postdate, type of post, short description of the post, and interactions happening in the post. This process is followed by the final phase, which is analyzing the coded data based on the categories already decided before collecting the data: engagement, listening, relationships, trust, authenticity, visibility, and branding.

IV. DISCUSSION

From the data collecting process, there were 28 posts of "Perpustakaan Bukuku Guruku" Facebook account from the first semester of the year 2018, which is from January to June 2018. It can be seen from Table 1 below.

TABLE I. CODING SHEET OF "PERPUSTAKAN BUKUKU GURUKU" FACEBOOK ACCOUNT POSTS FROM JANUARY TO JUNE 2018

No	Date (2018)	Type of Posts	Short Description	Interaction
1.	Jan 09, 05.50 pm	Photos with caption	Photos of English language tutoring activity in Puro Village Library	22 Likes, 7 positive comments
2.	Jan 10, 02.36 pm	Photos with caption	Photos of Posyandu literacy activity in Pilangrejo dan Karas Posyandu	27 Likes, 1 positive comments
3.	Jan 13, 05.56 pm	Photos with caption	Photos of tutoring activity in Puro Village Library	22 Likes, 1 positive comment
4.	Jan 19, 05.12 pm	Photos with caption	Photos of Perpuseru visitation in Puro Village Library	23 Likes, 0 comment
5.	Jan 21, 04.54 pm	Photos with caption	Photos of kids coloring competition in Puro Village Library	36 Likes, 3 neutral comments
6.	Jan 29, 04.36 pm	Photos with caption	Photos of kids activity (games) in Puro Village Library	32 Likes, 0 comment, 1 Share
7.	Feb 01, 11.32 am	Photos with caption	Photos of village library forum Sragen Regency event in Sragen regional library	18 Likes, 0 comment
8.	Feb 04, 11.01 am	Photos with caption	Photos of Math tutoring activity in Puro Village Library	25 Likes, 2 positive comments
9.	Feb 09, 09.09 am	Photos with caption	Photos of Posyandu literacy activity in Kartini Sepreh Posyandu	21 Likes, 0 comment, 1 Share
10.	Feb 10, 12.48 pm	Photos with caption	Photos of Posyandu literacy activity in Sumber Mulyo Posyandu	39 Likes, 5 positive comments
11.	Feb 13, 04.53 pm	Photos with caption	Photos of English language tutoring activity in Puro Village Library	14 Likes, 0 comment
12.	Feb 20, 09.04 pm	Photos with caption	Photos of BU JAYA activity in Puro Village Library	18 Likes, 0 comment
13.	Feb 28, 06.47 pm	Photos with caption	Photos of visitors activity in Puro Village Library	27 Likes, 5 neutral comments
14.	March 5, 05.46 pm	Photos with caption	Photos of Math tutoring activity in Puro Village Library	25 Likes, 0 comment
15.	March 13, 11.54 am	Photos with caption	Photos of mobile library activity of Puro Village Library	24 Likes, 0 comment
16.	March 17, 03.52 pm	Photos with caption	Photos of Math tutoring activity in Puro Village Library	41 Likes, 1 neutral comment
17.	March 20, 04.25 pm	Photos with caption	Photos of English language tutoring activity in Puro Village Library	33 Likes, 4 neutral comments
18.	March 23, 04.27 pm	Photos with caption	Photos of BU JAYA activity in Puro Village Library Photos of BU JAYA activity in Katukan	23 Likes, 1 positive comment

19.	March 25, 04.22 pm	Photos with caption	Photos of tutoring students having vacation to Sangiran, Sragen	28 Likes, 0 comment 1 Share
20.	Apr 01, 03.13 pm	Photos with caption	Photos of Math tutoring activity in Puro Village Library	12 Likes, 4 positive comments
21.	April 04, 11.32 am	Photos with caption	Photos of Diponegoro University students visitation for conducting research in Puro Village Library	26 Likes, 1 positive comment
22.	Apr 14, 05.28 pm	Photos with caption	Photos of free Math tutoring activity in Puro Village Library	9 Likes, 2 neutral comments, 2 neutral responds
23.	Apr 24, 04.14 pm	Photos with caption	Photos of free English language tutoring activity in Puro Village Library	4 Likes, 0 comment
24.	Apr 26, 02.40 pm	Photos with caption	Photos of Perpusdes of Gunungkidul Regency visitation to Puro Village Library	9 Likes, 0 comment
25.	May 04, 12.43 pm	Photos with caption	Photos of technical guidance in Sukoharjo Village Library, Yogyakarta	10 Likes, 0 comment
26.	May 05, 05.06 pm	Photos with caption	Photos of Posyandu literacy activity in Katukan Posyandu	8 Likes, 0 comment
27.	May 31, 12.56 pm	Photos with caption	Photos of BU JAYA activity in Puro Village Library	16 Likes, 1 positive comment
28.	Jun 29, 05.45 pm	Photos with caption	Photos of the Village Child Friendly field verification team visitation in Puro Village Library	54 Likes, 8 positive comments

Source: from data collection, "Puro Village Library" Facebook Account, "Perpustakaan Bukuku Guruku"

Generally, the post type of "Perpustakaan Bukuku Guruku" account is very monotonous; out of 28 posts during the first semester of 2018, all posts were categorized as 'photos with caption' posts. There are other types of posts in social media, particularly in Facebook, such as: status (in words), photo post without caption, and video post with or without captions. It is beneficial if the administrator of the Facebook account used all of the features to reach a higher scope of customer.

The first theme, engagement, can be analyzed from the interaction between "Perpustakaan Bukuku Guruku" account and other Facebook users. It is similar to the explanation by Agostino, et.al., in Sherbrooke & Mosconi on the concept of customer engagement. They described it as "psychological state that occurs by virtue of interactive, cocreative customer experiences with a focal agent/ object (e.g., a brand) in focal service relationships".

The number of likes is an indicator that can show how an organization engages the audiences and customers. By looking at the number of likes in each of the post, it is hard to say that Puro Village Library has built an outstanding engagement with the audience of the Facebook account that finally lead to the costumer of the library. All of the posts from the research period had likes ranging from 4 to 54. The post hhaving the highest number of likes is the post on June 29, 2018 which shows 51 likes. It is a post about field visitation of the Village Child Friendly team to Puro Village Library. Engagement can also be studied from the comments. From Table 1, it can be seen that the comments of the posts were so low. Out of 28 posts, only 15 were commented by other Facebook users. Engagement also may be seen from the number of shares. Facebook also has a feature called Share that allows people to broaden the interaction. Based on Table 1, it can be seen that out of 28 posts, only three of them where shared by other users: the posts of January 29, February 09, and March 25. The small number of shares may cause minimum effect of an organization engagement

The second theme, listening, is also an important aspect in communicating an organization, particularly in using social media. Li and Bernoff in Voss and Kumar [6] explained that listening to the audience is a crucial theme regarding the use of social media. When a market terget speaks to the organization through the social media, it is a good sign, since he/she cares about the organization; he/she wants to be heard and the organization can get insights such as opinions through this media. In the context of this research, the listening theme appears in a deeper engagement between the organization and the public, that is by checking up on the response of the organization. Although the organization does not always respond to the likes and comments, there was a post where the organization answered a comment related to the program of the village library in the posts. This theme will form a closer connectivity between the organization and the public, which can be seen in the third theme, relationship.

In the relationship theme, there are two parts involved: the organization and the public. Engaging an audience can establish relationships [6]. The manifestation of this theme has everything to do with the second theme, listening. It can be seen that from the analysis in the second theme, the relationship is still very small that it cannot even be called a relationship. In a good relationship between the organization and the public, there are several factors that need to be fulfilled, such as trust, commitment, community involvement, participation, and satisfaction [28]. Some of the factors are already in the Facebook account of Puro Village Library. However, the low engagement results a low relationship. Moreover, one of the factors of relationship, community involvement, is not very well seen. From the posts already collected, the highest number of comments is only 8 comments for a post.

The fourth theme, trust, has a close relation to the previous theme, relationship. Dutta [6] said that people want organizations to pay attention to them and give response so they understand that they are heard. If this happens, they will feel more connected to the organization. Meanwhile, O'Hara-Devereaux and Johansen in Sarker et. al. [29] described trust as a glue which can put together even some elements that are not similar. Therefore, in the context of the "Perpustakaan Bukuku Guruku" account, the trust seems low, since there is no empirical evidence to show that the glue works in an optimum way. Table 1 shows that the interaction between the administrators and the other users is so minimum; out of 28 posts, only 1 post contains a response from the administrator. It can be seen from 2 neutral answers posted by the administrator as the response of user questions due to the photos that are posted.

The fifth theme is authenticity. It can be shown by the creative program that are being informed in some posts of the Facebook account of Puro Village Library. They are able

to show the authenticity and creativity that never existed before in other libraries, especially village libraries. Some of the programs are kind of general programs, but it is special because it happened in a library, and the management finds that creativity can be derived from the naming of the program which is considered to be unique and easy listening.

The sixth theme is visibility. It was hard to be visible when a Facebook account rarely posts anything. From the coding sheet, it can be seen that the number of posts of "Perpustakaan Bukuku Guruku" Facebook account is minimal – only 28 posts within 6 months oor 28 posts within 180 days. Compared to the number of posts, it is a small number of posts for an organization that needs to engage its audience which will lead to loyal customers. The frequency of appearance in the Facebook newsfeed is crucial for Puro Village Library. By posting frequently, the account will appear more often so the audience will also be notified more often. For an organization that needs to grow steeply, this number is considered low.

The last theme is brand. From Table 1, it can be seen that it is hard to read the "Puro Village Library" brand from "Perpustakaan Bukuku Guruku" account posts. The branding dimension can be understood from the esthetic layout [6] of the Facebook account. Specifically, it can be seen from the style of the caption, the consistency of the messages shared in the form of words and pictures. Unfortunately, this is not shown clearly in the posts of "Perpustakaan Bukuku Guruku" account during the first semester of 2018.

V. CONCLUSION

From the analysis done in the previous section, it can be concluded that the Puro Village Library in Sragen has utilized ICT by using social media (Facebook) as its channel to communicate with the customers. However, based on the seven themes that were used as the dimensions of the communication process, the usage of Facebook is not optimal; the engagement between organization and the public is lacking. The seven themes are engagement, listening, relationship, trust, visibility, and branding.

Future research regarding to utilization of ICT in the development of village library may be done in terms of the factors considered as obstacles in achieving a maximum result. It is important to follow up the implication of the study, which can possibly be done in terms of social media management literacy for the village library managers, so they can utilize social media optimally as a prominent channel of communication..

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A COBIT-Based Critical Asset Evaluation of Electronic Certificate Management in Central, Urban, and Rural Government Agencies: Study and Analysis

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***Abstract*— The authority for digital procurement certification in Indonesia, known as Otoritas Sertifikat Digital Pengadaan Secara Elektronik (OSD PSE), is provided by a unit at National Cyber and Crypto Agency. This is an in-demand service for many sectors that require secure electronic procurement. Our study analyzes and identifies the vulnerability of electronic certificate assets using COBIT 5.0 framework. There are four assets that are at high risk when OSD PSE services are interrupted: OSD PSE Private Key Compromise, Spamkodok Auditor Application, EJBCA Application, and Hardware Security Module. We evaluated these assets using COBIT 5's goals cascade mechanism, which is designed to achieve enterprise and IT goals and to determine domain processes. Based on our evaluation, the EDM03, APO12, APO13, and BAI06 domain processes require deeper study. Additionally, we identified 10 secondary priority processes.**

Keywords*— *COBIT 5, Enterprise Goals, IT Goals, Domain Process

I. INTRODUCTION

Because of Government Regulation No. 82 year 2012 on the Electronic System and Transactions, known as Penyelenggaran Sistem dan Transaksi Elektronik (PSTE), the implementation of electronic certificates for every electronic transaction has become a widely discussed and well-studied topic. The regulation states that each electronic transaction must include a certificate of reliability or an electronic certificate that ensures the authenticity of the parties involved.

The rapid development of information and communication technology has influenced multi-level government institutions, including rural governments. People can easily access and collect information then digitally publish service transactions in various sectors, such as e-identity and e-taxation. However, vulnerabilities and threats exist.

Electronic certificate is a method to guarantee the security of electronic public services. The authority for digital procurement certification, known as Otoritas Sertifikat Digital Pengadaan Secara Elektronik (OSD PSE), is a trusted third party whose role includes signing, issuing, and maintaining digital certificates, at the request of users, for the exchange of documents and information during the e-procurement process. This trusted service, called Balai Sertifikasi Elektronik (BSrE), is provided by a unit at National Cyber and Crypto Agency (BSSN).

The main business purpose of OSD PSE is to manage electronic certificates, including private keys, which are a critical element of information assets. A private key is a cryptographic key pair that can be used to open secure messages and to create a digital signature. If the electronic certificate management process is interrupted, then OSD PSE cannot fulfill the electronic certification process of Layanan Pengadaan Secara Elektronik (LPSEs), which is established in all government agencies.

Based on the BSrE incident handling report, there is a vulnerability that prevents OSD PSE services from operating. An incident occurred that resulted in the loss of a list of electronic certificate owners, which was stored in the virtual server device (i.e., a virtual machine). This vulnerability has a negative impact on information security risks in the electronic certificate management process.

There are vulnerabilities and potential threats to critical assets that have a major impact on the electronic certificate management process. These assets include OSD PSE Private Key Compromise, Sistem Pengamanan Komunikasi Dokumen or Spamkodak Auditor Application, Open Source PKI Certificate Authority or EJBCA Application, and Hardware Security Module (HSM). To address these vulnerabilities, information security risk management is necessary in the electronic certificate management process.

This paper analyzes and identifies the vulnerability of BSrE's electronic certificates by using the Control Objectives for Information and Related Technology (COBIT) 5.0 framework.

Our research contributes to the literature by determining the domain processes, which was determined by performing a vulnerability analysis and identifying potential threats to the servicing assets of OSD PSE using COBIT 5. In a previous study, researchers found that several elements of OSD PSE services do not conform to certificate standards, thereby causing vulnerability[1] and expansion of the impact and consequences of OSD PSE implementation[2]. COBIT 5 can be applied to risk management frameworks for cloud computing[3] as an effective method for evaluating information security services and IT governance performance, given numerous technological changes and stakeholder needs[4][5][6][7]. COBIT 5 standard has five

domains and 37 processes that synergize goals and policy organization[7].

Our paper is arranged as follows. Section I discusses the problem statement and our contribution to the research field. In Section II, the literature review, we describe COBIT 5, including its problem identification methods, its goals cascade concept, and its processes. Section III presents our research scenario. In Section IV, we describe the steps taken to obtain the results. Finally, Section V presents our conclusions.

II. Literature Overview

A. COBIT 5

The COBIT 5 framework contains an end-to-end business explanation of corporate information technology governance and explains the key roles of information and technology in achieving corporate objectives [7].

COBIT 5 offers the advantage of integrating existing standards, including those of the International Organization for Standardization (ISO) and COSO, and frameworks, including the Capability Maturity Model Integration (CMMI), the Open Group Architectural Framework (TOGAF), and IT service management. Fig. 1 illustrates the basic principles of COBIT, which are used by companies as a guide for implementing IT and information security services[9].

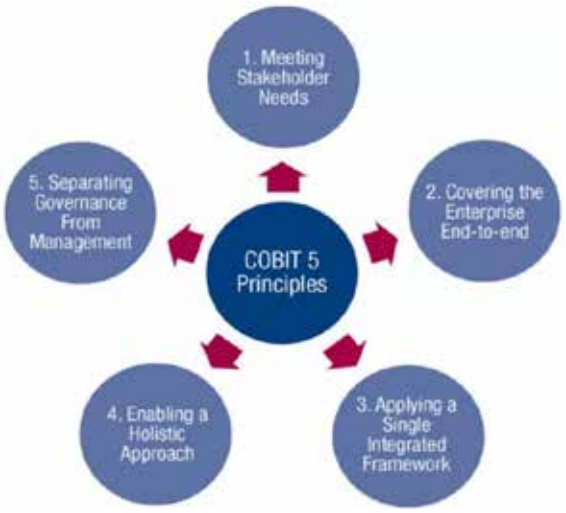

Fig. 1. COBIT 5 principles [9]

Basic Prinsiples of COBIT 5 as shown in Fig. 1 are described as follows:

- Accommodates all processes and enablers to realize the goals and targets of the company's business achievements through IT implementation (i.e., meets stakeholder needs).
- Integrates corporate IT management into corporate governance by considering all entities in the company as complementary parts (i.e., covers the enterprise end-to-end).
- Functions in harmony with relevant standards and high-level frameworks related to IT governance and management.
- Supports the implementation policy organization and IT goals by taking a comprehensive approach and considering the components that interact with each other (i.e., enables a holistic approach).
- Features two main components: governance and management. Governance ensures the needs, conditions, and choices of stakeholders, whereas management includes activities to plan, build, run, and evaluate all governance activities (i.e., separates governance from management).

B. Problem Identification

The goal of the problem identification stage is to obtain information from the object of observation. Researchers should recognize and understand the problems that exist within the research object [8]. There are several methods for identifying a problem related to information security risk, namely, COBIT 5, ISO 31000, ISO 27005, and OCTAVE. In the present research, risk management is required based on the needs of electronic certificate management in OSD PSE services.

In COBIT 5, method used for problem identification is top-down approach, starting with defining the overall organizational goals and then executing the most appropriate and most relevant risk scenario analysis. In other words, all issues are compiled to identify IT-related risks. Later, evaluating the data, considering the existing risk management measures, company policies, and the individuals responsible for the risk or incident report.

C. Goals Cascade

COBIT 5's goals cascade concept, which applies the principles of top-down approach, is a mechanism or technique used to translate stakeholder needs into a strategic organizational plan which is specific to the organizational IT objectives. This is generally done by targeting specific goals at every level, as shown in Fig. 2.

Fig. 2. COBIT 5 goals cascade[10]

Goals cascade enables companies to more easily align organizational needs and solutions to problems in IT services[3].

In Fig. 2, the topmost component is stakeholder drivers, which includes factors that influence changes in the company's strategy, core business, and corporate environmental policy. This category also includes new technologies that are adopted.

- The identification of stakeholder needs is based on three governance objectives: benefits realization, risk optimization, and resource optimization. These needs can be identified by conducting interviews with relevant parties and by reviewing applicable standards and documents. There are 17 generic enterprise goals related to governance objective, as shown in Table I.

TABLE I. COBIT 5 ENTERPRISE GOALS

BSC Dimension	No	Enterprise Goal	Relation to Governance Objectives		
			Benefits	*Risk*	*Resource*
Financial	1	Stakeholder value of business investments	P		S
	2	Portfolio of competitive products and services	P	P	S
	3	Managed business risk (safeguarding of assets)		P	S
	4	Compliance with external laws and regulations		P	
	5	Financial transparency	P	S	S
Customer	6	Customer-oriented service culture	P		S
	7	Business service continuity and availability		P	
	8	Agile responses to a changing business environment	P		S
	9	Information-based strategic decision making	P	P	P
	10	Optimisation of service delivery costs	P		P
Internal	11	Optimisation of business process functionality	P		P
	12	Optimisation of business process costs	P		P
	13	Managed business change programmes	P	P	S
	14	Operational and staff productivity	P		P
	15	Compliance with internal policies		P	
Learning and Growth	16	Skilled and motivated people	S	P	P
	17	Product and business innovation culture	P		

In terms of governance objectives, "P" indicates a primary relationship and "S" indicates a secondary relationship.

- The achievement of enterprise goals can be measured by referring to Information and Related Technology Goal and IT BSC Dimension. There are 17 IT-related goals, as shown in Table II.

TABLE II. INFORMATION AND RELATED TECHNOLOGI GOALS

BSC Dimension	No	Information and Related Technology Goal
Financial	1	Alignment of IT and business strategy
	2	IT compliance and support for business compliance with external laws and regulations
	3	Commitment of executive management for making IT-related decisions
	4	Managed IT-related business risk
	5	Realised benefits from IT-enabled investments and services portfolio
Customer	6	Transparency of IT costs, benefits and risk
	7	Delivery of IT services in line with business requirements
	8	Adequate use of applications, information and technology solutions
	9	IT agility
	10	Security of information, processing infrastructure and applications
Internal	11	Optimisation of IT assets, resources and capabilities
	12	Enablement and support of business processes by integrating applications and technology into business processes
	13	Delivery of programmes delivering benefits, on time, on budget, and meeting requirements and quality standards
	14	Availability of reliable and useful information for decision making
	15	IT compliance with internal policies
Learning and Growth	16	Competent and motivated business and IT personnel
	17	Knowledge, expertise and initiatives for business innovation

- Applications and enablers are needed to achieve IT-related goals. An enabler is defined as something that can help in achieving organizational goals.

There are seven categories of enablers, as shown in Fig. 3. Those are:

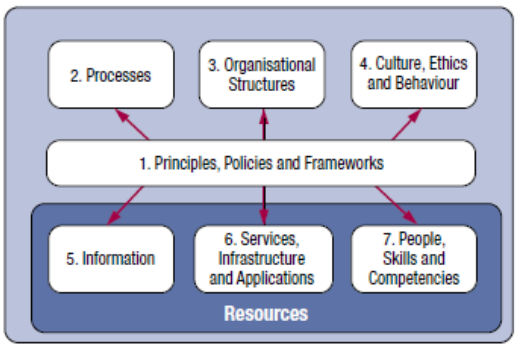

Fig. 3. COBIT 5 enterprise enablers[10]

- A guide that contains the working principles that must be applied (i.e., Principles,policies and frameworks).

- Organized activities to support the stated goals (i.e., Processes).
- Position level and person in charge of the company.
- Personnel habits and behavior in supporting company goals.
- Information is a critical asset in the company so that its security needs to be guaranteed.
- Infrastructure conditions and number of applications will be comparable to the service process provided.
- All activities in the company are supported by people who have the appropriate abilities and competencies.

D. *Processes*

Processes, one of the seven COBIT 5 enterprise enablers, refers to a set of organized activities intended to achieve a goal and to produce an output that supports the achievement of targets.

The guiding principles in this enabler area are divided into two groups, namely, governance processes and management processes, as shown in Fig. 4.

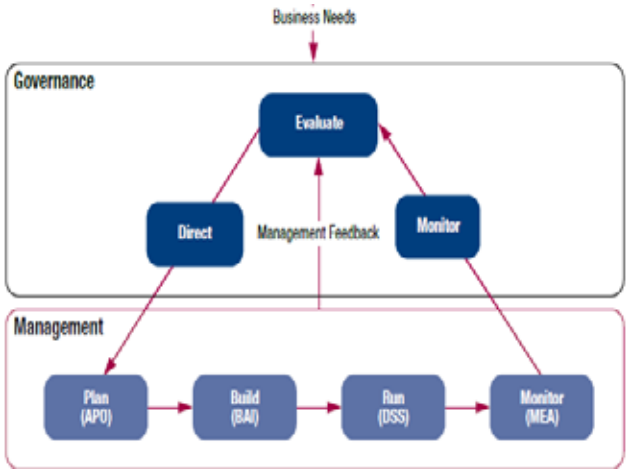

Fig. 4. Governance and management key areas[8]

- Governance processes represent stakeholder needs, such as evaluating targets, providing a direction for IT purchasing, and monitoring the achievement of targets.
- Management processes include planning, building, running and monitoring activities. Management must provide feedback on the governance of the target sets.

III. Research Scenario

Using the COBIT 5 framework, we relied on the following methods to obtain the data for evaluation, as shown in Fig. 5:

- Face-to-face interviews with resource personnel, observation, and the distribution of questionnaires to center administration electronic procurement (PPE) to collect data and information and to identify problems in OSD PSE services. The data is then processed to determine the level of threat and vulnerability.
- Identification of organizational objectives related to IT, represented by IT-related goals.
- Determination of the domain processes, especially for internal organizational factors. At the time of incident handling, the main factor that needs to be evaluated is the company's internal factors.
- Combining points b and c, the identification of which processes have a primary relationship (P) and which have a secondary relationship (S).
- Determination of the domain process based on stakeholders' needs and policies.

Fig. 5. Flowchart for determining domain process

IV. Study And Result

This case study focuses on BSrE, which provides OSD PSE services. To carry out the evaluation using COBIT 5, it was necessary to identify the problems in advance.

a. The first step was to conduct interviews with OSD PSE personnel. Then, we collected references to basic criteria related to risk management, scope, limits, and information security risk management organizations in relation to OSD PSE services.

Subsequently, to ensure the completeness of the document, we collected data related to manpower, core business activities, regulations, criticizing a set, problems, issue certificates, and major vulnerabilities.

TABLE III. Vulnerabilities

Vulnerabilities	Code	Value	Level Security
OSD PSE Private Key	A13T17 V18	8	High
SPAMKODOK Auditor Application	A32T44 V46	6	High
EJBCA Application	A27T36 V38	6	High
Hardware Security Module (HSM)	A22T27 V30	6	High

There were four vulnerabilities with high levels of existing problems: OSD PSE Private Key, Spamkodak Auditor Application, EJBCA Application, and HSM. Based on interviews with resource personnel, these four vulnerabilities require special treatment and should obtain high-level security. Table III displays the risk assessment of these vulnerabilities on a scale, where 0–2 indicates low risk, 3–5 indicates medium risk, and 6–8 indicates high risk, based on ISO 27005: 2011 standards [11].

TABLE IV. PRIORITY OF ENTERPRISE GOALS

Enterprise Goal	A13T17V18	A32T44V46	A27T36V38	A22T27V30	Recom en-dation
Stakeholder value of business investments	No	No	No	No	
Portfolio of competitive products and services	Yes	No	No	No	
Managed business risk (safeguarding of assets)	**Yes**	**Yes**	**Yes**	**Yes**	Priority 1
Compliance with external laws and regulations	Yes	Yes	No	No	
Financial transparency	No	No	No	No	
Customer-oriented service culture	Yes	No	No	No	
Business service continuity and availability	Yes	Yes	Yes	Yes	Priority 2
Agile responses to a changing business environment	No	Yes	No	No	
Information-based strategic decision making	Yes	No	No	No	
Optimisation of service delivery costs	Yes	No	No	Yes	
Optimisation of business process functionality	Yes	No	No	No	
Optimisation of business process costs	No	No	No	No	
Managed business change programmes	Yes	No	No	No	
Operational and staff productivity	Yes	Yes	Yes	No	
Compliance with internal policies	Yes	No	No	No	
Skilled and motivated people	No	Yes	Yes	No	
Product and business innovation culture	Yes	Yes	Yes	Yes	Priority 3

Next, we applied a framework related to Rencana Strategis Pemerintah (Strategic Planning) that focuses specifically on risk optimization to determine the enterprise goal. Then, we generated three high-priority enterprise goals, as shown in Table IV:

- First priority: to manage business risk (i.e., safeguard assets);
- Second priority: to ensure the continuity and availability of business services; and
- Third priority: to maintain a product and business innovation culture.

Based on the results of interviews with relevant parties, we concluded that managing business risk (i.e., safeguarding assets) has the highest priority for further analysis.

b. The following step was to collect information on the IT goals related to managing business risk and safeguarding assets. Table V presents the identified relationships. There are 11 secondary relationships, or less important goals (01, 02, 03, 06, 07, 08, 09, 12, 13, 14, 15), and three primary or important goals (04, 10, 16). The most important goal is goal 10. We then further defined the IT goals chosen.

TABLE V. ENTERPRISE-RELATED IT GOALS

IT Related Goals	Enterprise Goal 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	P	P	S			P	S	P	P	S	P	S	P			S	S
2			S	P											P		
3	P	S	S					S	S		S		P			S	S
4			P	S			P	S		P			S		S	S	
5	P	P				S		S		S	S	P		S			S
6	S		S		P				S	P		P					
7	P	P	S	S		P	S	P	S		P	S	S			S	S
8	S	S	S			S	S		S	S	P	S		P		S	S
9	S	P	S			S		P			P		S	S		S	P
10			P	P			P								P		
11	P	S						S		P	S	P	S	S			S
12	S	P	S			S				S	P	S	S	S			S
13	P	S	S			S				S		S	P				
14	S	S	S	S			P		P		S						
15			S	S											P		
16	S	S	P			S		S						P		P	S
17	S	P				S		P	S		S		S			S	P

c. We set the domain group on IT goals (Table. V) whose having a primary (P) scale and fit to stakeholder needs and strategic goals. We concluded that the highest priority to be implemented in the management of the OSD PSE digital certificate is internal IT Related Goals: 10. The security of information, processing infrastructure, and applications.

d. In the last step, we linked the standard processes and IT goals to obtain the domain processes. These processes contain the actions and reactions for handling an OSD PSE asset risk. We ultimately determined four domain processes for P-scale treatment (i.e., EDM03, APO12, APO13, and BAI06). We identified an additional 10 domain process for S-scale treatment (i.e., EDM01, APO01, APO03, APO07, APO09, APO10, BAI02, BAI08, BAI09, and BAI10), which is displayed in Table VI, and the defined domain processes are presented in Table VII.

As shown in Table VI and Table VII, we identified 14 processes that are suitable for supporting IT goals (10). This study focused on determining domain processes on the P scale. This means that the most significant processes for identifying vulnerabilities and potential threats to critical OSD PSE assets are EDM03, APO12, APO13, and BAI06. The results are summarized in Table VIII.

TABLE VI. IT GOALS AND DOMAIN PROCESSES

	IT-Related Goals																
COBIT -5 Process	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*
EDM01	P	S	P	S	S	S	P		S	S	S	S	S	S	S	S	S
EDM02	P		S		P	P	P	S			S	S	S	S		S	P
EDM03	S	S	S	P		P	S	S		P			S	S	P	S	S
EDM04	S		S	S	S	S	S	S	P		P		S			P	S
EDM05	S	S	P			P	P						S	S	S		S
APO01	P	P	S	S			S		P	S	P	S	S	S	P	P	P
APO02	P		S	S	S		P	S	S		S	S	S	S	S	S	P
APO03	P		S	S	S	S	S	S	P	S	P	S		S			S
APO04	S			S	P			P	P		P	S		S			P
APO05			S	S	P	S	S	S	S		S		P				S
APO06	S		S	S	P	P	S	S			S		S				
APO07	P	S	S	S			S		S	S	P		P		S	P	P
APO08	P		S	S	S	S	P	S			S	P	S		S	S	P
APO09	S			S	S	S	P	S	S	S	S		S	P	S		
APO10		S		P	S	S	P	S	P	S	S		S	S	S		S
APO11	S	S		S	P		P	S	S		S		P	S	S	S	S
APO12		P		P		P	S	S	S	P			P	S	S	S	S
APO13		P		P		P	S	S		P				P			
BAI01	P		S	P	P	S	S	S			S		P			S	S
BAI02		S	S	S	S		P	S	S	S	S	P	S	S			S
BAI03	S			S	S		P	S	S		S	S	S	S			S
BAI04				S	S		P	S	S		P		S	P			S
BAI05	S		S	S	S		S	P	S		S	S	P				P
BAI06			S	S	S		S	S	S	P	S	S	S	S	S		S
BAI07				S	S		S	P	S			P	S	S	S		S
BAI08	S			S	S		S	S	P	S	S			S		S	P
BAI09		S		S		P	S		S	S	P			S	S		
BAI10		P		S		S		S	S	S	P			P	S		
DSS01		S		P	S		P	S	S	S	P			S	S	S	S
DSS02				P			P	S		S				S	S		S
DSS03		S		P	S		P	S	S		P			P	S		S
DSS04	S	S		P	S		P	S	S	S	S	S		P	S	S	S
DSS05	S	P		P			P	S			S	S		S	S		
DSS06		S		P			P	S		S	S	S		S	S	S	S
MEA01	S	S	S	P	S	S	P	S	S	S	P		S	S	P	S	S
MEA02		P		P		S	S	S		S				S	P		S
MEA03		P		P	S		S			S					S		S

TABLE VII. DEFINED DOMAIN PROCESSES

Domain	No	Process	Scale
Evaluate, Direct and Monitor	EDM01	Ensure Governance Framework Setting and Maintenance	S
	EDM03	Ensure Risk Optimisation	P
Align, Plan and Organise	APO01	Manage the IT Management Framework	S
	APO 03	Manage Enterprise Architecture	S
	APO 07	Manage Human Resources	S
	APO 09	Manage Service Agreements	S
	APO 10	Manage Suppliers	S
	APO 12	Manage Risk	P
	APO 13	Manage Security	P
Build, Acquire and Implement	BAI02	Manage Requirements Definition	S
	BAI06	Manage Changes	P
	BAI08	Manage Knowledge	S
	BAI09	Manage Assets	S
	BAI10	Manage Configuration	S

TABLE VIII. RESULTS SUMMARY

Enterprise Goals	IT-Related Goals	Domain Process
3	10	EDM03, APO12, APO13, BAI06

V. CONCLUSION

In our research, we identified critical OSD PSE assets and mapped these assets using the COBIT 5 framework to determine the domain processes. Our work differs from previous studies on OSD PSE. Whereas previous studies identified all assets using ISO 27001, we performed a vulnerability analysis and identified potential threats using COBIT 5 standards. Our work identifies domain process that must be studied more deeply: EDM03, APO12, APO13, and BAI06. However, this study recommends evaluating more than these four processes.

Processes on the S scale, which include non-priority processes that do not significantly impact asset management or the issues discussed in this research, might still be a cause for concern when determining future company policies.

Future research can further develop these results by using correlation methods COBIT 5 risk scenario and NIST to design a risk scenario document. There are four categories for evaluation: operational staff, information, infrastructure, and software applications. This final document will contribute to mitigating risk to electronic certificate management at BSrE.

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ICT Development Strategies for Farmer Communities in Rural Papua

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***Abstract*---There are at least three factors causing the digital divide in rural areas, i.e., technological factors, level of community ICT literacy, and the government's commitment to developing rural areas. This paper proposes a strategy of developing rural areas based on ICT development by making classification of ICT adoption. We use the Concurrent Mixed method by survey and interview to explore the conditions of farmer communities in Papua Province, Indonesia, based on (a) ICT infrastructures availability, (b) ICT Literacy, and (c) ICT Ecosystems in farmer communities in Papua. We consider two villages in Papua, i.e., Ekemenida and Idekotu to represent all villages in Dogiyai Regency, Papua Province, Indonesia. We found that the ICT infrastructure in those two villages of Dogiyai Regency of Papua Province is poor. On the other hand, we also found the fact of ICT illiteracy. Furthermore, we also observed that ICT ecosystem does not exist. We found several reasons causing this condition and provide strategies to solve the problems, which are expected to improve the level of ICT for farmer communities in Rural Papua.**

Keywords—ICT Empowerment, ICT Infrastructure, ICT Literacy, ICT Ecosystem, ICT Rural Areas.

I. INTRODUCTION

The utilization of Information and Communication Technology (ICT) has become an indicator of development in a society because ICT is believed to improve the welfare of a society, facilitate the completion of work, cut distance and time, and improve the quality of human life. ICT indirectly requires people to use it in all activities.

The insight of usage of ICT in Indonesia from "Communication and Information Technology Usage Survey and Its Implications on Social and Cultural Aspects of Communities" conducted by the Ministry of Information and Communication Technology in 2017 revealed that the use of individual ICT devices has increased over the years. It is noted that the use of ICT such as mobile phones reached 66.31% and the number of individuals accessing the internet has increased rapidly from the previous year by 45% [1]. The proportion of internet use in 2015 reached 35.1%. This figure is much higher than the two previous years which only reached 19.6% and 22.2% [2].

However, the results of this survey also show that the penetration of ICT use has significant differences between rural and urban areas. Respondents in rural areas recorded very little use of ICT, such as the use of computers, smartphones, and the internet. But the use of mobile phone with 2G technology has a high number compared to urban areas that reach 55.55% [3].

This fact shows that there is a digital divide in rural areas. There are at least three factors causing the digital divide that occurred in rural areas [4]: technological factors related to infrastructure readiness and quality of ICT services, community factors such as the skill of ICT users, and lack of participation of the central and local governments as policy makers in infrastructure development and community capacity building [5].

McKinsey [6] finds that the digital divide in rural areas has become one of the sectors that need to be improved to maximize the socio-economy of ICT in Indonesia. However, various diffusion projects of ICT innovation undertaken in Indonesia have frequently failed due to several reasons such as no adoption of the project or lack of technological sustainability. The application of ICT in rural communities has a higher complexity than the application of ICT in urban communities. The utility and convenience offered by ICT is often incompatible with the social and economic needs of the village. For example, the ease of calculation provided by a computer is not necessarily an important requirement for the village community.

Even according to Roger [7] the failure of adoption of ICT that occurs is not caused by the technical aspect of infrastructure alone, but it can also be caused by innovations that are not in accordance with the needs of the community, using communication channels that are not appropriate, not taking the proper implementation time into account, or not understanding the prevailing social system.

Papua is the easternmost province in Indonesia. It is the largest province but has a small population. The enactment of the Special Autonomy Law has made Papua one of the richest provinces in Indonesia in terms of regional income. But on the other hand, many Papuans still live below the poverty line. Data from Central Bureau of Statistics year 2017 show that Papua has the highest number of poor people among 34 provinces in Indonesia (27.76%) [8].

There are several factors causing poverty both structurally and culturally. Cultural poverty refers to people's attitudes caused by lifestyles, living habits, and cultures. Structural poverty is caused by unbalanced development and unevenly

distributed results. This is due to unequal ownership of resources, unequal societal capacity, inequalities of opportunity, and income generation resulting in unequal participation [9]. This is the case in Papua, where Papua is underdeveloped and suffers regional inequality. Lack of infrastructure and lack of knowledge and skills of human resources has caused the people of Papua who live in townships to be increasingly isolated. Inadequate facilities and infrastructure make village access to the city infrequent.

Dogiyai is a district in Papua. This district was formerly part of Nabire District. In 2008, due to the expansion of territory, Dogiyai separated away into a new district. The majority of people in Dogiyai live as farmers. The majority of their plantations are vegetables, sweet potatoes, and others that are consumed by themselves or sold in traditional markets for the needs of urban communities. One of the problems faced by several villages in Dogiyai is that the village funds have not been delivered yet. Thus some villages have not implemented village programs that can drive the economy and improve the welfare of the community.

Based on the previous study by the Ministry of Communication and Information Technology [3], villages in rural areas generally have three major obstacles in utilizing ICT: infrastructure, literacy, and ICT ecosystem. Although the villages in Dogiyai are categorized as village level one, farmer communities in this region still have the opportunity to be empowered in the utilization of ICT. Thus the utilization of ICT is expected to prosper the farmer communities in this rural area.

From the previous study in rural India, ICT can also help small farmers and artisans by connecting them to markets [10] as well as rural telecommunication access [11]. ICT grassroots intermediaries and involvement of the community are identified as the key factors that foster local ownership and the availability of content and services that respond to the most pressing needs of the poor [12]. For the farmers in rural China, the implication of community telecenters extend not only to economic aspects (such as better earnings or production), but also to human (such as e-literacy and new farming techniques) and social (such as creation of venues for community integration and knowledge sharing) dimensions [13]. The demographic factors, social influence, and facilitating conditions affect the acceptance and utilization of technology in rural areas [14].

Based on the above background, this study is aimed to formulate solutions (define minimum requirement) for the ICT Infrastructure building, ecosystem building, and ICT literacy building for the farmer communities in rural Dogiyai region, Papua, Indonesia.

II. FRAMEWORK OF ICT ADOPTION IN RURAL AREA

Based on a study by the Center of Informatics Application and Public Information and Communication Research and Development under the Ministry of Communication and Information Technology in 2017 [3], this study has developed the leveling framework to analyze the level of Dogiyai village.

The framework is obtained from the survey of 101 rural villages from 17 provinces in Indonesia. Each village should be levelled so that the treatment to accelerate ICT implementation will be specified according to each level.

The assessment to define the level of the villages is based on 4 variables: technology availability, technology literacy, technology affordability, and ecosystem support. There are 4 levels according to this study:

- Level 1 villages are early ICT adopters. The current variable of ICT infrastructure access is still very low, the literacy rate is very low, and the baseline index is very low. The treatment for level 1 villages is the introduction of ICT to the public (public education).
- Level 2 villages are 2G villages. The variables of access to infrastructure are close to the average (0.564), the level of literacy is still low, the purchasing power is still low, and the supporting ecosystem is still low compared to the baseline index. The treatment for level 2 villages is more on the optimization of 2G services (services for voice and text communication).
- Level 3 villages are internet beginner villages. The variables of access to infrastructure are above average (0.668), the literacy rate is close to the average (0.517), the purchasing power level is still low, and the supporting ecosystem is still low compared to the baseline index. The treatment for level 3 villages is the introduction of basic features of the internet, i.e. the need for information and communication search.
- Level 4 villages are ecommerce villages. There are 3 variables in this level that are above average: infrastructure, literacy, and purchasing power. The supporting ecosystem is close to the average (0.546). The treatment for level 4 villages is introducting the internet for economic productivity such as for online sale and purchase transactions.

In the case of bringing technology (ICT) to the village, a formal and cultural approach should be taken to each village level. Higher levels will increase the community participation towards ICT adoption and also empower the village community through ICT. The use of ICT in rural village communities depends on the leadership and the awareness of the leader of the importance of ICT for rural development.

TABLE I. AVERAGE SCORE OF ICT ADOPTION VARIABLES [3]

Level	Tech Availability	Tech Literacy	Tech Affordability	Ecosystem Support
1	0.522	0.283	0.310	0.303
2	0.564	0.431	0.437	0.404
3	0.668	0.517	0.503	0.479
4	0.732	0.613	0.651	0.546

Related to this framework, from McKinsey in 2015, ten ideas were proposed to maximize the socioeconomic impact of ICT in Indonesia [14]. Those ideas are:

- Developing a national ICT agenda and road map linked to Indonesia's economic and social-development priorities
- Working with the ICT industry to resolve major infrastructure bottlenecks and improve reach, cost, and bandwidth
- Addressing the ICT digital divide between urban and rural areas with more tailored policies and alternative supply models
- Ensuring that the regulatory environment can address effectively and constantly change ICT sector using ICT to foster accelerated, equitable economic growth
- Developing upstream and downstream ICT industries
- Increasing supply of skilled ICT workforce
- Encouraging ICT adoption by small and medium-size businesses
- Using ICT to support priority sectors Using ICT to enable sustainable social development
- Using ICT to improve citizen services
- Improving the quality and efficiency of public services

Based on those frameworks, this study will categorize the issue of ICT implementation in rural areas into 3 areas as explained below:

- ICT Infrastructure, such as the telecommunication infrastructure, the usage of ICT device, and the facilities provided by the government
- ICT Literacy, such as the issue of the knowledge, skill, and attitude of ICT implementation
- Ecosystem Support, such as the role of the local government and the components of the economic ecosystem such as banks, markets, post offices, and stores that provide ICT equipment.

The current condition of Dogiyai will be assessed according to those 3 areas to obtain the level of the villages in Dogiyai so that the treatment will be based on the level of the village.

According to Village Law No.6 year 2014, villages should be the foundation to build Indonesia [15]. The law gives a clear direction for the government to be present in the framework of facilitation, affirmation, integration, and acceleration towards the creation of an independent village. The policy is no longer in controlling capacity and dictating, but to trigger the original creativity of the village in an emancipatory way as well as filling the development needs that have not been able to be fulfilled alone by the village.

The efforts to strengthen village autonomy through community empowerment has been initiated through the Index of Developing Village [16]. The empowerment of the village community will be the main focus of the process of increasing the quality of participation, increasing knowledge, and improving skills, generally referred to as capacity building and capability of the villagers themselves.

The typology of Dogiyai as an agricultural village should be seen as the economic potential that should be optimized through ICT empowerment. However, the treatment will depend on the level of the village based on ICT adoption in rural area framewok.

III. RESEARCH METHODOLOGY

This study uses the concurrent mixed method approach. The data collection uses both quantitative and qualitative approaches, but the analysis and interpretation combine the two forms of data to seek convergence among the results. The structure this type of mixed method study does not clearly make a distinction between the quantitative and qualitative phases [17]. A questionnaire is used to obtain the quantitative result of four variables to define the village level. Empirical evidences from in-depth interviews are conducted with informants related to the issues. The informants consist of heads of villages, local government officials, and chairmen of farmer communities.

The object of this study is two villages (Ekemenida and Idekotu) with consideration that almost all villages in Dogiyai are homogeneous. The two villages are considered to represent the villages in Dogiyai. The data is collected from the empirical evidences, mass media, web articles, scientific books and journals, and other literatures.

The techniques of processing and data analysis in this study is done by coding the overall results of questionaires and data collected both through interviews, observation data, and other literature, and then categorized based on research problems to be answered. The data are then described descriptively according to the needs of the study.

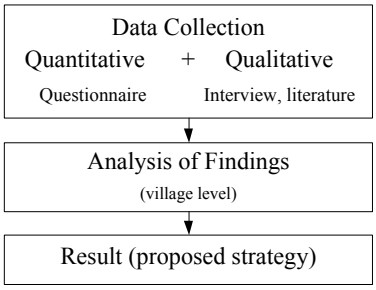

Fig. 1. Research Construct

IV. RESULTS AND DISCUSSION

A. Finding on ICT Infrastructure Current Condition

The development of rural areas in Indonesia is undergoing major changes. The development of villages is not only in agriculture, plantation and livestock sectors, but also in infrastructure development using ICT and is now a priority. These efforts aim at reducing the community's dependence on the government so that villages can be more independent, competitive, and creative. This is also reinforced in Law no. 6 Year 2013 on Villages which explains that an information

system of village development and area development will become a priority in rural development.

There are some things that are indispensable in Clause no.86 of the village law [15]: 1) access to information provided by the city local government; 2) government and local government development of village information system and rural development; 3) information systems, facilities, networks, and human resources; 4) village information systems including village data, village development data, rural areas, and other information related to rural development and rural areas development; 5) village information systems managed by the government and accessible to villagers and all stakeholders; and 6) information and planning on the development of the district/city for the Village provided by the district/municipal government.

Based on the results of the research, the two villages in Dogiyai are still far from implementing Clause 86 of the Village Law [15]. In the Ekemenida where the majority of the community is farmers who rely on gardening and livestock, the use of ICT devices by the community is very limited because there is no telephone network and no internet connection. The use of public ICT devices is limited to 2G mobile phones for calling and texting. Information about the farms are obtained manually when meeting with other farmers or in regular community meetings.

Similar to Ekemenida, most villagers in Idekotu also work as farmers who rely on gardening. The use of ICT devices in Idekotu village is also very limited due to the lack of telephone network and no internet connection. There are only few people who have used mobile phones with 2G technology to make phone calls and send text messages.

ICT infrastructure in both the Ekemenida and Idekotu is very limited. In both villages, no BTS is installed, and there is no public internet access (even paid public internet access) or any internet facilities from the government. The services of selling and buying telecommunication equipment and its components such as sales of phone credit and other ICT devices are not available within the villages. The nearest phone credit is around three kilometers from the villages. And the electricity supply is still limited only from generators from 4 pm to 6 am.

B. Finding on ICT Literacy Current Condition

The concept of literacy, among others, is technological literacy or the ability to utilize new media such as internet to access and communicate information effectively [18]. While according to Young [18], ICT literacy is a combination of intellectual ability, fundamental concepts, and contemporary skills that a person must have to be able to use ICT effectively. These definitions illustrate that a person already has ICT literacy if they are able to use ICT devices, either internet connected or not, to communicate or obtain information.

The results of this study indicate that people in Ekemenida and Idekotu in general still have relatively minimal ICT literacy. This is due to the unavailability of adequate ICT infrastructure in the village so people are not accustomed to using ICT devices. Actually, they are not against technology and are aware of the usefulness of ICT devices to improve welfare. However, the enthusiasm to learn the use of ICT devices is hampered because they do not have ICT devices, so their ability is limited to using 2G mobile only. The increase of ICT literacy both formally and informally has not yet touched this region.

> *"People in the Ekemenida have a major job as farmers. Generally, they use ICT limited to mobile phones, especially 2G mobile phones due to network limitations to call and no internet network. Besides, there are only a few people who have skills, and they feel that it is not important to use ICT. There are only a few people who already use mobile phones but are limited to calling and texting."(Interview with the village chief of Ekemenida, Rupinus).*

Similar to the conditions of Ekemenida, according to the village head of Idekotu, Klas Yobiee, Idekotu community also only have 2G mobile phones used for texting and calling only. In the farming process, the villagers also do the whole process of agriculture manually from seeding, planting, and harvesting to marketing without using ICT tools to support their work such as using the internet for marketing agricultural products.

The lack of ICT utilization among the people in Dogiyai illustrates the low level of their literacy. A chairman of the Ekowai Farmer Group, Ekemenida, Selvina Tigi, explains that almost all farmers do not have adequate skills in the utilization of ICT. Training provided to farmers in the village only cover cooking, baking cakes, hand skills (weaving), and planting. Training on the utilization of ICT equipment to support agriculture has never been given by the government.

In Idekotu, according to farmer Pius Yobe, farmers in his village are joined in farmer groups where planting and harvesting are done together. The goal is to empower the village community to meet the needs of the village community itself. Conducting this farmer group activity is done conventionally by face-to-face meetings, joint farming, and sellling crops together in traditional markets. The price of the crop is adjusted to the prevailing market price. This condition causes ineffective dissemination of information because the information could not directly reach the all the farmers.

> *"Information for the development of farmer group activities is obtained manually by word of mouth then done together if it is to support the activities of farmers. This includes the information of selling prices of agricultural product, obtained from farmers or sellers in traditional markets. We have never obtained any information regarding it via the internet or other ICT devices ". (Interview, farmer, Marcelebes Yobe).*

These results are consistent as described by previous studies [18] [19] that the digital divide can also be caused by the rural community's condition that relies more on geographical proximity and kinship closeness, thus emphasizing more on oral communication skills than technology. Therefore, the existence of this ICT facility becomes an unusual thing for rural

people. One of the problems of digital divide is also related to the lack of skill from human resources [20] [21].

C. Finding on ICT Ecosystem Current Condition

Fransman [22] explains that the ICT ecosystem is a key symbiotic relationship that exists between the four groups of players in the system. The four groups consist of operator networks, backbone networks, contents, and elements of provider applications. For the final consumer, the provider provides a platform used to deliver content and applications.

As for new ways and new governance modes where some are based on potential things, the ICT ecosystem includes policies, strategies, processes, information, technologies, applications, and stakeholders that together form the technological environment for a country, government, or company [22].

The results described in Table 2 reveal that the number of village officials in the two villages only consists of 13 people each. Among the existing village officials, only 3 of them use 2G mobile phones, namely the village head and the village secretary. ICT devices in both village offices such as computers and laptops are completely unavailable let alone the internet network. Thus, none of the village officials use them.

ICT-based village information systems also do not exist. All village programs are done manually and handwritten. There is no digital archive and everything is stored in the house of the village secretary. Village office activity is almost nonexistent. There are no ICT facilities for the general public in both villages such as wifi in public areas and internet cafes.

TABLE II. ICT ECOSYSTEM OF DOGIYAI

Current Condition	Ekemenida; **Idekotu**
Number of village officials	13 ; 10
Number of village officials using cellular phone	2 ; 3
Number of village officials using computer/laptop	none
Number of village officials using internet	none
Number of computer/laptop in village office	none
Number of public internet access in village	none
Village Information System	none
Archive /documentation (nondigital/using paper)	
This filing is paper and kept in the house of the village secretary and not in the village office	
ICT Public Facility for Rural Communities	none

If there is a link between the Fransman's concept and the Dogiyai ICT ecosystem, there is no policy of stakeholders for the use of ICT in supporting the work process for both the village apparatus and the farming community.

Ekemenida has a population of 1042 people with 524 families. Economic potential is from the sale of plantation, timber, stone and sand products. The problems of the village include infrastructure development, community lending and borrowing, community welfare, and empowerment of farming communities. The allocation of the village revenue and expenditure budget should be devoted to addressing the village problem above.

> *"The budget for Village Information System, Village ICT/ Internet Services, ICT equipment expenditure for personnel is not allocated because we do not need them and they are also expensive. The main thing is the infrastructure and the welfare of society only. Even until now the village funds for 2017 have not been granted, so we can not run the village programs. ". (Interview, To Village Ekemenida, Rupinus).*

Idekotu has a population of 5400 people with 2015 families. They also do not have special budget allocation for ICT. The community now only needs a program for welfare and empowerment, especially for the village farming community. The trainings conducgted so far are all about the development of agriculture in the field. There has never been a training in the field of ICT.

ICT ecosystems are an important factor in overall ICT development in rural areas. So that ICT can be a powerful driver of economic growth, appropriate and targeted ICT policy support is required. Unfortunately, the results of this study illustrate that the factors of ICT policy have not been built at all in the Ekemenida and Idekotu.

The summary of the current condition of Dogiyai district based on ICT Adoption Framework with the variables of technology availability, technology affordability, technology literacy, and ecosystem support categorized into Level 1 is illustrated in Table 3.

TABLE III. DOGIYAI CURRENT CONDITION

	Tech Availability	**Tech Literacy**	**Tech Affordability**	**Ecosystem Support**
Ekemenida	0.550	0.160	0.216	0.221
Idekotu	0.450	0.226	0.319	0.288
Average	0.50	0.24	0.27	0.25

D. Proposed Solution

Based on the empirical evidences explained above, this study aims to propose minimum requirement for ICT development solution especially for rural Papua Farmer Communities as summarized in Table 4.

These are the critical success factors for the ICT empowerment in rural area of Papua. First is the commitment of all stakeholders (central and local government, and the community). The related governments, Papua Provincial Government, the Ministry of Village, and the Ministry of Communications and Informatics, have infrastructure development programs in villages in Dogiyai. Second is the socialization program to increase public awareness and education (literacy) to accelerate the adoption of ICT in rural communities with infrastructure development. And third is the

development of an ICT ecosystem, one of which is networked by villages, initiated by using the same village network as the others.

TABLE IV. PROPOSED MINIMUM REQUIREMENT FOR ICT DEVELOPMENT OF RURAL PAPUA FARMER COMMUNITIES

	Level 1	Minimum Requirement	Requirement for Upgrading Level
A	**ICT Infrastructure**		
A1	Technology Availability	Adequate supply of Electricity	BTS (cellular signal), VSAT (Very Small Aperture Terminal)
		Radio Broadcasting	Public facility to access ICT devices
		Television Broadcasting	Public facility to access Internet
		Village road infrastructure	Proper access to village
A2	Technology Affordability	Distribute affordable equipment	ICT Services & Equipment Supply
B	**ICT Literacy**		
B1	Technology Literacy	Overcome Awareness Obstacle	Open Minded Mindset
		Literacy Building (How to use ICT Devices, ICT for Information gathering on farming)	Literacy Building (ICT for productivity spesificly for agribusiness)
C	**Ecosystem Support**		
C1	Economical	Village Market Availability	Village Owned Enterprise (BUMD) Empowerment, Village network Development based on the same commodity
C2	Local Government	▪ Top down instruction and enforcement from Central Government, ▪ Activate Village Office, ▪ Clear Action Plan on ICT Development	▪ Commitment on ICT development, ▪ Village community empowerment for ICT development program ▪ Allocate 30% of Village Budget for ICT Development
C3	Policy	Understanding of Clause no.86 of the village law	Law Enforcement, supervision of village funds on ICT Infrastructure & ICT Capacity Building

V. CONCLUSION

We have studied the ICT condition in Rural Papua and proposed strategies to improve the ICT level of villages in Dogiyai Regency, Papua Province, Indonesia. We used Concurrent Mixed method to explore the conditions of villages, of which are mostly farmers. Based on the empirical evidences found in Dogiyai Regency, the main obstacles to develop rural areas are the ICT literacy and the absence of ecosystem.

We found that the rural Papua villages can be categorized into Village Level 1 (the ICT early adopter) with minimum ICT infrastructure, ICT literacy, and almost no ICT ecosystem.

We have proposed a treatment for this level by fulfilling the minimum requirements on three aspects: (a) ICT infrastructure, (b) ICT literacy, and (c) ecosystem support.

To build the ecosystem comprehensively, we observed that the most important factor causing ICT infrastructure availability in rural Papua is the absence of ecosystem, for example, the undelivered village funding. We expect that the building of ICT for rural Papua, involving those three aspects, can improve the economy in Rural Papua, which is mostly farmers, such that they can utilize ICT to improve their productivities.

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ICT Development Strategy for Rural Areas in West Java

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***Abstract*—Information and communication technology (ICT) influences aspects of life, including its development in rural areas that have similar characteristics in the livelihood system of its inhabitants. ICT development for rural areas in West Java is carried out by identifying ICT needs for rural areas as the basis for further ICT development in West Java. This needs analysis can encourage the emergence of appropriate solutions for ICT development. Another step is to carry out ICT development by strengthening the development of ICTs that have been running regarding government and support from the community. In this paper, mapping of internal and external factors are done through strength-weakness-opportunity-threat (SWOT) analysis, then the ICT development strategy for rural areas is formulated as an action to strengthen ICT for rural areas in West Java. With information on ICT needs for rural areas and strategies to enhance the development of rural ICTs, activities are expected to be more targeted and appropriate to the needs of rural communities in West Java. Optimization of rural ICT development in West Java can be done by (1) accelerating infrastructure development by allocating budgets, and by collaborating with ICT providers; (2) strengthening the development of human resources, for village officials and for the community, (3) strengthening synergies and collaborations between agencies that have authority in the field of ICT and internal organizations.**

Keywords*—*ICT, rural, ICT development, West Java, community, strategy

I. INTRODUCTION

The development of ICT, especially the internet, shows the massive impact on the transformation of the communication model and the acquisition of public information. Its use has been adapted in various sectors such as trade, transportation, government and other sectors and has become an important part of people's lives, not only in Indonesia but also throughout the world [1][2].

In Indonesia, the government's target of ICT infrastructure planning is contained in Indonesia's broadband plan. Based on Indonesia's Broadband Plan 2014-2019 [3], for rural areas, broadband access infrastructure is still expected to reach 49% of households (10 Mbps) and 6% of the population, as well as mobile access to 52% of the population (1 Mbps). From the results of the ICT indicator survey in 2016, the percentage of household access to the internet for rural areas was 26.3% and based on the type of connection for rural areas dominated by mobile broadband [4][5].

In its implementation, there are obstacles to getting internet access in households and individuals in rural areas due to a number of things including inadequate infrastructure conditions, device prices and pulse prices/data packages that are not yet affordable for all rural communities, as well as distance accessibility to the city or a place that sells devices and refills them to get internet services [4][6][7]. Meanwhile, internal factors include the level of literacy or skills in using the internet and other ICT devices, the level of internet trust and other ICT devices [8][9].

The use of ICT in rural communities is still consumptive; most of it is used to meet the needs of entertainment and information that are less productive. In addition, the development of ICTs for rural communities and also government programs in the field of ICT for rural communities is still partial, not yet carried out comprehensively so that the benefits have not been widely felt by rural communities [6][8][9][10].

Rural ICT development efforts in Indonesia from the government side are carried out with infrastructure development, encouraging village information systems (sistem informasi desa) according to the mandate of the UU Desa, and e-government implementation [2][3][11]. Rural ICT empowerment, especially in West Java by the community has been running quite a lot, including Gerakan Desa Membangun, Desa Melek IT, Relawan TIK, and other communities, but it has not been optimized properly [6].

Actions to provide ICT infrastructure and service provision need attention to the interaction target between community welfare and spiral regional development, based on village needs. Approaches can be made by strengthening communities in local villages, and other forms of involvement and approval of the government and village communities. So the existing development is needs to be supported by development strategies from the government, the community and from the community. This study provides information on ICT needs in rural communities in

West Java as well as rural ICT development strategies in the West Java region of the government and communities so that rural ICT can be optimized.

II. METHODOLOGY

Primary data collection was carried out through in-depth interviews to gather information from informants using guidelines and interview guidelines as well as focus group discussions (FGD). FGDs are conducted to confirm data (primary and secondary) from the results of field data analysis and formulate ICT development strategies in rural areas. Secondary data collection techniques are carried out through the search of literature sources, documents, which are related to rural ICT development. The informants in this study include the local government, community, and villagers related to rural ICT development.

Based on the data collected, the identification of needs in the development of ICT in rural areas was prepared. Then analyzed using SWOT analysis to produce ICT development strategies in rural areas.

Data collection is divided into three parts, namely: (1) to identify ICT needs in rural areas in West Java by synthesizing the results of interviews and previous studies, (2) gathering information on strengths, weaknesses, opportunities, and obstacles from the perspective of the government through focus groups discussion with local government representatives in West Java from previous studies, (3) gathering information through interviews and prior studies related to the empowerment of ICTs by the community. Information results are mapped into strategies that can be carried out by the government and communities to support the development of ICT for rural areas in West Java.

III. RESULT AND DISCUSSION

A. ICT Needs for Rural Communities in West Java

The characteristic of the rural community is the homogeneity that exists in the livelihood system of the population, even though there are residents who are different in their livelihoods, but in general are usually dominated by one prominent livelihood and a characteristic of the rural community [12]. Statistical data shows that the classification of rural/districts according to income in West Java is dominated by agricultural activities (75.8%), followed by the manufacturing industry and services [13]. Villagers in West Java mostly make their living as farmers, and geographically there are areas that are quite far from the city. Information and communication technology needs to be developed in rural areas such as access to commodity information and all available resources in communities and rural areas.

To carry out the development and development of appropriate ICTs, identification of the needs of the ICT rural community identifies with a framework based on the type of region and characteristics of the village community. Identification of these needs is arranged based on interviews and observations of community representatives that are the presentation of rural communities. The synthesis results for the West Java region [6][10][14], the priority needs of ICT in rural communities are grouped as in the following Table I.

TABLE I. MATRICES IDENTIFICATION OF ICT NEEDS IN RURAL

No	ICT Needs	The Use	ICT Media
1.	ICT for communication	As a means of supporting communication and collaboration	Cellular phones, fixed telephones, messaging applications, social media, voice call applications, video calls
2.	ICT for livelihood support information	• Price information for livelihood support equipment (agriculture, fisheries, etc.) • Market price information for the production of rural communities • Market commodity price information	SMS based, web based, mobile application, social media based
3.	ICT for Promotion	Promotion of agricultural/fisheries products, tourist sites, organizing cultural arts festivals, and handicrafts	Web based, mobile application, social media based
4.	ICT for Access Public Services	Community services such as population administration (KTP), licensing arrangements, etc.	SMS-based, web-based, mobile application
5.	ICT for Business Access	Information regarding the processing of a business license, online business licensing	SMS-based, web-based, mobile-based application
6.	ICT for Access to Funding Sources	Ease of getting funding support	SMS based, web based

Agriculture in West Java is dominated by small-scale farmers with varied products and quality. Based on information from the community, there are limitations faced by farmers, including capital, skills, knowledge, and accessibility of market information and agricultural/fisheries technology, as well as farmers' bargaining position on the market. This information is identified and classified to analyze ICT needs. ICT needs refer to the needs that can support agriculture/fisheries, such as the need for livelihood support information, ICT for improving agricultural output through promotion or publication through websites and social media, online marketing, agricultural information systems, access to information related to agriculture through the internet, socialization and so on.

The results of classification of needs in general, rural communities in West Java need ICT as a means of communication and collaboration, information facilities, to support promotion, to get public services, to access the

business world and to facilitate in obtaining funding sources. By paying attention to the needs of rural communities, it can be information in undertaking rural ICT development efforts.

In the field of agricultural development, access to agrarian innovation is essential for the survival of the business. Adequate and timely agricultural innovation supported by other related agricultural information can be used as a basis for market control strategies and planning basis for further farming development [15], and this requires accessibility to obtain adequate information including through the utilization of appropriate ICT needs. This will affect the decision-making process in determining the commodities to be cultivated and the methods that farmers will implement.

The advancement of ICTs, especially the internet, can bridge the information gap that objects have more information and knowledge with objects that lack information to increase direct community participation and create networks and access to open information and business opportunities [16]. With the identification of ICT needs, it can be information for parties involved in the development of rural ICTs to encourage the development of ICTs in accordance with the needs in rural areas.

B. Rural ICT Development Strategy from The Government

Equitable access to information through ICT for rural areas in Indonesia is institutionally strengthened by the enactment of Law No. 6 of 2014 concerning Villages [11]. Article 86 states that the village has the right to have access to information through the village information system and the local government is obliged to develop and build the system. This foundation is only one foundation for the implementation of ICT development in rural areas, the needs arising from the community due to the development of ICT are also driving the importance of the development of ICT in rural areas. On the other hand, the potential of villages to develop ICT in their regions is still very limited both regarding infrastructure and concerning human resources who understand ICT.

Through in-depth interviews with informants (stakeholders related to the ICT field, village apparatus, and parties related to rural ICT development) identified strengths, weaknesses, opportunities and challenges for SWOT mapping. Furthermore, data and information are confirmed through FGD. From the results of the SWOT analysis, it is known that several strengths, weaknesses, opportunities, and obstacles from the village to develop ICT are shown in the following Table II.

TABLE II. SWOT MATRICES OF ICT DEVELOPMENT IN RURAL

Internal Factor	**Strength (S)** • Motivation from local village officials and ICT volunteers in rural areas. • The desire of village officials and communities to develop villages through ICT. • The village already has its own budget (ADD). • There are already internet networks in several villages.	**Weakness (W)** • Budget to build ICT infrastructure to rural areas that are inadequate. • The ability and mastery of the human resources ICT in the village. • The budget for procurement and maintenance of ICT facilities in the village is limited. • Culture and mind-set of some rural and rural communities that is still traditional and conventional.
External Factor	**Opportunity (O)** • Support from the Local Government. • ICT development program for villages. • Computer / network devices tend to be cheap & easy to obtain. • Increasing internet usage.	**Threat (T)** • The synergy between agencies that has the authority of the ICT field does not yet exist, so the ICT development program to the rural areas runs independently. • Regulations/policies for the development of ICT in rural areas do not yet exist. • Geographical conditions and locations in some villages that are still blank spot or difficult to access the internet. • Utilization of ICT has not been maximized.

Technological development is a social process, so it depends on how the perspective and values adopted in a community [17], from the results of the SWOT mapping above, the social construction of technology is very relevant to the conditions of the people in rural areas. Several weaknesses have been considered quite crucial such as the ability or literacy of ICT which is still minimal on human resources and the conventional mindset/culture of rural communities. The government as the policymaker for the development of ICT in the region needs to consider this when going to do an ICT development program for rural communities so that programs can be useful.

Adjustment between technology and local wisdom according to the suitability of the use of ICTs needs to be seen from the characters constructed with social and cultural values following the level of community needs [18]. In developing, it is necessary to analyze the needs of ICT in rural communities so that there is a match between the needs and the development that will be carried out.

From the identification of internal and external factors, a strategy was formulated through the synthesis of the results of the SWOT mapping by looking at each map of strengths and opportunities, weaknesses and opportunities, strengths and threats, as well as weaknesses and threats and through confirmation of the steps of the informants that needed to be done through focus group discussions. Furthermore, formulation of rural ICT development strategies in West Java as in the following Table III.

TABLE III. MATIRICES EXTERNAL INTERNAL COMBINATION STRATEGY

S-O Strategy	• Increase support from the government to develop / add facilities / infrastructure for ICT development. • Determine what applications are needed for public services. • Determine the required bandwidth requirements • Build cooperation with local internet service providers (ISPs) to access the internet in the village.
W-O Strategy	• Increase local government support to increase the budget for ICT infrastructure development. • Accelerate ICT development in rural areas. • Survey the necessary infrastructure needs • Include village officials or honorary staff to take part in training related to information provision and services, such as digital plans, implementation, reporting of village development.
S-T Strategy	• Encouraging synergy between agencies that have ownership in the field of ICT to develop ICT in rural areas • Coordinate with relevant parties to accelerate regulation making. ICT development in rural areas. • Collaborate with tower owners to use shared towers for intranet networks. • Conduct technical and educational guidance on computer and internet network training.
W-T Strategy	• Conduct inter-agency cooperation that has authority in the field of ICT to build ICT in rural areas. • Empowering hardware that is still potential to develop ICT. • Strengthen signals for villages that are difficult to get signals.

There are three essential things that need to be encouraged by the government to optimize the development of ICT in rural areas in West Java, namely (1) accelerating infrastructure development, including by allocating budgets, and by collaborating with ICT providers, maintaining the existing conditions of facilities and infrastructure (PC, Laptops, printers), strengthen cellular signals in the village, empower hardware that is still potential to develop ICTs, determine what applications are needed for public services; (2) strengthening the development of human resources, through involving village officials for education and training related to ICT, recruiting honorary workers who have knowledge and understanding in the field of ICT, so that they can help the village in the initial implementation of applications in the village information system so that the village can faster in providing public servants, involving village officials or temporary workers to take part in training related to information provision and services, such as plans, implementation, reporting on village development digitally; (3) strengthening synergies and collaboration between those who have authority in the field of ICTs and internal organizations, including building cooperation with internet service providers (ISPs) for internet access in villages, cooperating with tower owners to use shared towers for intranet networks, collaborating between agencies that have authority in the field of ICT to build ICT in rural areas. With a strategy to strengthen the development of rural ICTs, efforts are expected to be more targeted and appropriate to the needs of rural communities in West Java.

C. Rural ICT Development Strategy by The Community

ICT Community is a group that has similar interests or common interests in the ICT field. Community empowerment or community-based development can be seen as a bottom-up approach, which does not carry out an individual approach, but views community groups as a unit that has common interests in a particular field [19]. The role of the ICT community in helping the use of ICT in the community is carried out through training or mentoring to the community in the context of empowerment in the field of ICT in West Java. One example is the ICT community in Ciamis, namely the Ciamis IT literacy community (DedemIT), a group consisting of rural officials, ICT empowerment and volunteer activists. The activities carried out by the community are incorporated in the Gerakan Desa Membangun (GDM), disseminate and build open governance through rural information management. Classification of activities carried out by the community consists of several groups of activities consist of:

- Assistance in the field of ICT,
- Collaboration / collaboration,
- Knowledge sharing,
- Education through counseling and socialization,
- Publication and documentation of activities,
- Development (training) in the ICT field.

Empowerment of the community by these communities has not been carried out optimally because most communities have not directly empowered the community in the ICT field. In carrying out its activities, these communities first conduct activities to advance the community in general, or first develop and empower the community members themselves, such as conducting training or mentoring to community members. Empowerment activities for the ICT sector have not been maximized due to internal and external factors.

1) Internal factors include:

- From a financial standpoint: funds and operational costs of ICT community activities, sometimes using member self-help costs.
- Regarding program activities (time): constraints of division or time constraints of community members in carrying out activities, because most community members have primary professions such as students, private workers, or civil servants (Civil Servants).
- Regarding Human Resources (HR): (1) the ability and knowledge of community members regarding the ICT field are still lacking and (2) lack of consolidation and regeneration of community members.

2) External factors include:

- Regarding infrastructure and infrastructure: (1) Internet connections in rural areas that are poor (adequate), (2) limited facilities and infrastructure for the community or community to carry out activities, and (3) locations of remote settlements.
- Concerning human resources: (1) public awareness (farmers) about the importance of information to promote agriculture, (2) the low ICT literacy of farmers' communities influences the provision of ICT

information and training by the ICT community, (3) lack of trust from the community.
- Regarding government cooperation and support: (1) lack of support from the government, for example in financial terms. (2) assistance for community legality, for example in establishing legal entities for the community.

In facing obstacles and challenges, a strategy is needed to strengthen the development of ICT for rural areas in West Java from the community side. The strategy is carried out through the following:
- Strengthen cooperation with various parties in organizing activities.
- Improve training to increase knowledge and skills in the field of ICT.
- Strengthen community consolidation and regeneration.
- Improvement of ICT infrastructure.
- Improve facilities and infrastructure for community activities in the area.
- Increase public awareness of the importance of information and how to access it.
- Increased ICT literacy of rural communities.
- Conduct community-based empowerment to increase public trust.
- Financial and legality assistance for empowerment communities.

ICT development efforts for rural areas comprehensively can be encouraged by taking into account the needs of ICTs in rural communities. With a strengthening strategy from the government side and collaboration in synergy, it can support the creation of ICT optimization for rural areas in West Java.

IV. Conclusion

Actions to provide ICT infrastructure and service delivery in rural areas need to pay attention to the target of interaction between community welfare and the development of a spiral, need-based village area. The results of identification of ICT needs for rural areas in West Java include the need for ICTs for communication and collaboration, information facilities, to support promotion, to obtain public services, to access the business world and to facilitate funding sources.

Strategies that can be encouraged from the government can be mapped with: (1) strategy from mapping existing strengths and opportunities including: increasing support from the government to develop/add ICT infrastructure/ facilities; determine what applications are needed for public services; determine the required bandwidth requirements; establish cooperation with local internet service providers (ISPs) for internet access in the village; (2) strategies for mapping strengths and threats include: Encouraging synergy between offices that have authority in the field of ICT to develop ICT in rural areas, coordinating with relevant parties to accelerate the regulation of ICT development in rural areas, establishing cooperation with tower owners for use shared towers for intranet networks, conducting technical guidance and training in computer and internet networks; (3) strategies for mapping weaknesses and opportunities that include: increasing LG support to increase the budget for ICT infrastructure development, accelerating ICT development in rural areas, surveying necessary infrastructure needs, involving village officials or temporary workers to attend training related to provision and information services, such as digital plans, implementation, reporting of village development. (4) strategies for mapping weaknesses and threats include: undertaking inter-agency cooperation that has authority in the field of ICT to develop ICT in rural areas, empowering hardware that is still potential to develop ICT, strengthen signals for villages that are difficult to get signals.

Optimization of rural ICT development can be done by (1) accelerating the development of infrastructure by allocating the budget, and by collaborating with ICT providers; (2) strengthening the development of Human Resources, for village officials and for the community, (3) Strengthening synergy and collaboration between agencies that have authority in the field of ICT and internal organizations.

ICT development strategies for strengthening from the community side by strengthening cooperation with various parties in organizing activities, increasing training to increase knowledge and skills in the field of ICT, strengthening community consolidation and regeneration, improving facilities and infrastructure for community activities in the region, increasing public awareness the importance of information and how to access it, conducting community-based empowerment to increase community trust, financial assistance and legality for empowerment communities.

With information on ICT needs for rural areas and strategies to strengthen the development of rural ICTs, efforts are expected to be more targeted and appropriate to the needs of rural communities in West Java.

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The Importance of the Internet on Improving Economic Welfare: An Empirical Evidence from Indonesian Rural Household

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***Abstract*— This paper aims to examine the sources of the economic prosperity of Indonesian rural household with a focus mainly on the role of internet utilization. We utilize household income as the proxy of economic welfare. We employ a probit model with an instrumental variable to address the endogeneity issue, i.e., the possibility of a two-way causal relationship, of the Internet subscription and welfare. We apply the model to the data collected through a nationwide survey in 2016. This study empirically finds that the promotion of internet coverage has a positive impact on the household monthly income. This finding provides evidence of a new pathway to get out of poverty in rural areas. To increase Internet adoption so as the impact spreads more widely, the government along with all stakeholders have to concerns both, on the supply as well as on the demand side. On the supply side, in addition to encouraging infrastructure expansion, it is essential to continually ensure that all provided content on the Internet is reliable, secure, and relevant with local needs. The government also has to keep the internet service as well as user device cost affordable for all level of society. While on the demand side, the government has a responsibility to increase digital awareness and digital literacy of rural community so that they can utilize internet more effectively and reap more benefit from the Internet.**

Keywords— ***internet, rural household, economic welfare***

I. INTRODUCTION

Economists have identified the importance of information to enhance economic performance due to its ability to reduce market failure caused by the existence of asymmetric information among economic agents [1], [2]. Information has economic value because it facilitates economic agents to make better economic decisions than they would in the absence of information. However, the provision of information is costly or provided information is sometimes incomplete. One of the causes is in some cases we even do not know where the information we need exists or difficult to access.

Information and communication technology (ICT) has been developing and is expected to be a solution to the aforementioned problems. ICTs facilitate information provision, transmission, and manipulation to be easier and cheaper. Internet, among other ICTs, has a special place as a source of information due to its ability to provide it at the lowest cost. For example, farmers can utilize the Internet for gathering a vast amount of information regarding crops price, crops sales trend, the most appropriate fertilizer and pest control, weather forecast, and other related information, so that they can decide what crops to be planted to maximize their revenue and when, where, and at what price they should sell their crops. To obtain such information, farmers do not have to go to the information sources location. They can access it from everywhere as long as the Internet connection is available, hence minimize the cost.

The Indonesian government has stipulated several policies to drive the provision of internet access throughout Indonesia population, especially in non-profitable or rural areas. The most recent survey by the Research and Human Resources Development Agency, MCIT of Republic of Indonesia in 2017 shows that 32,5 % of Indonesian rural population have subscribed to the Internet. It is important to assess that the internet provision provides benefits not only to the service providers but also to rural society.

On the macro level, we can easily find studies concern on the relationship between the Internet use and economic performance with various samples, methodology, and period of data. For example, Choi and Yi(2009) have analysed the effect of Internet use on economic growth in 207 countries in the period of 1991 to 2000[3]. Farhadi, et al[4] used data over the period of 2000 to 2009 from 159 countries, and Ariansyah [5] used data from 2005-2016 from ASEAN countries to assess the relationship. All of those studies use GDP per capita as the endogenous variable and include Indonesia as one of their samples. However, there are several criticisms on GDP per capita when it is used to capture the society welfare. The first, GDP per capita only shows average income and neglect the distribution of income. The second critic is GDP only captures transactions that have a market price and exclude informal transactions that probably occur outside the market[6]. Unfortunately, even since the first Internet adoption in the 1990s, it is difficult to find a nationwide scale study concern on the impact of the Internet on rural household welfare in Indonesia. A study by Arifin [7] found the positive effects of ICT on Indonesian household welfare. However, the study only concerns on the impact of the mobile phone. Even though we can access Internet through mobile phone, especially smartphone, we can not assess the impact of the Internet through the impact of mobile phone for several reasons: the first, the penetration of smartphone, at the time of the study, is much lower than the mobile phone as a whole. According to eMarketer (2013), there were only 11.7 million smartphone users in 2011 in Indonesia. It was account for 9% of the total mobile phone users[8]. The second, mobile telephone and Internet come from different waves of digital innovations. While the mobile phone is considered as a first wave digital innovation, the Internet (along with cloud computing) is classified as the second waves. Each wave has its own period to give an impact on social and economic development. At present, the second waves have the biggest impact compared to others, while the thirds (internet of things, robotics, artificial intelligence, and machine learning) will have impact started in 2020 [9].

This study seeks to fill aforementioned gap by focusing on the role of the Internet on Indonesian rural household welfare. More specifically, this study tries to address the following question: Does Internet adoption cause the increase of rural household welfare?. We use household income as the proxy of household welfare. We also incorporate the mobile phone adoption and several control variables in the model to reduce the likelihood of bias from omitted variables.

The rest of paper is outlined as follows: Literature review is described in Section II, followed by Research Methods in Section III. We place Results and discussion in Section IV, while the conclusion of the study is presented in Section V.

II. LITERATURE REVIEW

A. Theoritical

The benefit of ICT on household welfare can be direct as well as indirect. Direct effects come from the supply side, while indirect effects emerge from ICTs use [10]. The supply side of Internet service is one example of direct effect of ICTs. It provides employment opportunity in the field of network and access device manufacturing, network deployment and maintenance, network administration, etc. The use of the Internet, as a channel of indirect effects of ICT, boosts economic through improvement of productivity gains, reduce transaction costs, and financial inclusion.

According to human capital theory, by keeping other things equal, people will have different income because of different amount of investment in human capital. For example, in some occupations, employees with Internet expertise will perform their jobs better and be more productive than others. Thus, they will gain higher earning. Their ability in utilizing internet effectively reflects their sacrifice to invest in human capital pertaining to the Internet utilization. Welfens (2008) also give a few examples of how ICTs affect productivity. He argues that ICTs enable improvement in the process of product innovation, trade, and facilitate faster diffusion and distribution of knowledge[11]. In the agriculture sector, farmers may utilize the Internet to gather information related to what should be planted in the next season to maximize their revenue. The Internet is also useful in providing and distributing information about what crops to plant, what fertilization and pest control to use, crop rotation, and details information pertaining to a particular pest. The Internet can also affect people productivity due to its ability to provide an entertainment. A study by Lesiuk found that listening to the music has altered mood to a more positive one. Further, this will increase the quality of work and shorten the time required to finish the job[12]. This impact can finally increase company revenue and labor income.

Transaction cost economics (TCE) theory believes that commercial transaction will not free of friction. Transaction costs emerge in every step of economic exchanges. According to Hobbs (1997), we can divide transaction costs into three main classifications, i.e., information, negotiation, and monitoring or enforcement costs[13]. Information costs arise before a transaction occurs. It includes the costs of obtaining information related to price and product and the costs to identify appropriate trading partners. Before the Internet era, information is conveyed through face to face communication, telegraph, telephone, facsimile, or courier/postal service. However, the introduction of the Internet changes the way of gathering and exchanging information in an easier and cheaper manner than before. The lower the information cost, the lower the transaction cost. In the agriculture sector, for example, farmers can utilize the Internet to search information about the market price of pesticide, seeds, and crops, so that they can buy and sell all related products that maximize their net income. Further, this will enable farmers to participate in commercial agriculture[14]. Similarly, Greenberg [15] argue that appropriate use of ICT help households to gather market price information of commodities they produce. This will eliminate middlemen and increase household revenue. The use of ICT also creates an opportunity to expand sales by enabling people to engage in an online transaction.

ICT also facilitates expansion and access to the formal financial services. The emergence of branchless banking services is one example of ICT utilization in financial sector. This will lead to the improvement of financial inclusion, especially for underserved groups in developing economies. Formal financial services enable people to make more efficient and safe financial transaction and to be better in income management. Economic agents can exploit financial service to make longer-term spending, saving, and investment decisions. It also enables people to engage in broader productive activities and to be more resilient against short-term financial shocks, such as unemployment and the loss of breadwinner [16].

B. Related works

Previous works have demonstrated the important role of the Internet on economic welfare and poverty alleviation.

Several cross-sectional studies found the positive relationship between internet use on US individual earnings. Goss and Phillips [17] used data from December 1998 of Current Population Surveys (CPS) to examine the impact of Internet usage on wages. Their study concludes that internet usage causes a wage gain of approximately 13.5%. A more recent study provided by Mossberger et.al [18] found that technology use at work causes a substantial effect on economic opportunity, that is, a 14.5% boost in earning for people who use a computer at work. They claimed that their study consistent with earlier findings of Krueger (1993) that conclude computer use is a cause of 15% wage premium. Mossberger et.al also provides empirical evidence pertaining larger boost in wages as an impact of internet/email use at work. Individuals who use internet have higher earnings of approximately 17% than those who do not use the internet in their jobs. DiMaggio and Bonikowski used the same data source but different in the time of data collection. They used survey data in 2000 and 2001 and found that access to the Internet did not only provide economic benefit for those who used it at work, but also for those who used it at home[19].

III. RESEARCH METHOD

A. Data

The data was collected through a nationwide survey in 2016. The data are cross-sectional and collected at the household level. The survey has been administered by the Research and Human Resources Development Agency, Ministry of Communication and Information Technology of the Republic of Indonesia. The original objective of the survey was to capture adoption of ICT devices and the habit of society in accessing ICT services, both in rural and urban areas. The survey succeeds to collect 9588 responses. For this study, we only utilize data collected from the rural area, with total responses of 5412. However, data cleaning led to the removal of 22 responses due to incomplete responses. Therefore, we only perform further analysis over 5390 responses.

The original questionnaire includes a wide range of questions related to household socio-economic background, ICT devices ownership, habits of family members in accessing and subscribing ICT services, e-commerce, and ends with two questions about print media. Yet, in this study, we only use a few variables considered as suitable with the objective of the study. For socio-economic background, we only use survey data related to head of family's formal educational background, geographical location and household monthly income. while ICT adoption consists of information about the Internet adoption.

Household monthly income as the dependent variable has five categories, i.e., less than IDR 1 million, IDR 1 to 2 million, more than IDR 2 to 5 million, more than IDR 5 to 10 million, and more than IDR 10 million. Formal educational achievement is categorized into six, i.e., none, elementary school, junior high school, senior high school, diploma or undergraduate, and graduate or post graduate.Respondents' geographical location has been differentiated into two categories, i.e., Java and non-Java. In terms of ICT adoption, it consists of mobile phone ownership and Internet subscription.

Surveys responses show that regarding educational attainment, 35.2 percent of respondents have an elementary level of formal education. It is followed by respondents with last formal education of senior high school and junior high school, with a response rate of 30.1 percent and 22.3 percent, respectively. Only 8 percent of respondents have a university level of education, and the rest (4.4 percent) have none achievement of formal school.

The highest response regarding monthly income comes from respondents having income between IDR 1 to 2 million (43.1 percent). It is followed by them with a monthly income of less than 1 million (35.9 percent). The next response rate is 19.0 percent. This rate represents respondents with the income between IDR 2 and 5 million. The least response (0.2 percent) comes from them with income between IDR 5 to 10 million. The rest, 1.8 percent, is respondents with monthly income more than IDR 10 million.

According to the distribution of respondents' geographical location, most of the respondents live in Sumatera island with 32 percent, while the least (9.9 percent) live in Bali and Nusa Tenggara island (Bali Nusra). The rest respondents live in Java island, Sulawesi island, Papua and Maluku island, and Kalimantan island, with response rate 21.6 percent, 14.2 percent, 11.2 percent, and 10.9 percent each.

Regarding Internet adoption, only 25.5% households have at least one of family members subscribed to internet service, either through fixed or mobile. However, in this study we consider a family as an internet adopter if at least one of its members have access to the internet not only by their own subscription, but also through the internet access at school, at work, at public wi-fi, etc. There will be a spillover of information to other members if at least one of them have access to the Internet.

Before we perform further analysis, firstly we have to conceptualize all variables into the categorical scale, specifically ordinal scale. Categorical scale for each variable is presented in Tabel 1.

TABLE 1. CATEGORICAL CODE FOR EACH VARIABLE

Variable name	Categorical code
Income	(0) less than IDR 1 million (1) between IDR 1 to less than 2 million (2) from IDR 2 to less than 5 million, (3) from IDR 5 to less than 10 million (4) higher than IDR 10 million.
Education	There are 7 level of formal education achievement in the questionnaire. a. none b. elementary school (EDU_ES) c. junior high school (EDU_JHS) d. senior high school (EDU_SHS) e. junior high school (EDU_JHS) f. undergraduate (EDU_UG) g. postgraduate (EDU_PG) each level use code (1) to represent that head's final educational achievement is in that level, and (0) if in the other levels. None is used as reference so that it is excluded from the model to prevent multicolinearity
Geographical location (GEO)	(0) Other than Java (1) Java
Internet	(0) Not subscriber (1) The subscriber

B. Analysis method

Given that the monthly household income as a dependent variable takes on more than two categories, and among categories have a natural ordering, the ordered probit (or logit) model would be a most appropriate approach. However, one concern when we examine the causal relationship between internet adoption and household income is the potential of the existence of a two-way causal relationship between the two variables, known as the endogeneity issue. We use ordered probit approach with an instrumental variable to overcome the issue. The instrumental variable is a variable that has no direct effect on the household income, but indirectly through the Internet adoption. Li (2017) used provincial mobile coverage rate in 2005 as an instrument of internet access in 2013, in China[20]. Due to unavailability of the data of provincial mobile coverage, this study utilizes provincial mobile base transceiver station (BTS) density in 2014 as the proxy of the coverage to instrument the household internet access. Provincial mobile BTS density is the number of 3G and 4G BTS over the number of households per province. We gather information of the number of BTSs from mobile operator annual report, while the number of households per province comes from the central statistical bureau (BPS) publication. The reason of choosing this instrumental variable is due to a high dependence of the Internet connection in Indonesia on mobile connection. Therefore, the 3G and 4G BTS density in 2014 to some extent captures regional endowments of mobile Internet access in 2016. Equation (1) and (2) present the first stage and the second stage estimation, respectively. Significant and positive estimators of BTS density at the first stage and the predicted of internet access on second stage provide convincing evidence for the real effects of internet coverage on household income through internet adoption.

$$P(Internet_i) = \alpha + \beta\, instrument\ var_i + \gamma X + \varepsilon_i \quad (1)$$

$$P(Income_i) = a + b\, probability\ of\ internet\ access_i + cX + e_i \quad (2)$$

X is vector of variables of education, geographical location α, β, γ, a, b, c are vectors of unkown parameters.

IV. RESULT AND DISCUSSION

This section presents statistical results of proposed ordered probit model with instrumental variable and the discussion of the findings.

Table 2 displays the output of first stage model. As we can observe that indevendent variables, which consist of various level of education, geographical location, and 3G and 4G BTS density in 2014, significant at the level of 1%, except for educational level of elementary school. These findings consistent with most of the existing literature that the higher the educational attainment, the higher the probability of someone to be an internet adopter. The respondents reside in Java have also confirmed to have higher probability to use the Internet. The results also find that the higher the 3G and 4G BTS density in a province, the higher the probability of households located in respective province to access to the Internet.

Table 3 shows the output of second stage model. As we can see, among all indevendent variables, which consist of various level of education, geographical location, and predicted probability of internet access, all variables, except geographical location, significant at the level of 1%. In terms of the internet access, the finding means the access to the Internet of at least one family members have positive and significant impact on household welfare.

TABLE 2. FIRST STAGE ESTIMATION

Dependent Var.	internet access
Independent Var (Coef.)	
edu_es	0.1732
edu_jhs	0.3245***
edu_shs	0.8092***
edu_ug	1.415***
edu_pg	2.1011***
geo	0.3163***
btsdensity3g4g2014	0.2621***

TABLE 3. SECOND STAGE ESTIMATION

Dependent Var.	Household Income
Independent Var (Coef.)	
edu_es	0.2695***
edu_jhs	0.5844***
edu_shs	0.8104***
edu_ug	1.1747***
edu_pg	1.6291***
geo	-0.0174
internet access (predicted prob)	1.3748***

***, **, *, means significant at 1%, 5%, and 10%, respectively

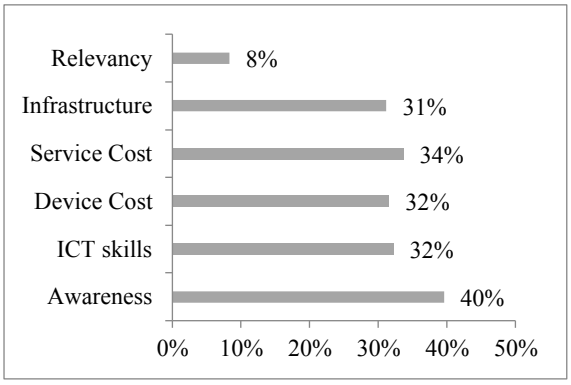

Fig. 1. Barriers to the internet

Unfortunately, the impact is not evenly distributed yet since the internet penetration, particularly in rural areas, is relatively low. As reported by Research and Human Development Agency of MCIT, only 32.5% of the rural population aged between 9 to 65 years old who use the internet[21]. Considering the importance of the Internet as pointed out by this study, it is important to encourage more people to engage on the Internet. The first step to accomplish is identifying the barriers and then followed by removing them. The survey found that out of ten barriers, there are six barriers cited most by respondents. They are awareness, device cost, service cost, ICT skill, infrastructure, and lack of relevant content. Each of barriers has been cited by non-user respondents as presented in Figure 1. These findings are in accordance with what GSMA has delivered that to promote Internet penetration, all stakeholders have to devote their efforts to provide infrastructure ubiquitously, to increase awareness as well ICT skills of society, to improve device as well as service affordability, and to provide more relevant content [22], [23].

1) Infrastructure

Concerning ICT infrastructure, the last ITU's ICT development index (IDI) put Indonesia in 105th place out of 176 countries [24]. In Indonesia, the difficult terrains have impeded the investment in the fixed broadband internet. Therefore, the Internet connection heavily relies on the mobile network. 3G and 4G based services have covered the population of 91.54% and 78.37%, respectively[25]. It is required more effort to cover the entire population. Infrastructure sharing, active as well as passive, could be an good solution to reduce the capital as well as operational expenditures. Another problem related to infrastructure is the availability of electricity to power the base transceiver station (BTS) as well as to charge the user device. In December 2017, the electrification ratio in Indonesia was 95.35%[26]. It means there is 4.65% of households has not electrified yet.

2) Awareness

It is essential to increase non-user's awareness about the presence of the Internet and to educate them about the full range of content available on the Internet. It is possible that people do not use the Internet because they do not know what benefit they will reap by subscribing to the Internet. It is also important to clarify a misconception of the Internet. An anomaly emerged in a survey in which Facebook users outpace internet users. Many respondents even deemed that the Internet is only for non-productive activities[27]. All of these issues will inhibit non-users to subscribe to the Internet.

3) Readiness

Readiness is not only about society readiness, but also government readiness. Society readiness encompasses ICT skills and gender equality, while government readiness concerns on the availability of initiatives and strategy to address the digital divide. Skill sub-index of ICT Development Index 2017 places Indonesia in 109th position[24]. In ASEAN, Indonesia's index is only better than Vietnam, Lao, Cambodia, and Myanmar, but worse than the others.

4) Local content

Internet content could be any form of media available on the Internet. Local content might be internet content in the local or native language or content relevant to local needs. In rural areas, where residents are often to have lower education, they may only able to speak in native language. It will be a hindrance for them when accessing the Internet services as most of the Internet content uses international as well as national language.

5) Affordability

Affordability is related to internet connection tariffs, and smartphone price as the percentage of income. Broadband Commission has set a target of the entry-level broadband price not more than 5% of average monthly income. The Alliance for Affordable Internet (A4AI) has criticized the target as it does not consider the income inequality. A4AI argue that imposing broadband price at the level of 5%, or even lower at 4% or 3%, will cause the broadband remains unaffordable for 20% of the lowest income earners. Besides the price, A4AI also criticizes the amount of data plan in which the affordability is currently measured, that is 500 MB. According to A4AI, this data allowance is not enough to access the valuable resources on the Internet for one month. A4AI proposes to redefine affordability of broadband as "1 to 2" which means the price of mobile broadband data of 1GB does not exceed 2% of average monthly income[28].

In 2017, the price of prepaid mobile data plan of 500 MB in Indonesia was about 1.36% of GNI per capita[29]. Even though this percentage is less than 5% of GNI per capita as targeted by Broadband Commission, the rate might be higher in lower-income households which mostly reside in rural areas. The percentage is also higher than proposed by A4AI. Concerning the user device, currently, we can easily find a smartphone with a price less than IDR 1 million.

Those enablers are linked to each other. It is not enough to concern only on some factors but neglects the others.

V. Conclusion

Empirical evidences point out that the promotion of internet infrastructure density has a positive impact on the household monthly income. This finding leds us to a further conclusion that the Internet does not not only provide benefits to households in developed countries as presented in earlier works, but also to those in developing countries like Indonesia.

The findings provide a new pathway of getting out of the poverty, that is through the promotion of the Internet subscription. To encourage higher penetration, the Indonesian government has to concern on several drivers of the Internet adoption, such as ubiquitous internet infrastructure, society awareness about the benefit of the internet, the improvement of digital literacy, local content creation, and the affordability of service as well as user device cost.

The limitations of this study are as follows: This study only investigates the causal relationship between Internet service adoption and economic welfare, without going deeper to investigate the impact of actual usage of the Internet. Besides, the use of cross-sectional data naturally has limitation due to its selective bias.

VI. Acknowledgements

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The Potential Adoption of the Internet of Things in Rural Areas

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***Abstract*— Half of Indonesian population living in rural area. So that, the development of the rural area is very crucial. Along with technological advances, the Internet of Things(IoT) devices have been increasingly used by numerous parties, including the use of IoT for the growth of rural areas. This study follows PRISMA protocol to explores the various uses of the field area, IoT devices, and technology in rural areas in diverse works of literature systematically including consideration during implementation, then reviewed their implication for potential adoption in rural areas of Indonesia. This study recommends that the agriculture field should be prioritized to implement IoT because it is feasible than healthcare. Besides stakeholder support in infrastructure, user education also becomes challenge consideration of implementing IoT in rural areas.**

Keywords—adoption, Internet of Things, rural, PRISMA

I. INTRODUCTION

Rural areas have several unsolved problems widely. Lack of infrastructures, low economic scale, unemployment and inadequate health facilities is part of problems in rural areas [1] [2], [3]. Indonesia as an archipelago country has 17,504 islands with 82,038 rural areas in 2017 [4] with the proportion of 47% of the population living in rural areas [5]. Specifically, majority problems in rural areas in Indonesia relate to economic, poverty and health. The Government legislated Rural Act in 2014 to boost the development of the rural areas which focuses on two main sectors, i.e., improvement the rural infrastructure and society empowerment [6]. Despite the progress of implementation of The Rural Act, the problems of the rural areas still remain. The report of acceleration of the adoption of ICT in rural areas on 2017 determine the obstacles of rural area. First, the obstacle related to infrastructure are 27% of rural areas are not covered by signals, and 21% of rural areas are not electrified. Next obstacle is 62% of people in the rural area said that the price of the ICT devices is still high. Furthermore, 23% of people in rural area are not aware of the advantage of ICT usages. The last problem is connected to a native culture which shows 5% of people in the rural area believe that ICT usages will damage their morality [7].

Technology expected to be an enabler to overcome the problem in the rural area. The technology which suitable to develop a solution in a rural area should have characteristics as follows: reasonable prices, wireless, using a frequency allocation that does not require permission/unlicensed, and broad service area [8]. Based on those specifications, Internet of Things (IoT) is the best choice to be implemented in the rural area since its advantages, i.e., enables many devices connected [9], consume low power and low cost [10]. Moreover, the IoT platform includes the emerging technology which needs 2 to 5 years to reach the peak of the hype cycle curve [11] which means IoT still on developing as a new technology.

The purposes of this work are exploring the various uses of IoT devices in rural areas in diverse works of literature systematically including recommendation during implementation, then reviewed their implications for potential adoption in rural areas of Indonesia. The contribution of this work is providing a comprehensive recommendation for potential implementation of IoT devices in the rural area based on prior studies, and investigating its implication for Indonesia, as the country that has an enormous number of rural areas.

Our work is organized as follows : the next section describes the IoT concept. In the third section, we explain the methodology that we follow to conduct a literature review. In section four we provide the findings. In the last section, we conclude the study.

II. IOT CONCEPT OVERVIEW

ITU-T Y.4000 has defined the key to IoT, i.e., connection, people, and information [12]. Furthermore, ITU-T has been developing the specification of those IoT key through ITU-T Study Group (SG)-20. This study group is working on IoT standardization requirements, which initial focus on IoT applications in smart cities and communities [13]. Along the advancement of IoT, not only the regulator/government involved but also industry and academic researcher. Some literature review showed that many researchers have concerning on IoT, mainly focusing on the concept.

A comprehensive study by [14] pointed out the essential component of IoT system includes devices, communication, services, management, security and application. The minimum requirement of devices in IoT system are sensing, actuating, controlling and data management. Sensing requires sensor connect to the object such as air-sensor, humidity sensor, etc.

The function of communication component is how the devices could connect with the servers. There are many services of IoT servers i.e. device recognizing-controlling-modelling and data publishing-analytic. Management

component used to maintain the IoT system to track down the principal management of IoT system. The function which provided by security component i.e. authentication, authorization, message-content integrity and data privacy. Last, application is the last-mile component of IoT system. This component perform as an interface between the system with the user. Furthermore, application also provides analysis and forecast mode which could be modified by user.

The using of proprietary wireless technologies in IoT would enable the finest solution to solve the problem. There are many alternatives of wireless technologies to support IoT. Basically, wireless technology to support IoT requires some parameters such as low power consumption, low cost, scalable, reliable, low latency, wide coverage and secure. Paper by [15] classified those wireless technologies into two i.e. long range communication technologies (LPWAN) and cellular IoT (CIoT).

LPWAN has objective to provide wide coverage for connecting many devices in area. Raza, Usman et al examined LPWAN technology which has specification i.e. low power, low cost, and low throughput [16]. LPWA could be a low cost technology since it use unlicensed spectrum. The options of LPWAN for instance SigFox, LoRa, Wightless, Ingenu (on-ramp wireless), Telensa and Qowisio.

In spite of LPWAN, cellular technology also develop wireless technology to support IoT in licensed band. Cellular technology developer has been trying to expand the existing technology. Since it use licensed band, might be the price of this technology would be higher than unlicensed LPWAN. Nevertheless, 3GPP still working on the IoT cellular technology so it would be low cost. One of the first attempts is extended coverage GSM (EC-GSM). Although those technology still far from being deployed, at least it could be an alternative wireless technology. Next step, 3GPP on going to advance LTE technology for IoT which is called by LTE-M. Those technology still consume much bandwidth, i.e. 1.4 MHz [17]. To overcome with the consumption of bandwidth, later on there was Narrow Band-LTE-M (NB-LTE-M) which utilize less bandwidth, 200 KHz [17].

Research by [18] explained briefly about 3 central vision of IoT that consists of things, internet and semantic. This research also predicted the significant challenges related to those vision, i.e., security, data protection, and standardization. Moreover, the support of IoT would be linked to big data analytics, cloud and fog computing [19].

Besides the technology and architecture, people play a prominent role in IoT. There will be shifting about the sociology of things in the IoT era. By utilizing IoT people do not need to control the things. IoT will allow things to not only to communicate with a human but also things itself. Thus, the transformation of sociology should be paid attention [20].

III. METHODOLOGY

A. Systematic Review, Protocol, and Registration

This study has used a systematic review to ensure that both the search and the retrieval process have been accurate and impartial. A systematic review is defined as a research technique that attempts to collect all empirical evidence in a particular field, to assess it critically and to obtain conclusions that summarize the research. This systematic review has followed the quality reporting guidelines set by the Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) group as performed in [21], [22]. A review protocol is describing each step of the systematic review, including eligibility criteria, was therefore developed before beginning the search for literature and the data extraction. Protocol of systematic reviews and meta-analyses allow for planning and documentation of review methods, act as a guard against arbitrary decision making during review conduct

B. Eligibility Criteria

The following inclusion criteria were used: articles published in English (IC1) and articles that deal with user IoT implementation in the rural area (IC2). Only articles are written in English (IC1) were included since the Scientific Community favors this language in the publication of research studies. Finally, IC2 was included to answer the research question.

C. Information Sources

Author collecting papers from relevant electronic databases such as Science Direct and IEEE that published between 2011 and 2018. It considered that this period would allow the retrieval of a current number of studies on the topic and detect the research trend for this topic. The author also scanned the reference lists included in articles to ensure that this review would be more comprehensive.

D. Study Selection

The study selection was organized in the following four phases:

1. The search for publications from electronic databases related to the information system and computer science. This phase was performed by using the following search string: (“internet of things” AND “rural” AND “adoption” OR “implementation”), which adapted to the databases’ search engines.
2. Exploration of title, abstract and keywords of identified articles and selection based on eligibility criteria.
3. Complete or partial reading of articles that had not been eliminated in the previous phase to consider whether they should be included in the review, by the eligibility criteria.
4. Scanning the reference lists of articles to discover new studies which were then reviewed as indicated in phases 2 and 3, but these articles had to satisfy the inclusion criteria.

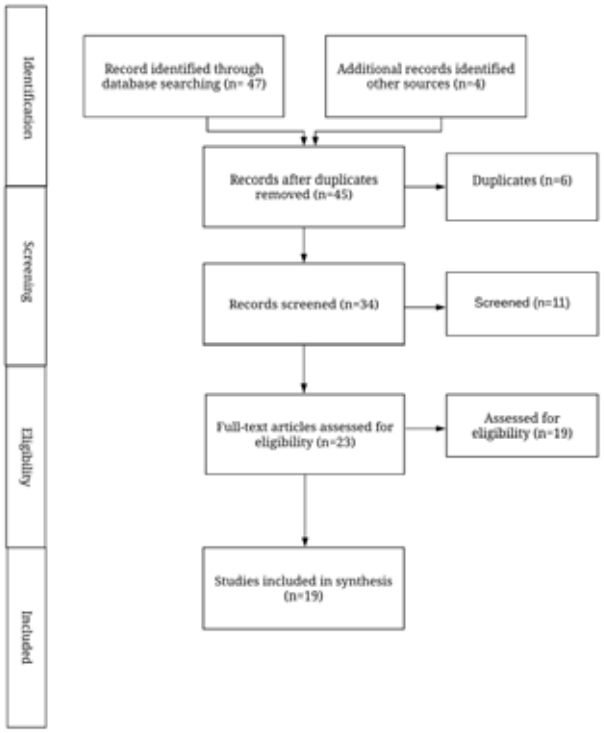

Fig. 1. Flow of search process

IV. Results & Discussion

This section provides the result of study selection and study characteristics.

A. Study Selection

A total of 19 articles were selected in the review. The search of databases provided a total of 51 studies; then six were removed because it duplicates other and were discarded because they were not written in English (IC1). The title, abstract and keywords of the remaining 30 articles were examined, and 11 of these have been discarded due to the screening result that they did not meet the criterion of IC2. In this section, the author describes the essential features of the studies included in the review. Fig. 1 shows a PRISMA flow diagram in which this process is summarized.

B. Summary of Evidence

To provide a comprehensive overview of IoT implementation in a rural area, three main research questions and their corresponding refinements were used to guide the review, as shown as below:

RQ1. *Demographic data and trends. Identify active researchers (countries) and the distribution of papers over the years.*

Our first findings reveal that the topic of IoT in a rural area has been researched in several countries, with the most contribution coming from India and the second most coming from countries in Africa, see Table 1. Moreover, over the time span between 2011 and 2018, there has been an increasing interest in IoT implementation for a rural area. Moreover, areas of implementation interest also explored as seen in Table 2.

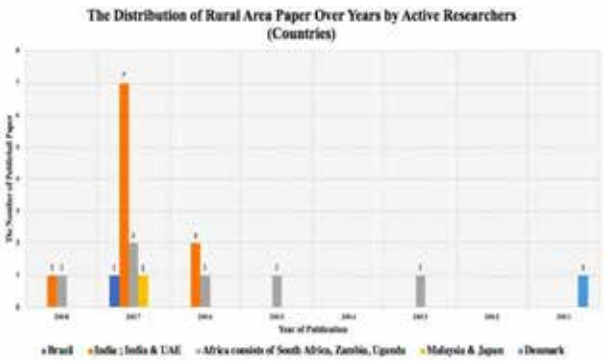

Fig. 2. Distributions of Rural Area Paper Over Years by Active Researches (Countries)

TABLE I. Overview of Selected Studies

Papers	Location of Authors institution	The issue highlighted in the paper	Field Area	Location of Study Conducted
Carrillo & Seki (2017)[23]	Brazil	Architecture	General	Not mentioned
Natarajan & Kumar (2017)[24]	India	Connectivity	Energy management; smart irrigation system; waste management; health monitoring system	India
Dlodlo, Mofolo & Kraguara (2017)[25]	South Africa & Uganda	Potential application	Agriculture	Not mentioned
Khrisnan, et al. (2017)	India	Cloud	Healthcare	India
Pham, Rahim, & Cousin (2016)[1]	Africa	Platform	Smart rural village	Sub-Saharan Africa
Dlodlo & Kalezhi (2015)[26]	South Africa; Zambia	Sensor Devices	Agriculture	Zambia
Raj, Jain & Arif (2017)[27]	India	Hardware & software interface, the workflow of a prototype system	Healthcare	Not mentioned
Pham et al. (2017)	Africa	Platform	Farming	Africa
Prakashan, et al. (2017)[28]	India	Services & application	Healthcare	India
Kaur (2017)[29]	India	Connectivity	Infrastructure, agriculture, Farming healthcare, education	India
Yogaraj et al. (2017)[30]	India	Monitoring system	Healthcare	India
Rohokale et al. (2011)[31]	Denmark	Monitoring system	Healthcare	India
Verma & Usman	India	Devices	Agriculture	India

(2016)[32]				
Nordin et al. (2017)[33]	Malaysia; Japan	Reliability	Water management	Tasik Chini, Malaysia
Sivathanu (2018)[34]	India	Device Adoption	Healthcare	Pune city and its suburbs, India
Bagula, Mandava & Bagula (2018)[35]	South Africa	Framework	Healthcare	Not mentioned
Roy, Zalzala & Kumar (2016)[36]	India; UAE	Adoption Model	General	Ahmedabad & Kolkata, India
Velagaleti & Kumar (2017)[37]	India	Architecture	Environmental monitoring; Smart lighting; energy consumption	Gudlavalleru, India
Dlodlo,Nomusa (2013)[38]	South Africa	Potential Application	Health	South Africa

The characteristics of rural area that discussed in these papers are: lack of essential infrastructure[1], [24], [25] i.e. proper irrigation system, electricity and water; lack awareness about schemes and subsidies[24]; lack of access to socio-economic infrastructure and services[24], lack of public amenities and government services; high cost of devices; complexity in deployment[1]; lack of technological ecosystem and background, considered as smallholder households and derive income from agriculture-based[26] and forest-based activities, and some of them depends life on nature[33].

RQ2: *What kind of IoT devices that implemented or adopted in a rural area?*

Various devices and technology are discussed in these studies as seen in Table 2.

TABLE II. SCOPE OF DEVICES AND TECHNOLOGY IN REVIEWED STUDIES

Broader Area	Specific Area	Scope of Technology	Scope of Devices
Healthcare	Tele-medicine	LTE, LoRaWAN; RFID	Portable sensing unit[27]: Pulse oximeter; ECG; EMG; GSR; Body temperature; blood pressure[31]; blood sugar; hemoglobin; Smart beds[29]
	Biomedical system [30]	WiFi	Sensors[30] for temperature, heart bit, ECG
Agriculture	Pest management	RFID	Sensors[26] for humidity, precipitation, crop type, soil fertility, leaf wetness, temperature, winds, soil moisture
	Soil system		Sensors for soil condition and properties[32]
	Irrigation system	RFID	Automated drip irrigation[26]
	Logistic system		[25]
	Surveillance system	RFID	Motion detector sensors[32]
Farming	Smart farming		Sensors[29]; satellite
	Surveillance system	LoRa	Low-cost IoT hardware platform for Collar[39]
	Smart dairy		[29]
Education	Smart education	Mobile app	Video; visual alert[32]
Environmental management	Energy management	WiFi, LTE, Ethernet	Battery, solar panel; Sensors[37] for temperature, humidity, gas; light status
	Weather management	WiFi, LTE, Ethernet	[24]
	Waste management	WiFi, LTE, Ethernet	[24]
	Hydrological management	LoRa, Wireless Sensor Network, NB-IoT	Sensors[33] for water quality, climatology and water level
	Disaster management		[25]
Infrastructure	Fire building		Heat intensity Sensor[26]; Camera
Tourism	Smart tourism		[25]
Surveillance	Smart surveillance system		Camera and sensors[29]

Most of the studies discuss the use of connectivity included Long Range Access, Wireless Sensor Network, Long Term Evaluation (LTE) and Narrow Band-IoT(NB-IoT). Various use of sensors also discussed. The characteristic that is used by technology to support IoT in the rural area, i.e., using unlicensed spectrum has broad coverage, and also included the open platform. The use of unlicensed spectrum hopefully can reduce the end cost of IoT application. Meanwhile, broad coverage is a must to cover the rural area. IoT open platform now being a trend especially to provide cheap access to the rural area. With the IoT open platform, the developer thought that investment only happens once when the first system built. After that, the advancement of the system would be handled by the society.

Many scholars interest in the potential IoT implementation agricultural field, especially in India, where farming is the major of households' income. [26] proposed the various concept of IoT agriculture from irrigation to surveillance programs to guide agricultural intervention. A study from [32] attempts to proposed model that composed of IoT devices that combine available technologies such as soil detection, weather forecasting, water management system and surveillance system for better data capture.

Healthcare field also attracts researchers to explore kind of IoT implementation.[27] proposed methodology on remote e-health telemedicine system that consists of a various type of portable sensing unit, as well as a study conducted by [30]. While [28]suggest connecting modules with the things that people use in their daily life such as

slippers or clothes, to overcome cost challenge for the user in the rural area.

RQ3: *What kind of consideration that is proposed when IoT is implemented in a rural area?*

[1] believed that it is crucial to handle more extended ranger for rural access, cost of hardware and services and limit dependency to proprietary infrastructures and provide local interaction models. Several studies propose a model and framework for integration among system. Another aspect that needs to be aware of is education. Education and knowledge for potential users are challenging to adopting the technology. Such an educational foundation and the technological sophistication needed to manage the tools. For example, a study from [32] discusses the implementation of visual and voice messaging alert system in their mobile app to help uneducated farmer that illiterate.

C. The implication for Rural Areas in Indonesia

As discussed in the prior section, the characteristic of rural areas that reviewed in the literature have similarities in rural areas of Indonesia. Based on the findings, this session discusses area, devices, and technology that have implication for rural area in Indonesia.

a) Area of Implementation

Although the role of agriculture in GDP declined from 23 percent in 1982 to only 13.14 in 2017[40], this sector still absorbs a large labor sector, reaching 31.17 percent in 2017[41]. So that, agriculture still also become the primary sector in the Indonesian economy. The agricultural sector of Indonesia comprises large plantations that owned by state and private, and also smallholder production. With the different implementation of IoT in the field of agriculture discussed in the study, it can be a reference that this field is an area that has the potential to be developed in both the research area and working areas in Indonesia. The Indonesian government has started revitalization programs for smallholding farmers. Adoption of IoT devices in rural areas might become potential added-value for the irrigation system and pest management, for example, could help rural farmers in Indonesia to minimizing crop failure and improve the efficiency of the resources.

The health sector is indeed a necessity for people in rural areas, as prior study presented that telehealth is economical feasible in Indonesia[42]. However, this field requires more complex ethical and technical attention, so this area may be placed in a medium and long-term implementation plan.

b) Devices and Technology

Table 2 provided many alternative technologies to support IoT in a rural area. The utilization of technology should meet with the needs of the rural area in Indonesia. In fact, price, awareness, and infrastructure are the main problems as we described in section 1. Thus, the best technology has to affordable, easy to install with the existing infrastructure and increase the prosperity. We recommend that the technology should have good coverage with the lowest investment.

To build a system is need not only the technology but also devices. Similar to our consideration in the previous paragraph, the devices should be cheap. Fortunately, IoT application does not need many sophisticated devices with the high price. Some IoT applications could be built from sensor and camera like a smart surveillance system which does not require complicated devices. The problem is the price of the last-mile devices. Although the system to build IoT is not costly, sometimes the devices to access which is controlled by the user, still expensive. The government should have a subsidiary mechanism to figure out that problem.

c) Consideration of Implementation

The Indonesian government has developed the draft of IoT masterplan. The draft consists of short-term, medium-term and long-term planning in IoT. The issues identified in this study can provide valuable information to recognize the needs for supporting the development of IoT masterplan. Education and awareness for the potential user also become critical issues because of the diversity of citizen literacy level, especially in rural area.

Stakeholder support with collaboration from government, industry, and academia undoubtedly provide significant result in IoT adoption. As discussed earlier, IoT requires minimum connectivity that must be provided by the government. But the role of the government in promoting the implementation of IoT needs to be supported by industry and researchers in seeing what is possible to be implemented by people in rural areas with all their limitations in the short term, medium term and long term. The economic improvement of rural areas is the primary objective of rural development, so that areas that are the vital income of the community should be a priority for the adoption of IoT, such as agriculture and animal husbandry.

V. CONCLUSION

The aim of this work was to present a comprehensive overview of IoT implementation research in the rural area. For this purpose, a systematic review has been conducted which included planning, conducting and reporting phases.

Various areas of IoT implementation in rural areas have been identified from 19 selected literatures. Likewise with devices and technology discussed in these articles. In this study also identified considerations that need to be considered in implementing IoT in rural areas.

Based on findings, this study also provides a recommendation to conduct more research for IoT adoption in Indonesia, especially for the rural area. Most of the Indonesian citizen live in the rural areas so that the development of the rural area is a necessity. There is the viable further research to explore the implementation and adoption of IoT in the field of agriculture, especially in dealing with problems that are often experienced by farmers to minimize crop failure and improve the efficiency of farm resources owned.

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Assessing the Information Technology Governance Trust Using Readiness And Usability Models: A Model Development Study

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***ABSTRACT*— Information Technology Governance (ITG) is important for schools and stakeholders to manage rights and responsibilities for decision-making processes. Institutional policies, systems, and users are the basic components of the proposed ITG model. The success of ITG is a primary concept in this topic. It occurs when users have a good level of trust in IT. The success of ITG implementation depends on the IT knowledge. There are several dimensions to measure in ITG implementation: readiness model, usability model, and input-process-output model. The researchers included level of trust into the input-process-output model, thus a new model of ITG implementation is obtained. Instead of using empirical evidence, this study develops the ITG implementation model by using theories from previous studies. The model is proposed and developed by incorporating the Nielsen usability model and the Parasuraman readiness model into the input-process-output model. The result is a model of IT governance trust that consists of 9 variables in 23 influential relationships. This study also shows coherent aspects of the process model, the causal model, and the questionnaire of each indicator.**

Keywords— IT Governance; combination model; usability; readiness; IPO model

I. INTRODUCTION

In principle, information technology (IT) has become an enabler for organizations to achieve their goals [1]. Satia argues that the use of computers play a significant role in education so that it is required for students and teachers [2]. As shown by Ling, IT is useful for users from the risk of use and perceived technology [3]. Koufaris argues that the IT ease of use begins with understanding the website in order to reduce asymmetric information, process, and information behavior as well as to increase the online trust level [4]. Bianchi argues that IT users should have beneficial goals when implementing IT for work performance improvement [5].

Subiyakto argues that there are two indications of successful information system (IS) implementation [6]. They are the effectiveness and efficiency of task completion as well as business processes. According to Lee, trust in ICT is the accumulation of the level of trust present in every use of IT [7].

Dahiya sees that ICT development potentially gives positive impacts on public services [8]. Satia argues that, for a business to be carried out by means of communication, the development of business infrastructure cannot be separated from IT development [2].

Jogiyanto [9] argues that an IT system strategy is built and applied based on IT system functionality, efficiency, memory, satisfaction, and readiness [10]. Godoe argues that understanding the adoption of technology readiness is important [10]. It is interesting to continue the ITG study through a new ITG model. Some variable constructs are interrelated, and some other are combined. It is necessary to conduct IT governance studies continuously to improve and explore IT governance [11-14]. Several ITG models are developed by referring to previous theories.

This study aimed to get a better understanding about the mutual influence of readiness and usability. In addition, this study assessed the level of trust in ITG by using the readiness model and the usability model. There are two questions in this study:

Q1: What is the conceptual relation between readiness and usability of technology?

Q2: How are IT readiness and usability integrated into a model?

The discussion of this paper is divided into 5 sections. The first section is conceptual introduction. The second section is literature review, in which theoretical frameworks are discussed. In the third section, research method is described. The fourth section presents the results and discussions. The final section is conclusion.

II. LITERATURE REVIEW

A. Readiness Model

Upon the use of the system, users prefer the adoption and integration of new technologies to achieve their desired goal [15]. Readiness system is comprised of four influential dimensions, namely hopefulness, breakthrough, discomfort, and insecurity. Hopefulness is a belief that technology can improve control, flexibility, and efficiency and a positive perspective of technology. Breakthrough is a user's desire for new product or technology services. Discomfort is a negative attitude toward technology which may lead to lack of confidence and technology acceptance. Insecurity is the distrust of technological security especially regarding the security of personal data. Through these dimensions, Parasuraman proposed a readiness model namely Technology Readiness Index (TRI).

B. Usability Model

Madan proposed the following questions that relate to the usefulness of technology [16]:

- How satisfied is the user with the IT usage based on his or her expectations and time of use?
- How many errors may occur when the user is using IT?
- How relevant is IT to the user's skill level and job/task?
- What are the strategies for mastering IT effectively and proficiently?
- To what extent may IT improve job performance, and how many people are needed to address IS problems?

Nielsen formulated problems from the usability theory [17], which are:

- How is the user able to remember (memorability) or maintain knowledge after a certain period of time and continue to remember the updates?
- How may the user perceive the easiness of IT usage and the effectiveness in completing the tasks and problems?
- How is the quality of information technology available at that time easy to learn and use in completing their respective tasks and problems?
- Efficiency: How may IT assist the user to do his or her works in a simple way and solve the problems that may emerge?
- How do you achieve a level of satisfaction (free from discomfort) and lead to a positive attitude toward IT products from the user side?
- What is the number of errors caused by IT implementation including the level of security error, which impacts on the data usage and storage, and vice versa ?

The Nielsen usability model consists of 5 dimensions:

- Effective in learning IT (related to the level of learning ability) that existed at the time.
- Efficient in assisting the completion of work and tasks from the use of IT that existed at the time.
- Easy to learn and remember from the IT that existed at the time.
- Lack of error tolerance from the use of IT at the time.
- Providing satisfaction, attractiveness, and at the same time fun when using IT that existed at the time.

C. Integrating Model

Integration model is a combination of two or more models. Based on the IPO model [18], the authors tried to integrate the readiness model and the usability model. The author's adoption of the model was based on how Subiyakto integrated the readiness model [15] and the success model [19] into one model, namely the IPO model [18]. The authors followed the integration process conducted by Subiyakto to adopt the model – integrating the readiness model [15] and usability model [17] into one model, with an addition of a variable trust factor [7] into the integration process. Finally, the IT governance trust model, a model of trust in IT governance, was formed. In connection with modern IT, there is a relationship related to the definition of usefulness in IT. Axup argues that IT products should be able to be perceived and used efficiently [20]. Tsourella argues that gender and age may influence the IT adoption and perceived usefulness [21].

D. Trust Variable

The variable trust is one of the important variables that influence ITG [7]. Trust is defined as follows:

- Trust is accumulated values from history and expected values for the future.
- Trust can be measured quantitatively in order to evaluate the physical component values, value chain, and human behavior for decision-making processes.
- Trust is applied to the social, cyberspace, and physical domains.
- An entity is "trusting" at a given time if there is an assumption that the other entity will become exactly as the first entity expected.
- Trust denotes the relationship between two entities when each believes that the other will behave exactly as expected.
- Trust is a strong belief in the reliability and correctness of information or in the ability and disposition of entities to act appropriately in certain contexts.
- Trust is dependence on someone's character, ability, strength, or truth.

E. IT governance

According to Tonneli, IT governance is a capability that is very important for IT strategic alignment and business delivery [13]. The relational mechanism between IT and business is a determining factor for IT performance and positively correlates with organizational performance.

Benaroch argues that the board-level ITG is responsible for monitoring managerial IT decisions and provides policies for controlling IT resources [11]. The companies need to determine their board IT competency level. In addition, it is expected that CIO turnover is lower in IT-intensive companies where the change can be more disruptive.

Zhang also explains that IT governance is an important precursor of IT capabilities, builds superior IT capabilities, and indirectly creates companies achieving competitive advantage [14].

III. RESEARCH METHOD

Based on prior model development studies [6, 18], there are four main steps (Fig. 1) to create a model development study.

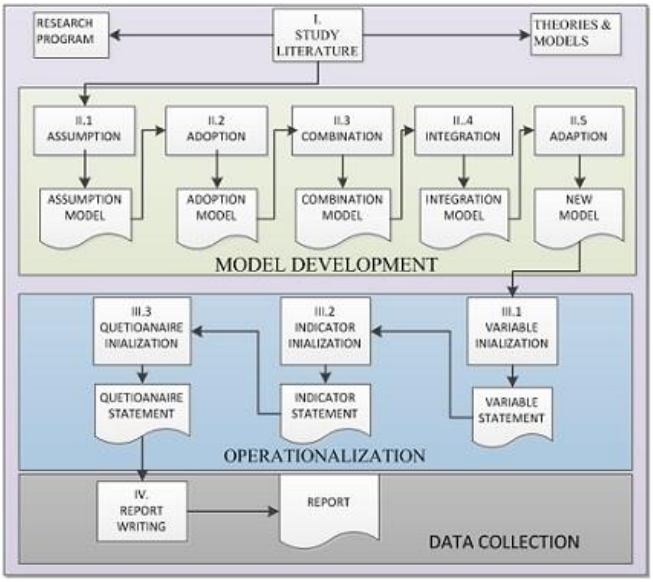

Fig. 1. The research procedure

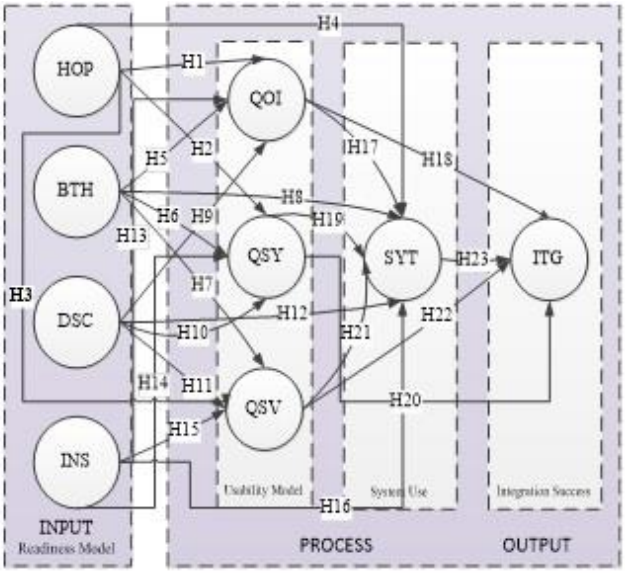

Fig. 2. The proposed of ITG model

The first step is to look at IT governance in schools that already have a computerized system in all academic and non-academic activities [22], then researchers conduct literature studies related to the usefulness of developing the model for initial research initiation.

The second step is to develop a model with the assumption, adoption and integration between usability [17] and readiness [15], the level of satisfaction associated with readiness [23], a combination and adaptation of the IPO model [18], and finally the variable trust incorporated as a proposed model for shape IT governance.

The third step is to define variables and indicators, followed by developing questions in relation to assessing a new system model.

In the final step, researchers applied the writing results into the research, which was then reported and assessed for the proposed new model.

TABLE I. ELEMENT OF THE THEORIES AND PRIMARY MODELS

The Theories and Primary Models	Reference
Technology readiness model	[10, 15]
Technology usability model	[16, 17]
Information technology governance	[1, 11-14, 22]
Causal model and progress model development	[6, 7, 12, 18, 24, 25]

IV. RESULT AND DISCUSSION

The proposed model with its nine variables and 23 relational ideas is shown in Fig 2. The development model was generated from the integration of the readiness model [15] and the usability model [17].

Following the assumptions of Subiyakto's IPO model, the readiness model consists of a number of variables [15], namely hopefulness (HOP), breakthrough [BTH], discomfort [DSC], and insecurity [INS], overall positioned in the model input dimensions. On the other hand, the usability model [17] contains quality of information [QOI], quality of system [QSY], and quality of service [QSV]. Integration of the readiness model and the usability model with and addition of the variable trust as proposed in the implementation of IT governance will be brought up in a trust system [SYT] to produce IT governance [ITG] as the main objective.

The proposed trust variable in the expectations of ITG quality serves as a product (Q1). Trust as a proposed variable is integrated into the IPO model [18] as the cause of the development model [6, 7, 12, 18, 24, 25], and finally, a relational hypothesis emerges and is developed to meet influential relationships between models (Fig 2). Overall, the logic of the integration of the variable trust into the IPO model [18] becomes a linear presentation. The following tables explain the variables definition and indicators of the models and questions proposed (Q2).

TABLE II. VARIABLES AND DEFINITIONS [6, 15, 17]

Var	Definitions
HOP	The quality of belief that IT will probably happen.
BTH	The quality of IT being an advanced system.
DSC	The quality of perception that IT is an unpleasant condition
INS	The quality of distrust of IT integration as to whether it is able to handle harmful potentials
QOI	The quality of IT based on the consistency of user expectations
QSY	The quality of IT content
QSV	The quality of excellent IT services
SYT	The quality of the satisfaction level of users when they are utilizing of the IT
ITG	The achievement of IT governance

TABLE III. INDICATORS AND DEFINITIONS [6, 15, 17]

No	Indicators	Definitions
HOP1	Convenience	The quality of system ability to be free from constraints, difficulties, and troubles
HOP2	Access Time	The quality of IT ability to connect with other IT systems
HOP3	Efficient Way	The quality of IT in producing maximum output from minimum resources
HOP4	Effective Way	The quality of IT in achieving high performance
HOP5	Productize	The quality of system support in producing an output when being compared to the resources needed to produce an output
BTH1	Solution	The quality of system support in finding solutions to problems.
BTH2	Freedom	The quality of system support in being free from controls or influences
BTH3	Heavy lifting	The quality of system support in achieving something within a problem
BTH4	Encourage Improve	The quality of system support in enabling something to happen, develop, or stimulate
BTH5	Convincing Win	The quality of system in supporting users to be more successful
DSC1	Sophistication	The quality of system feature being confusing or difficult to deal with
DSC2	Trouble	The quality of IT operation as to whether a real process is not easily operated
DSC3	Reliance	The quality of IT performance when other parties need to operate it
DSC4	Loss of Support	The quality of IT operation performance which is lacking support from others
DSC5	Unsuitable	The quality of being unsuitable
INS1	Fiasco	The quality of a system likelihood of posing possible danger
INS2	Menace	The quality of a system that could cause harm or dangerous situation
INS3	Cut down Communication	The quality of IT implementation in reducing the size, amount, and importance of human interactions
INS4	Interaction	The quality of IT utilization in receiving more attention and focus from people
INS5	Uncertainty	The quality of system being dubious in its utilization
QOI1	Precision	The suitableness quality of the produced information which is the real standard
QOI2	Suitability	The quality of IT processing in planned time duration
QOI3	Complete Way	The quality of IT processing all operations with nothing missing
QOI4	Continuity	The possibility of IT implementation to demonstrate operations, services, maintenance, or qualities by the same information
QOI5	Appropriate	The impact quality of IT with its subject matters
QSY1	Ability to use	The quality of IT being free from constraints, difficulties, and troubles
QSY2	Stabilize skill	The quality of IT having easy maintenance
QSY3	Interlude	The length of time IT system takes for responding user commands
QSY4	Access Time	The quality of IT system being operable according to requirements
QSY5	Harmless	The irresistible quality of IT from the unexpected attacks

TABLE III. (CONTINUED) INDICATORS AND DEFINITIONS [6, 15, 17]

No	Indicators	Definitions
QSV1	Sensitiveness	The quality of IT implementation in making a response in an appropriate way, at the appropriate time and under an appropriate situation
QSV2	Move Easily	The quality of IT in adapting to requirements
QSV3	Sanctuary	The quality of integrated IT implementation in serving users safely
QSV4	Access Time	The quality of IT service in suiting functional requirements
QSV5	Extra Service Time	The quality of IT service scope in exceeding functional requirements
SYT1	Efficient Way	The quality of IT implementation in attaining maximum achievement outputs
SYT2	Effective Way	The quality of IT system capability to fulfill user needs
SYT3	Resilience	The quality of IT in adapting to and suiting required demand
SYT4	Generally Pleasure	The quality of making users pleased with the overall aspect of the system
ITG1	IT Efficient Way	The quality of IT output value
ITG2	IT Effective Way	The quality of IT system capability to fulfill user's desire.
ITG3	User Pleasure	The quality of IT in helping users create business value.
ITG4	Productivity Development	The quality IT implementation in improving output
ITG5	Competitive advantage	The quality of integrated favored by users connected to the business competitions

TABLE IV. THE QUESTIONNAIRE STATEMENTS [6, 15, 17]

Variable	Statement of The Questionnaires
HOP1	The IT implementation is free from troubles.
HOP2	The IT can be accessed easily by other systems.
HOP3	The IT can be operated with minimal resources.
HOP4	The IT can be operated with maximal outputs.
HOP5	The IT can be operated in an efficient, effective way.
BTH1	The system is a tool and is used to help users solve problems
BTH2	The system is a tool and is used to control or helps users.
BTH3	The system is a tool and is used to support users and tackle difficult situation or problem.
BTH4	The system is a tool and is used to achieve a goal and encourage users
BTH5	The system is a tool and is used to support users to be more understanding than their competitors.
DSC1	The system is not familiar to users.
DSC2	The system is not fully supported in its operation.
DSC3	Users are confused when using the system.
DSC4	Users cannot use the system easily.
DSC5	Users cannot operate the system freely.
INS1	Users cannot operate the systems according to the development plan.
INS2	The system is harmful or dangerous to users.
INS3	The system makes fewer interactions with users.
INS4	The system is unfocused to users.
INS5	The system is corrupt to use.
QOI1	Information is produced accurately.
QOI2	Information is produced at most fitting time.
QOI3	Information is produced completely.
QOI4	Information is produced consistently within the system operation.
QOI5	Information is produced relevant to users' needs.
QSY1	The system is convenient to use.
QSY2	Users can maintain the system implementation easily.
QSY3	Users feel that the system is able to respond quickly.
QSY4	Users feel that the system is able to carry out all of planned functions.
QSY5	Users feel that the system is safe to use.
QSV1	Users feel that the system renders services quickly.

TABLE IV. (CONTINUED) THE QUESTIONNAIRE STATEMENTS [6, 15, 17]

Variable	Statement of The Questionnaires
QSV2	Users feel that the system renders adaptive services for them.
QSV3	The system renders harmless services.
QSV4	The system gives a contribution to the requirements of users.
QSV5	The system gives its contribution based on the required functions.
SYT1	Users are happy with the efficiency of the system.
SYT2	Users are happy with the effectiveness of the system.
SYT3	Users are happy with the system's ability to be moved easily.
SYT4	Users are happy with the performance of the system.
ITG1	The integration of the system is performed efficiently.
ITG2	Integration of the system is performed effectively.
ITG3	The integration of the system improves user satisfaction.
ITG4	The integration of the system improves the operational productivity of the institution.
ITG5	The integration of the system is performed efficiently.

In developing the model, some initial conclusions are drawn. Firstly, the conduct of the research is transparent as explained in the research method. Secondly, questions can be reversed based on indicators, variables, and assumptions.

The study of the perspectives development model [26] demonstrates how to assess the validity. In the beginning, the study is conducted intelligibly, and this serves as the validity trust point. In this study, the authors use the development assumptions, adopt the readiness model [15] and the usability model [17], combine both models, and adapt variables, indicators, and questions in relation to IT governance. To validate this study the authors invite readers to see inversely based on the indicators, variables, and assumptions besides the utilization of the assumptions, adoption, combination, and adaptation processes. Referring to Subiyakto [25] and Eddie [26], the authors describe that the model has been validated based on how the model can present a real phenomenon.

The authors refers to the model of the validity point in the validity model [25]. The model validity point is concerned about how the model can present the real phenomenon. It can be done by employing the inverse retrieval from the model development process. The cohesive interrelation between the proposed model and the question measurement may present the validity point of the model.

There are two contributions from the research: the transparency of the development model will be processed and the rationality model will be developed. Different model propositions can be shown from the use of other understandings, assumptions, and perspective points. Thus, it is necessary to re-evaluate the model and the instruments of the research due to the research's limitations, which can serve as a consideration for future works.

V. CONCLUSION

This study explains the connection between readiness and usability in terms of IT governance implementation and how to combine readiness and usability models in the use of information technology. The author proposes a combination model by integrating four readiness model variables and 3 variables from the usability model to generate system trust. In the end, IT governance is formed. As a consideration for future research, this study has some limitations in the theory understanding, assumptions, problem perspectives, the proposed model, and the instruments to proceed to the examination stage.

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The Digital Poverty and Empowerment Issue in Indonesia

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***Abstract* — In Indonesia as many other developing countries, ICTs in rural areas are still facing connectivity challenges. However, the empowerment becomes matter and tipping point for the success of the policy. This paper discusses about the important of empowerment through ICT needed in rural areas. The digital poverty in Indonesia will describe this empowerment condition. The data were processed from national surveys on the use of ICT in households and individuals from 2013 to 2017 and also secondary data. In general, it is found that in the last five years, the growth of digitally "wealthy" is very low below the infrastructure growth and its gap between rural and urban also shows an increasing trend. Human capital and economic factors still hampered the access and use of ICT in the rural area in Indonesia. The benefits of ICT are always felt only by most villagers who have higher income and education. Therefore, the empowerment issues should be a serious concern the agenda-setting of rural ICT policy.**

Keywords—ICTs, digital poverty, empowerment

I. INTRODUCTION

The development of Information and Communication Technologies (ICTs) especially the public's access to the internet shows a significant increase. The ICT indicator data issued by Research and Human Resources Development Agency, Ministry of Communication and Informatics recorded the number of internet access by households in Indonesia in 2013 amounted to 19.6%, while in 2016 it reached 36% of households. Whereas, the use of the smartphone by individuals showed the 66,31% % in 2017, with the proportion of 50,39% in rural and urban as much as 83,04%. The last number indicates not only the digital divide between urban and rural but also the exciting phenomena more than half of rural people use the smartphone.

The phenomena are interesting because ICTs can or can't empower rural people. ICTs being used for productive activity or just consumption and even become a burden for rural people. It was based on the World Bank (2016) proved that 80 percent of the worldwide poor live in rural areas. More ever, in Indonesia, rural poverty is more than double that of urban areas. The national socioeconomic survey data, Central Bureau of Statistics in March 2017 showed that the contribution of pulse consumption to per capita consumption per month of poor people in Indonesia reached 25%. This data indicate the presence of information technology encourages consumption even in the case of poor people in Indonesia.

The World Bank identified three critical areas in poverty reduction efforts such as opportunity, empowerment, and security. Therefore, this paper focuses on the particular issue of how to encourage the use of ICTs in the empowerment of rural people. Pigg (2002) in Prastyanti (2013) states that empowerment is an effort to provide or transfer power to others. Empowerment is a change process whereby individuals or groups gain the ability and power to control their lives (World Bank, 2011). Zimmerman (1995) means empowerment not only from the outcome but also the process. Every action, activity, and structure must be seen in assessing the empowerment of society. As a process, the result of empowerment is not only measured by tangible outcome, but also the intangible outcome. Therefore, the scope of empowerment becomes wider. It's not only socio-economic dimensions but also psychological dimensions [1]. This psychological dimension is related to intrapersonal, interactional and behavioral factors. The most important empowerment was seen in the availability of opportunities to access and use information and develop skills obtained through ICTs [2]. In the context of modern agriculture, knowledge became significant factor. ICTs could be optimized in knowledge management used to accelerate agricultural development [3]. ICTs have become a new approach to the agricultural extension. It services more efficient and effective through the improvement of availability and ability to access information about natural resources, technology and agriculture strategy, market information and banking services [4].

The psychological dimensions of ICT empowerment such as increasing of individual capacities, becomes aligned with the concept of digital poverty developed by Barrantes (2007). People were called digitally poor, not only because of the lack of digital access but also the lack of knowledge using digital technology. Therefore, the people who are not poor economically, but they have lack of knowledge, makes them *digitally poor*. This digital poverty concept is very close to ICT literacy. One is called digitally "wealthy" when he accesses ICTs interactively to get government services, e-commerce activities, and banking services [5]. The person can access many resources because of ICT, and this becomes closely related to the psychological dimension of empowerment.

Based on the use of rural ICT in Indonesia and the relationship of digital poverty with the dimensions of empowerment, this paper will describe the digital poverty condition by comparing with ICT infrastructure growth. The shape of digital poverty is also explored in the context of rural-urban, gender, education, household income and livelihood. It is to see the digital inclusiveness which is part of the dimension of empowerment [17]. Therefore, the

picture of digital poverty and empowerment become more comprehensive. All of this description will emphasize the concern of the empowerment dimension in the development of rural ICT policies.

II. METODHOLOGY

The descriptive analysis is used to describe various gaps between infrastructure growth and digital poverty, the digital poverty conditions in rural and urban, and some inclusivity issues in the context of gender, education, household income, and livelihood. The nonparametric statistical tests such as chi-square and contingency coefficients are used to measure the significance of differences and the relationship between digital poverty and demographic and socioeconomic factors. The data was processed from surveys of ICT used by households and individuals' conducted by the Research and Human Resources Development Agency, Ministry of Communication and Informatics from 2013 until 2017 and also other secondary data. These surveys used multi-stage stratified random sampling for households and individuals. The number of respondents was 8045 in the year 2013; 8693 in the year 2014; 9638 in the year 2015; 9588 in the year 2016 and 9419 in the year 2017.

III. CONTEXT AND CURRENT LITERATURE OF THE DIGITAL POVERTY AND EMPOWERMENT

ICT for Rural development still faces the connectivity problem. However, the question of whether ICT can solve the problems occurring in rural areas becomes a growing discussion in both the academic and policy maker. An interesting issue is about ICT as a solution for empowering rural communities. It will be a solution to the problem of poverty and easy access to basic needs services, such as education and health or even it becomes a catalyst for new issues or disempowering (cultural shock, digital divide, etc.).

ICT-based initiatives on poverty issues are not able to reconfigure the balance of power in rural areas, and even ICT becomes a tool to strengthen of the existing social power structures [2]. However, some research is enough to show the position of ICT in poverty reduction. Households without ICTs were found to be poorer in all dimensions compared those with ICT [6]. In the frame of multidimensional poverty (economic, financial, human, social, health access, market access, etc.), ICT is concerned to be a potential solution [6] [7] [8].

One of the multidimensional poverty approaches is digital poverty. Digitally poor is individuals who has limited access to information and communication technology. It is not only due to the lack of income but also the lack of digital technology knowledge [5]. Barrantes (2007) said digital poverty is a visible variable for analyzing ICT needs and May (2012) also proposed digital poverty as an alternative for scaling ICT access. These scales divide 4 (four) categories: a. *Extremely digitally* poor is someone only using ICT to receive information (one way). Even though digital access is available, due to the age limitations and ability to learn become obstacles to know the use of digital services; b. *Digitally poor* is someone who has communication media (two-way) such as a telephone. Because of the limitations of digital media capabilities, it is only used to receive information and communicate; c. *Connected* are those who already have internet access, but their use is still passive limited only to receive information and communicate; d. *Digitally "wealthy*", namely someone who already has and is able to actively access the internet and has the ability to conduct transactions and interactions to take advantage of various digital services such as e-commerce, government services, e-business and content creation [5]. For the context of Indonesia, the author in earlier paper categorize people in extremely digitally poor for households or individuals who do not have access to information technology [9]. Digital poverty also defines by considering socio-demographic factor. It is absolute, moderate and relative ICT poverty. Absolute ICT poverty means people who do not have access to ICTs tools such as the Internet, computers, and smartphones. Moderate ICT poverty is people who sometimes fail to meet basic needs and access to ICT is limited. And then, relative ICT poverty is people who have the right basic need and services, but ICT usage is hindered by social and geographic, political or economic divides [10].

How about linking digital poverty with community empowerment? Zimmerman (1995) emphasizes empowerment as a process and outcome. Thus every action, activity, and structure must also be seen in assessing community empowerment. Empowerment is seen in 5 dimensions, namely: economic, family & social empowerment, politics, knowledge, and psychology [11]. The aspects of knowledge and psychology have been explored in other research. In psychological empowerment, there are 3 (three) dimensions, namely intrapersonal, interactional and behavioral. The intrapersonal dimension is strongly related to perceived control, motivation, competence, confidence. While the interactional dimension consists of critical awareness, decision making ability, solving problems and leadership abilities. Then the behavioral dimensions include participation and copying or copying behavior [1].

Based on the information as an important resource, ICT can drive enhancements to the decision-making capability. Some research have shown this case for the agricultural sector as the primary sector of rural communities, even though there are some records [12][13][13][14]. The other research looks empowering from aspects of capacity building, trust, and self-actualization. By describing these dimensions on a Likert scale, it was found that crop maximization projects have an impact on empowering small farmers in Sindh Province, Pakistan even in moderate levels [15].

The existence of knowledge and psychology aspects in the dimension of empowerment strengthens its connection to the concept of digital poverty. Even though this is only a part of the empowerment process, there is a level in digital poverty that makes a visible variable for measuring community empowerment. The wealthier people in digital will access resources easier reflected in e-commerce activities, essential services (health and education), and various banking services.

TABLE I. DESCRIPTION OF DIGITAL POVERTY LEVEL [9]

Category	
Extremely Digitally Poor	Person who only uses technology to receive information such as radio and television. It is included a person who does not have any access to information technology
Digitally Poor	Person who has used information and communication technology (TV, Radio and telephone). The telephone is used only for communication not for internet access
Connected	Person who has used the internet, both at home and in public places. The using is still passive. It only replaces the function of searching information and communication in general (for example: e-mail, chat browsing, etc.)
Digitally "Wealthy"	Person who has actively used the internet for buying and selling transactions, interaction between government services, e-business, banking and content creation

Moreover, the digital poverty concept was developed based on literacy and knowledge as one of the keys [5]. A person can have access to ICT, but because of the lack of knowledge, he cannot maximize the benefits of ICT. By using poverty digital classification as the previous author's paper (table 1), the analysis was developed further to see the reality of community empowerment through ICT by looking at ICT inclusiveness based on geographical factors (rural-urban), social conditions (gender and education), and economic factor (livelihood and household income).

IV. RESULTS AND DISCUSSION

A. *The Digital Poverty and Base Transceiver Station (BTS) Growth*

This paper can't show the coverage area of the Base Transceiver Station (BTS) in detail. It is vary depends on the geographical conditions. Therefore, the BTS growth will be presented accumulatively compare with digital poverty conditions which presented accumulatively too. BTS is intended for all BTS both 2G, 3G and 4G. Especially for 2016 and 2017, BTS growth is calculated from the number of BTS by three major operators in Indonesia: Telkom, XL Axiata and Indosat. It means that the BTS growth of other operators considered fixed. Figure 1 shows the growth of BTS compared to increase of digital poverty from 2014 to 2017.

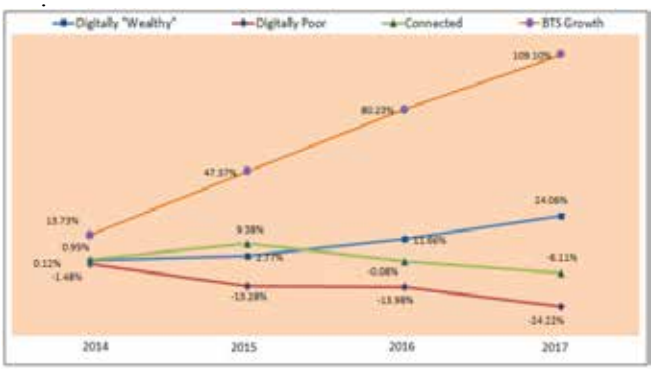

Fig. 1 The growth BTS and digital poverty 2014 – 2017 (base line year 2013).
Source: processed from surveys of ICT use by households and individuals' & the annual report of telecommunications operator

By using the baseline data in 2013, it was found that digitally "wealthy" growth was still below the growth of BTS. Indeed it is recognized that there was an increase of 24.06% in digital "wealthy" in 2017, but this figure is far from the growth of BTS which reached 109.1% in the same year. Although, there is a decrease in digitally poor by 24.22% in 2017, but the gaps in infrastructure growth with digitally "wealthy" strengthen the importance of empowerment in the development of ICT in Indonesia. The picture of the gap also shows the need of ecosystem development that encourages the ICT literacy and empowerment along with the massive infrastructure development. The digital exclusion can occur if supportive ecosystem development is not carried out. This problem will occur because the development of essential services such as education health and social security being digitally.

B. *Digital Poverty in Rural and Urban*

ICT empowerment issues become more fundamentally if we compare the number of digital poverty between rural and urban. Figure 2 shows the increase of "digitally wealthy" both in urban and rural areas, but there is a significant gap between them. Even the gap figure rises every year from 2.85% in 2014, 5.98% in 2015, 12.26% in 2016 and 21.13% in 2017. This is an indication of the need for accelerated adoption of technology that encourages the empowerment of rural communities. The effort to promote the use of technology in productive and meaningful activities is a significant responsibility for stakeholder, especially the government. This is because rural areas are non-commercial areas and less attractive to the private sector.

Furthermore, the digitally poor show the indication of impairment every year. This condition occurs in both rural and urban areas. This means that less and fewer people who do not have access to digital technology. However, the gap between villages and cities still shows an upward trend. It indicates that accessibility through the development of ICT infrastructure in rural areas is still important issue and must in line with the efforts of community empowerment as mentioned earlier.

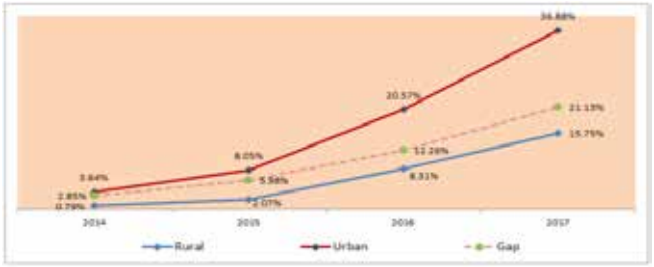

Fig. 2 The number of digitally "*wealthy*" 2014 – 2017.
Source: processed from surveys of ICT use by households and individuals'

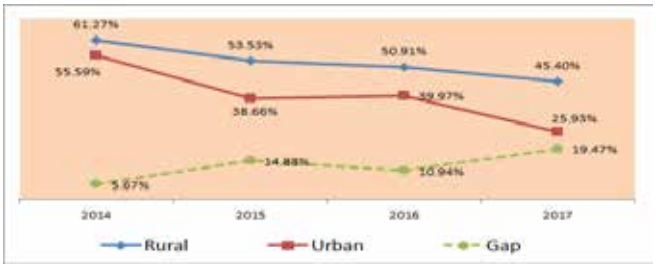

Fig. 3 The number of digitally poor 2014 – 2017.
Source: processed from surveys of ICT use by households and individuals'

TABLE II. THE NUMBER OF THE DIGITAL POVERTY IN RURAL AND URBAN (YEAR 2014-2017)

Year	Rural-urban	Digital poverty category			
		Extremely digitally poor	Digitally poor	Connected	Digital "Wealthy
2014	Rural	18%	61%	20%	1%
	Urban	6%	56%	35%	4%
2015	Rural	18%	54%	27%	2%
	Urban	8%	39%	46%	8%
2016	Rural	19%	51%	21%	8%
	Urban	8%	40%	31%	21%
2017	Rural	25%	45%	14%	16%
	Urban	12%	26%	26%	37%

TABLE III. THE VALUE OF THE DIGITAL POVERTY GAP BY RURAL – URBAN

Year	Chi-square test	Contingency coefficient	Approx. Sig.
2014	5.297E2a*	0.240*	1.75E-114
2015	7.294E2a*	0.265*	8.99E-158
2016	6.216E2a*	0.247*	2.05E-134
2017	1.033E3a*	0.314*	1.01E-223

. *significant p-value < 0,05
α5%, df 3, chi-quare test > chi-square table

Table 3 shows the chi-square test and contingency coefficient. From the result of this test can be concluded that there are gap or difference between digital poverty and geographical factor. The digital poverty gap in rural – urban area shows chi-square value significantly in all year (2014, 2015, 2016 and 2017). The correlation between digital poverty and rural-urban also indicates a significant value. This means the geography condition (rural-urban) still being the hindering factor of access and use of ICT. This correlation value increases each year.

The pattern of digital poverty between rural and urban shows exciting things. It is showed in Table 2. In 2014 the most significant number of digital poverty in rural was the digitally poor group while the largest number of urban also occurred in the digitally poor group. This means that in 2014 the most significant gap constraint was still on connectivity issues. And then in 2015 and 2016, the largest number occurred in the digitally poor for rural areas, while in the urban the largest number is for connected groups. This means that the distribution of connectivity in the form of internet is inequality between rural and urban. Whereas in 2017, shows the need for rural ICT empowerment. The largest number in rural areas is still in the digitally poor group, while the largest number is for the digitally "wealthy" in urban area. This gap reinforces that ICT empowerment needs attention, otherwise digital exclusion has a great opportunity for those who live in rural areas.

Digital inclusion for overcoming poverty in rural areas will be further away from reality if digital literacy strengthening is not carried out [16]. The development of digitally base in public services, especially essential services such as education, health, and social security will have an impact on rural communities. Potential problems that can arise are not only the digital exclusion, but also social exclusion.

C. Digital Poverty in Rural by Socio-economic Factor

Empowerment is closely related to the issue of inclusiveness [17]. The whole community must enjoy information access. Therefore, the issue of ICT empowerment in rural areas will be clarified by further exploring the digital poverty condition in rural areas based on social factor (gender and education) and economic conditions (household income & livelihood). This quantitative exploration is carried out in 2017 as the most updated year.

Table 4 and 5 show the digital poverty in rural area clarified by gender, education, livelihood and household income. The existence of digital poverty gap among various socio-economic factors is evident by the significant chi-square value. However, the correlation between digital poverty and each of the socio-economic factors has significant value. Statistically, the p-value of the contingency coefficient is significant, but the correlation between digital poverty and gender group (male and female) is quite small at only 0.09. This figure, according to Blaikie (2003) shows the correlation can be ignored. These results indicate that the social structure of gender in Indonesia is not a barrier to the realization of digital inclusion. ICT in rural areas will develop the empowerment of both men and women. Through ICT, women in rural areas will be able to access and use information and participate actively in development. In India, despite the socio-economic constraints that hinder rural women, the use of ICT, especially mobile phones, become an important facilitator in socio-economic transformation [18] and even can improve income for farm women [19].

Human capital and economic factors still hampered the access and use of ICT in the rural area in Indonesia. The benefits of ICT are always felt by most villagers with higher income and education. The results of this research could not show the strengthening of the socio-economic structure in rural areas by existing groups, as noted by Ullah (2017), but the gap between levels of education and income in rural communities has underlined the importance of the alignment of ICT development and increasing human capital. Digital literacy is the first point [16].

However, the strengthening of economic networks in rural areas has become a reinforcement, so that there will be no migration of HR from villages to cities or even abroad. ICT offers a form of modern agriculture with a network between supply-demand chains and even between regions [11] [13] [13] [14]. Modern agriculture should be able to attract the young generation to work in the agricultural sector. And this is still a common problem to integrate ICT with the livelihoods of rural communities. This is proven in this research. The gap of ICT access and use between farmer and non-farmer still exists.

Based on the results of the 2013, agricultural census conducted by The Central Bureau of Statistics (BPS), shows that for ten years (2003 - 2013) there have been a transformation in the agricultural sector, including the interest of the young generation to become farmers to decline. ICT offers particular attention for young people in agribusiness. The emergence of various e-marketplace platforms has become the link between the agricultural sectors in the village end-end to the broader market.

TABLE IV. THE NUMBER OF THE RURAL DIGITAL POVERTY BY SOCIO-ECONOMIC FACTOR (YEAR 2017)

Socio-economic factors		Extreemly Digitally Poor	Digitally Poor	Connected	Digitally "Wealthy"
Gender	Man	21.20%	47.80%	15.10%	15.90%
	woman	29.00%	42.50%	13.00%	15.60%
Education (individual)	> elementary	49.60%	48.30%	0.00%	2.20%
	midle	15.50%	45.40%	22.40%	16.70%
	bachelor	2.00%	33.40%	0.90%	63.70%
Job (individual)	farmer	29.30%	56.40%	9.20%	5.10%
	others	22.50%	40.00%	16.50%	21.00%
Household income	< 1million	37.90%	46.00%	7.90%	8.20%
	1-2 million	25.70%	46.20%	14.40%	13.70%
	2-5 million	10.10%	44.80%	19.80%	25.30%
	> 5 million	4.70%	34.70%	24.10%	36.50%

TABLE V. THE VALUE OF THE RURAL DIGITAL POVERTY BY SOCIO-ECONOMIC FACTOR (YEAR 2017)

Year	Chi-square test	Contingency coefficient
Gender	40.592a*	0.091*
Education (individual)	1.625E3a*	0.502*
Job (individual)	2.939E2a*	0.24*
Household income	4.995E2a*	0.306*

*significant: p-value < 0,05, α 5%, chi-quare test > chi-square table

V. CONCLUSION

ICT development problem is not only a matter of connectivity (infrastructure) but also about the digital inclusion as part of the empowerment issue. The digital poverty reflects the availability and capacity in access to many resources and essential services such as education, health, and social security. By this research, the facts have been found. In general, the gaps in infrastructure growth with digitally "wealthy" strengthen the importance of empowerment in the development of ICT in Indonesia. The gap of digital poverty still occurs between rural-urban and also among socioeconomic factors. ICT efforts to reduce poverty will face socio-economic problems, such as education, household income, and individual livelihood. This condition means that digital exclusion potentially can happen in rural areas. The benefits of ICT are always felt only by the people who have higher income and education. Rural ICT policy must emphasize the need for well-being, strengthening digital literacy and ICT alignment with the necessity of rural communities' livelihoods.

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Gender Inequality on the Internet Access and Use in Indonesia: Evidence and Implications

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***Abstract*—Gender equality is a substantial means of sustainable economy as well as providing benefits to the society and humanity. Unfortunately, the gender gap persists worldwide, hindering women from reaching their full potential. It is essential to measure existing gender gaps as an initial step prior to establishing an appropriate policy to promote the equality. This study focuses on examining the gap in Information and Communication Technology (ICT), especially in the access and use of the Internet. Removing the gap in ICT is important because ICT is potential in promoting the equality in other fields. We propose a logistic model regression to measure the gender gap in Internet access, and a cross-tabulation to measure the differences on Internet use. We employ a logistic regression due to its ability to present the likelihood of internet users to be male compared to female. The model is applied on the data collected from 9574 respondents in 34 provinces in 2016, covering urban and rural areas. The results show that gender gap in Internet access exists in which the male has 1.046 times the likelihood to be an internet user than female. However, the difference is statistically insignificant. Concerning the Internet usage, male participation is relatively higher than female for most activities. The gap in rural areas, in both access and usage, is relatively higher than in urban areas. This implies that there is more potential in rural areas that cannot be maximized. There are several barriers for women to adopt the Internet, namely awareness, affordability of devices as well as service cost, digital skills, online security, and relevant contents. To close the gender gap, it is mandatory for all stakeholders to perform coordinated and concerted actions to remove the barriers. The existence of higher gaps in rural areas indicates the need to pay more attention and to devote higher efforts to realize the equality.**

Keywords—*gender gap, internet access, internet use, rural, urban*

I. INTRODUCTION

Gender equality is essential to reach a peaceful, prosperous, and sustainable world[1]. The importance of gender equality has been affirmed in the United Nations Sustainable Development Goals (SDGs), especially the fifth goal. According to the World Bank, women account for half of the world's population. The existence of gender inequality will hinder the global economy from reaching its full economic potential because every disparity has economic consequences. A Study by McKinsey showed that improving gender equality will lead to the addition of USD 12 trillion to the global annual GDP by 2025. This economic potential will increase up to USD 28 trillion if women have identical roles to that of men in labor markets [2].

The World Economic Forum (WeForum) has published the last Global Gender Gap Report in 2017. It put Indonesia in 84th place out of 144 countries in terms of the gender gap. Small improvements have been made from 2006 to 2017. In 2006, the overall score was 0.654, while in 2017 it increased to 0.691. There are two sub-indexes, i.e., Educational attainment and Health and survival, having a score close to 1 (one) that indicates that the two are almost in the level of parity. The sub-index of economic participation and opportunity has a lower score (0.691), while political empowerment is the worst with the score of 0.193[3].

There is a recognition pertaining to the vital role of ICT to promote gender equality. We can utilize ICT as a catalyst of political, social, and economic empowerment for women [4] [5]. ICT allows people to access the same resources and opportunities available online. Women can utilize ICT as a tool for breaking constraints to have a stronger voice in the public space. It is common now to exploit ICT to mobilize national and international public opinion regarding a discriminatory issue. ICT also eases women to have better access to basic healthcare information, education, jobs, and financial inclusion. Female entrepreneurs can also utilize ICT to enter the global market and to boost their business.

To gain the benefit of ICT in promoting gender equality, it is essential for women to have the same access to ICT as men. As pointed out by ITU Broadband Commission, the first step of bridging the gender gap in Internet access is to assess the sex-disaggregated data on Internet access and use [6]. A study by Rohman and Bohlin published in 2011 has confirmed the role of gender in predicting the subscription to the mobile Internet, where men have 1.3% to 1.4% greater likelihood to be subscribers than women [7]. Their study used survey data in 2009 which was collected by Ericsson Consumer Lab, Regional South East Asia office in Kuala Lumpur, Malaysia. The survey was carried out in eight cities in Indonesia: Jakarta, Bandung, Surabaya, Semarang, Medan, Makassar, Balikpapan, and Batam. Most of the cities are in Java island, and none of them represents the easternmost provinces of Indonesia, i.e., Papua, West Papua, Maluku, and North Maluku. Although the study includes urban and rural areas as a predictor in the model, the study did not capture the differences in the gender gap in urban and in rural areas separately. It is better to capture the detail of the gap, so all stipulated policies will be more targeted and focused. Another study by Puspitasari and Ishii, published in 2016, concerns on the digital divide in Indonesia. The study shows

that gender has significantly affected the mobile Internet subscription, where women have 0.339 times of likelihood to be subscribers compared to men [8]. This indicates there exists a significant gap between men and women on mobile Internet access. However, this study only focusses in three large cities in Indonesia, namely Jakarta, Bandung, and Yogyakarta. Consequently, their research only is relevant for the case in urban areas. Besides, all survey locations are in Java implying less ability to generalize the findings to the entire Indonesian population.

This study seeks to fill aforementioned gaps by taking the case of the Internet in general (not only mobile Internet) and using survey data from all provinces in Indonesia. In addition to capturing the gender gap in all samples, this study also analyzes the gap in urban and in rural areas separately to obtain the gap in more detail.

The structure of the rest of the paper is outlined as follows: Literature review is described in Section II, followed by Research Methods in Section III. We place Results and Discussion in Section IV, while the conclusion of the study is presented in Section V.

II. LITERATURE REVIEW

A. Gender inequality on the Internet

When innovation is introduced to the society, some will adopt it as soon as it is available while others will wait and observe for a period of time before deciding whether to adopt it. Diffusion of innovations is a theory popularized by Everett Rogers that tries to explain how, why, and at what rate an innovation spread in the society. Roger argues that the spread of innovation will depend on four factors, i.e., the innovation itself, communication channels used to introduce the innovation, time, and the social system[9]. To the adopters, the adoption of a new technology is usually attributed to the age, gender, educational level, economic level, place of residential (urban or rural), and ethnic status (majority or minority) [10]. Gender is one of the inequality dimensions often associated with the technology diffusion, including access and use of the Internet. Some researches presented details regarding ways in which men outperform women in terms of technological skills development and ownership. For example, men relatively have higher interest and spend more time using computers than women[11] [12]. Bimber (2000) has a different view that the difference in the adoption rate between men and women is not directly associated with gender itself, but the difference of the socioeconomic status [13]. The difference in opportunities to get education also results in a gender gap. Education is a powerful tool for communicating the gender gap in Internet access and use [14]. Terry and Gomez (2010) conveyed another explanation pertaining to the gap; the existence of economics, cultural, and literacy barriers will inhibit women from using technologies despite having access [15]. It is important to pay attention to this inequality since those who use the Internet at lower rates have a risk to be excluded from some opportunities and lose political influence [16]. If gender dimensions of ICT are identified and addressed, ICT can be a powerful catalyst for political and social empowerment of women, and a tool to promote gender equality [5].

B. Related works

Previous works have investigated differences in accessing and using the computer and the Internet among different socioeconomic and demographic factors, including gender. Most of them use cross-sectional data and apply discrete analysis methods, such as probit and logit.

Bimber (2000) used survey data collected in 1996, 1998, and 1999 to find the gender gap in the access, frequent use, and moderate use of the Internet. He found that in 1996 and 1998, men are 5% more likely to have access to the Internet than women. This gap is statistically insignificant. In 1999, the gap has increased to 10% and was significant [13]. Another study by Ono and Zavodny (2003) used data from US Current Population Survey (CPS) and found that in the mid of 1990s, there was a significant gap between men and women in using the Internet. By 2000, the gap in Internet use disappeared, but women remain less frequent and less intense in using the Internet than men [17]. In Indonesia, Rohman and Bohlin used cross- sectional survey data collected in 2009. The main goal of their study was to find the cause of the digital gap with a focus on the demand and supply problem. They use socioeconomic and demographic factors, including gender, into the list of redictors in their proposed model. They found that the gender gap in mobile Internet access is relatively low, where men have a higher likelihood to subscribe to the Internet of 1.3% to 1.4% compared to women [7]. The most recent related study was published in 2016 by Puspitasari and Ishii. They obtain data through a survey in three cities in Indonesia. Their research confirmed the existence of the gender gap in mobile Internet access in those cities (Jakarta, Bandung, and Yogyakarta).

III. RESEARCH METHOD

A. Data and variables

This study uses nationwide survey data collected in 2016. The survey was commissioned by the Research and Human Resources Development Agency, Ministry of Communication and Information Technology of the Republic of Indonesia. The survey team succeeded to collect 9588 responses, of which 14 are removed due to incomplete answers. Hence, a total of 9574 responses are used in the analysis; 4169 of them reside in urban areas, while the rest are in rural areas.

The questionnaire captures a wide range of respondents' socio-economic background and access and the use of the Internet. This study will only utilize a few suitable variables, such as the Internet access, gender, spending per month, education, and age.

Internet access is a binary choice, "yes" or "no". "yes" is an option to indicate that the respondent is an internet user. *Internet user* is a person who uses the Internet at least once in the last three months. *Gender* has two options: male and female. *Spending per month* has five caterogies: less than IDR 500,000, between IDR 500,000 to IDR 1 million, between more IDR 1 million and 2 million, between 2

million and 5 million, and more than IDR 5 million. *Formal educational* attainment has six categories: none, elementary school, junior high school, senior high school, diploma or undergraduate, and graduate or post graduate. *Age* captures the actual age of the respondents.

B. Analysis method

We perform two kinds of analysis. We apply logistic regression to measure the gender gap in the access, while on the usage we employ cross tabulations. We use logistic regression analysis when the dependent variable is categorical [18]. The dependent variable, i.e., the Internet access has only two categories, i.e., the Internet user and non-Internet user, hence binomial logistic regression is deemed to be the most appropriate method. The same method has been used by earlier works to assess the gap in ICTs. For example, Bimber (2000) used logistic regression to measure gender gap on the Internet in United State [13], Hu, et al (2009) applied the method to examine gender difference in Internet use by taking case in a university in North America[19], while Puspitasari and Ishii (2016) utilize a logistic model to investigate digital divide in Indonesia[8]. We propose a logistic model to answer the study objective as presented in equation (1). The equation estimates the likelihood of being an Internet user (Y=1), which is influenced by gender, monthly spending, education, and age. We measure the gap through the odds ratio, the exponential value of the coefficient, of each independent variable. Odds ratio represents the likelihood that an outcome will occur given a certain condition of an independent variable, compared to reference condition. In this context, an odds ratio shows the likelihood of men to be Internet subscribers compared to women. Odds ratio of 1(one) indicates the gender gap on the Internet access does not exist, while the less or higher value depicts the existence of the gap. The farther the likelihood value from 1 (one), either less or more, the higher the gender gap.

$$P_i = E(Y = 1 | X_i) = e^Z / (1 + e^Z) \quad (1)$$

where,

$$Z = \beta_0 + \beta_1 GENDER_i + \beta_2 SPEND_i + \beta_3 EDU_i + \beta_4 AGE_i$$

GENDER is the respondents' sex. *SPEND* is the total monthly spending. *EDU* is the respondent's last formal education achievement. *AGE* is the age of the respondent and classified into three categories. i.e., below 25 (AGE25), 25 to 45 (AGE2545), and more than 45 years old (AGE4).

To obtain the gap on Internet use, we simply deduct the percentage of women who participate in a certain activity in the Internet from percentage of men who participate in the same Internet activity.

IV. Result and Discussion

A. Respondents profile

Survey responses show that the Internet has been adopted by 34.88% of respondents. Concerning gender, the composition of men and women is relatively close, with 50.84 percent male and 49.16 percent female. The highest response for formal education attainment is the senior high school with a response rate of 35.79%, and the lowest is postgraduate at 0.58%. The response rates of elementary school, junior high school, and undergraduate or diploma are 25.98%, 22.58%, and 11.79%, respectively. 3.27% of respondents have none of the formal educational attainments. According to the distribution of respondents' monthly spending, most of the respondents spend between IDR 500,000 to 1 million in one month, with a response rate of 31.76%. Only 1.33% of respondents spend their money higher than IDR 5 million. Regarding the respondents' age, the survey shows that more than 50% come from the age of between 25 to 45 years old, while respondents under 25 years and over 45 years old have almost the same proportion, 24.04% and 25.82%, respectively.

B. The gap on the Internet access

Prior to performing binomial logistic regression, each variable response is converted to a categorical scale as we display in Table 1.

We analyze the gender gap in the Internet access in Indonesia in three groups of samples. The first group (Group 1) consists of all samples, 9574 responses. The second (Group 2) and the third group (Group 3) comprise

TABLE 1. CATEGORICAL CODE FOR EACH VARIABLE

Variable name	Categorical code
Internet (INTERNET)	(0) not internet user (1) internet user
Sex (GENDER)	(0) Female (1) Male
Monthly spending	Reclassified from original options (less than IDR 0.5 million, IDR 0.5 to less than 1 million, IDR 1 to less than 2 million, IDR 2 to less than 5 million, and higher than IDR 5 million) to: a. SPEND2: less than IDR 2 million b. SPEND25: IDR 2 to 5 million c. SPEND 5: higher than 5 million SPEND2 is used as reference dummy, therefore it is excluded from the model to avoid multicollinearity. Each category use code (1) to represent that the respondent's monthly spending is in the range of the category, while (0) otherwise
Education (EDU)	Regrouped from original options (none, elementary school, junior high school, senior high school, undergraduate, and postgraduate) to: (0) up to senior high school (1) undergraduate and postgraduate
Age	Age is classified into three categories. i.e., below 25 (AGE25), 25 to 45 (AGE2545), and more than 45 years old (AGE45). Age of more than 45 (AGE45) is used as reference dummy, therefore we exclude it from the model to avoid multicolinearity. Each category use code (1) to represent that the respondent's age is in the range of the category, while (0) otherwise

TABLE 2. STATISTICAL TEST OF INDIVIDUAL VARIABLES

VARIABLE	Odds Ratio		
	Group 1 (All)	Group 2 (Urban)	Group 3 (Rural)
GENDER	1.046	1.042	1.113
AGE25	2.521 ***	2.789 ***	2.608 ***
AGE2545	1.350 ***	1.285 **	1.614 ***
EDU	4.709 ***	4.472 ***	4.198 ***
SPEND25	3.074 ***	3.035 ***	2.683 ***
SPEND5	13.616 ***	16.253 ***	8.893 ***

Note: *, **, *** denotes the significant level at 5%, 1% and 0.1%

subsamples collected from the urban and rural area, respectively. In all groups, men have a higher penetration of the Internet access than women, with gaps of 4%, 1%, and 8.4% for each group. To investigate the significance of the gap, all groups apply the same logit model as presented in equation (1). Table 2 shows the results. From the table, we can observe that all variables are relatively consistent in explaining the likelihood of being Internet users. They have an odds ratio of higher than one indicating that respondents who are male, better educated, more affluent, and younger have a higher likelihood to be an Internet user. Among the variables, gender is the only variable that has a significant level higher than 10% in all groups. Although its odds ratio is higher than 1, the magnitudes are relatively low compared to the others. Group 1 has a gender's odds ratio of 1.046. This means that in overall men have 1.046 times of likelihood to be an Internet user than women. Among the three groups, Group 3 (rural group) has the highest odds ratio. From this empirical result, we can infer that the gap between male and female in Internet access is relatively higher in the rural area.

C. The gap on the Internet use

Table 3 displays the cross-tabulations of gender and the activities on the Internet for all groups. The table shows the percentage of men and women engaging in various activities on the Internet accompanied by the gap of each. Most of the activities predominantly by men. Out of 16 activities, the highest difference is in the use of the Internet for searching information about governmental services, with gaps of 8%, 6.8%, and 10% for each respective group. This finding is consistent with that of Akman, et.al (2005) that reveals the significant gap between males and females in accessing public (government) web sites in Turkey [20]. One plausible explanation is that because of the patriarchal character of the society, women have not been able to derive equal benefits from various government initiatives [21]. A Study in India shows that while it is generally assumed by policy makers (mainly male) that e-governance programs will benefit men and women equally, in reality there is a vast difference in the availability, use, and access of e- governance schemes for men and women [22].

In Group 1, 14 out of 16 listed activities, the participation of men is higher than women with the gaps varying between 1% to 8%. The two other activities, namely looking for information about school lessons and online transactions, are predominantly done by women. Yet, the differences

TABLE 3. ACTIVITIES ON THE INTERNET BY GENDER

No	The use of the Internet	Group 1 (All)			Group 2 (Urban)			Group 3 (Rural)		
		Male	Female	Gap	Male	Female	Gap	Male	Female	Gap
1	Information of goods and services	45.7%	39.6%	6.0%	50.4%	44.1%	6.3%	39.3%	32.7%	6.6%
2	Information on education	38.3%	37.4%	1.0%	40.7%	37.1%	3.6%	35.2%	37.8%	-2.6%
3	Information on health	33.3%	31.0%	2.3%	35.4%	33.8%	1.5%	30.6%	26.7%	3.9%
4	Information on government services	22.9%	14.9%	8.0%	23.7%	16.9%	6.8%	21.7%	11.7%	10.0%
5	Email	34.3%	31.0%	3.2%	38.9%	34.8%	4.1%	28.1%	25.2%	2.8%
6	Video Call	20.6%	19.0%	1.6%	24.5%	22.2%	2.3%	15.3%	14.0%	1.3%
7	Instant messaging	43.8%	41.4%	2.4%	46.2%	46.1%	0.1%	40.7%	34.3%	6.4%
8	Information of school lesson	29.9%	30.3%	-0.4%	32.8%	33.1%	-0.4%	26.2%	26.0%	0.1%
9	Game	36.9%	32.9%	4.0%	40.3%	37.3%	3.0%	32.3%	26.0%	6.3%
10	Movie	40.7%	36.3%	4.4%	44.6%	39.4%	5.2%	35.6%	31.6%	4.0%
11	Shareware	21.5%	15.2%	6.4%	25.2%	18.8%	6.4%	16.6%	9.5%	7.1%
12	News	26.9%	23.5%	3.4%	30.0%	26.3%	3.7%	22.8%	19.2%	3.6%
13	Jobs	23.7%	20.2%	3.6%	26.9%	23.4%	3.6%	19.5%	15.2%	4.2%
14	Accommodation service	13.6%	10.3%	3.3%	16.7%	14.8%	1.9%	9.4%	3.3%	6.1%
15	Networking/forum	9.6%	7.2%	2.4%	11.3%	8.7%	2.5%	7.4%	4.8%	2.6%
16	Online transaction	19.4%	20.2%	-0.8%	23.7%	23.1%	0.5%	13.7%	15.7%	-2.0%

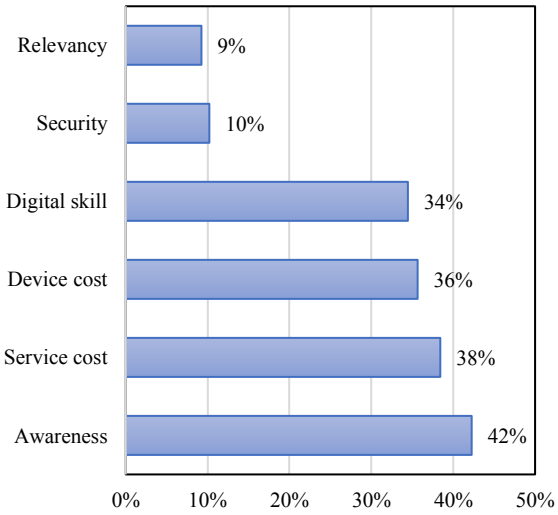

Fig. 1. Barriers of women to be internet users

are relatively small, less than 1%. In Group 2, except for the activity of looking for school lesson, the participation of men outnumbers women. In Group 3, searching for education related information and online transactions place women as having higher participation than men.

If we classify activities into information-related, entertainment-related, communication- related, and transaction-related activities, we find that the average gap of entertainment- related activities (games and movies) is relatively higher than the others for all groups of samples, with a range of difference between 4.1% to 5.2%. Meanwhile, the lowest average gap is in transactions-related activities (accommodation services and online transactions) in which the gap varies between 1.2% and 2%. With such a classification, we observe that the highest gap consistently remains in the rural group. Disparities in telecommunication infrastructure, human capital, and education services between rural and urban areas explain this rural-urban gap [23].

D. Barriers of women to be internet users

The questionnaire also contains questions regarding the reasons for not being internet users. There are several barriers restricting women to be an Internet user as presented in Fig.1. The figure displays the percentage of women non-users who consider them as hinderances of being Internet users. Among others, lack of awareness is considered as the main barrier by 42% of women non-user respondents. A recent survey report by GSMA published in February 2018 also confirmed this issue. The report showed that women relatively have lower awareness of mobile Internet than men with the gap of 6% [24]. It is important to educate non-users regarding the benefit they can obtain by accessing the Internet.

The second barrier is affordability. This barrier is highly related to women's income, the Internet service cost as well as the price of the user device. A study by Sohn found that women's earnings in Indonesia is approximately 30% less than men [25]. Similarly, Taniguchi and Tuwo (2014) confirmed that men received higher wages than women in both urban and rural areas[26]. In terms of the Internet service price, an ITU report showed that the price of prepaid entry-level mobile data plan (500 MB) in Indonesia was about 1.36% of the GNI per capita [27]. This price level has yet to meet the ideal target as proposed by the Alliance for Affordable Internet (A4AI), i.e., less than 2% of average monthly income for 1 GB of mobile data plan [28].

The next barrier is lack of digital skills. As cited by Broadband Commissions, people with lower level of education often lack digital skills, restricting them from accessing the Internet. Statistical data published by the Central Bureau of Statistics also (BPS) shows that the average years of schooling of men older than 15 years old is higher than women, i.e,. 8.75 and 8.09 years, respectively [29]. We can improve women's digital skills through capacity- building initiatives, either by integrating them in formal education or through informal trainings.

Another barrier restricting women to access the Internet is online security. The fears of any kinds of harmful contents as well as various types of cybercrime influence women's decision of not adopting the Internet. The last barrier is the lack of relevant content. Relevant contents could be contents in the native language or contents useful for women's daily lives. Developing online contents that are accessible for women with limited digital literacy and skills is important to encourage them to be internet users.

V. CONCLUSION

This analysis shows that the gap in Internet access exists between men and women in which men have a higher likelihood to be Internet users. However, the differences are low and statistically insignificant. Regarding the Internet use, the participation of men is relatively higher than women for almost all listed activities, both in urban and in rural areas. Among the groups of samples analyzed, the highest gap is present in the rural group. We have identified several hindrances for women to access and use the Internet, namely awareness, affordability of user device as well as service cost, digital skills, online security, and relevant contents.

The implications of the findings are as follows: there are more potentials in rural areas are less maximized. It requires more attention and greater efforts from all stakeholders, including policymakers, industry, nongovernmental organizations (NGOs), and academia, to close the gender gap in rural areas. There are several proposed actions to remove the gaps which include: a) increasing the awareness of women about the benefit of the Internet, especially non-users; b) improving affordability of access device as well as service cost; c) increasing women's digital skills to ensure that they utilize the Internet effectively, hence maximizing the benefits they can reap from the Internet; c) guaranteeing that women are protected when accessing the Internet; d) integrating the target about gender equality into a national ICT plan; e) providing more women-related contents to increase women's interest on the Internet. This can be realized by increasing the number of female content developers.

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Public Acceptance Strategies for Digital Terrestrial Television (DTT) in the Border Areas

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***Abstract*— Digitalization of television broadcasting networks is essential due to efficient use of spectrum. To achieve this goal, the Ministry of CIT has a strategy by developing broadcasting infrastructure and providing associated devices required by end users, 61 million household approximately who live in the border region. In this paper, we analyze the strategy using the Strength, Weakness, Opportunity, and Threat (SWOT) methods. The results of the study indicate the need to increase the number and variety of broadcast content to increase public interest in digital terrestrial television (DTT) in the border region. In addition, the provision of Set-Top-Box (STB) needs to be equipped with antennas and other supporting devices, as well as installation. Furthermore, the involvement of local governments and local communities needs to be encouraged to increase public awareness and support for DTT.**

Keywords—border area, digitalization, digital terrestrial television, SWOT

I. INTRODUCTION

Information is an essential and strategic commodity needed by the community. Therefore, the democratic state must fulfill the right of the people to obtain information regardless of territorial boundaries. Broadcasting institutions are a channeling medium and source of information, building public opinion and forming perceptions. The existence of broadcasting institutions must be felt by all people, including residents in the border region. As a space of political entity that is a line of upholding the sovereignty of a country, the border region is a sign of the legitimacy of the nation and is a locus of connectivity and discontinuity between countries [1].

Despite having a strategic position, the border area has been synonymous as a remote and backward region. Not all broadcasting institutions are able to reach border areas, there are even blank spot areas due to geographical conditions or are not economically profitable for broadcasters to establish. In addition, broadcasting on the border also faces broadcast spillover from neighboring countries [2]. This condition causes the existence of foreign broadcasters more dominant than Indonesian broadcasting institutions. Based on data from the Directorate General of Resources Management and Postal and Information Technology Equipment, the Ministry of Communications and Information Technology, Barelang TV, Batam received frequency interference from TV1 Malaysia since 2010 [3]. The exposure of impressions from neighboring countries that are consumed continuously is also feared to cause ideological and cultural imperialism [2].

Concrete steps are needed to penetrate broadcasting in border areas. The Public Broadcasting Institution- LPP must be present and maximize its role in se`rving information, entertainment and education needs for the community. Law number 32 of 2002 concerning Broadcasting mandates LPP TVRI as a public service broadcasting television that serves to provide services for the benefit of the community. Public broadcasting is assumed to be a cultural role, which differentiates from other public service enterprises. An excellent public service system should at least presents audience members that would stretch their minds and horizons [4].

Public service broadcasting continues to bring significant benefits to society in many ways. It ensures diversity in the media and plurality in the news and creates programming which reflects and examines wider society. It also plays an important economic function in supporting the broader creative industries, particularly the independent production sector [5]. New technologies and the dynamic effects of convergence are changing the way consumers access audio-visual content. The broadcasting sector includes Public service broadcasting has been undergoing significant technological and structural changes, which have given consumers access to a great variety of communications and media services. Convergence is changing the way in which consumers use communication services and consume content, as it is available on new platforms and various wireless portable devices. At the same time, technological change has impacted on regulation and conditions of competition [6].

Digital television broadcasting policy In Indonesia, it is carried out to provide opportunities for channel availability for broadcasting, both the development of existing technology and the demand for new broadcasting that cannot be accommodated with analog technology [7]. The Indonesian government has made various efforts for DTT, including the development of DTT infrastructure and the policy of distributing set-top boxes or the procurement of DTT broadcasting devices for residents in border areas. Provision of broadcasting infrastructure in border, remote and outermost areas is a real effort so that the needs of the community for educating and enlightening information can be carried out.

Telecommunication and Informatics Financing Provider and Management Center- BP3TI which has the task of providing ICT infrastructure in the 3T region including the border area, since 2016 has built television transmitters and provided set-top boxes for border communities so that they can access information disseminated through DTT of TVRI. This program is to reduce information gaps between regions in Indonesia and increase LPP TVRI's ability to expand information dissemination and increase the capacity of TV

programs. Therefore, the right strategy is needed for public acceptance of DTT to get the appropriate target.

This paper comprises five sections. The second section discusses digital broadcasting, public broadcasting in the border area where digital television system is a need for information technology development and DTT Broadcasting. The third part presents the government program to encourage DTT broadcasting in the border region by providing broadcast infrastructure and supporting devices. This section also discusses Public acceptance strategy of DTT in border areas. The fourth section presents the conclusion.

II. LITERATURE REVIEW

A. Digital Broadcasting

Deegan and Tanner [8] explain that digitization is a convention of all forms of printed documents or other types of digital presentation. Flew [9] mentioned that digital information has its own characteristics such as manipulative, networkable, dense, compressible and impartial. World migration to switch from analog television broadcast systems to digital television broadcasting systems is conducted to answer the demands of the development of information technology. The International Telecommunication Union (ITU) held a conference to explain the demands of technological development from analog to digital in 2006.

In analog systems, one channel can only be filled with one frequency, while in a digital system, one channel can be filled with more than seven frequencies at once. In the digital system, frequency widening can be done. Unlike analog technology that allows only one frequency for one broadcast slot [10].

B. Public Broadcasting in the Border

The United Nations universally recognize freedom of information through Article 19 of the Universal Declaration of Human Rights [11]. In Indonesia, Article 3 of the Broadcasting Law in 2012 [12] states that broadcasting is carried out with the aim of Strengthening national integration.

In addition, the 1945 Constitution also guarantees the public to obtain information as stated in article 28F that "Everyone has the right to communicate and collect data to develop their personal and social environment, as well as the right to seek to obtain, possess, store, process, and convey information using all types of channels available. Public broadcasting in various countries varies in form, the manner of funding, relationship with politics, governance, independence and the responsibility of the answer.

Collins [13] reviewed various concepts about public broadcasting. A critical approach to understanding public broadcasting is to use the idea of neo-Habermas which holds that public broadcasting is a guarantor and institutional instrument of the modern public sphere.

C. Digital Terrestrial Television

The most dynamic and technically complex environment of TV content distribution is DTT broadcasting. Digital terrestrial broadcasting can be designed to work with roof-top antennas but also with small antennas built into portable devices and for mobile reception. In case of a disaster, devices that do not depend on larger antenna installations are more likely to continue serving the public than, for example, satellite TV which relies on parabolic dish antennas [14]

Terrestrial broadcasting is uniquely important because it is wireless (supports receivers that can move), infinitely scalable (point-to-multipoint and one-to-many architecture), local (capable of delivering geographically local content), timely (provides real-time and non-real time delivery of content) and flexible (supports free-to-air and subscription services). The attribute of wireless delivery of media content to a potentially unlimited number of receivers makes terrestrial broadcasting a vital technology all over the world [14]

III. RESEARCH METHODOLOGY

A. Data Collection

We have collected primary data by interviewing Head of broadcasting sub-division, infrastructure division of Telecommunication and Informatics Financing Provider and Management Offices (BPPPTI). Meanwhile, the secondary data are obtained from the literature study on existing regulation and previous research related to digital terrestrial television.

B. Research Analysis

The data collected are analyzed using Strength, Weakness, Opportunity, and Threat (SWOT) methods. SWOT analysis is a strategic planning tool which examines internal strength and weakness, also opportunities and threats which are external factors of an organization.

In 1992, Kearns [15] introduced a SWOT model, which considered as a more appropriate overview for relevant policy issues [16]. The typical SWOT model matrix is given in Table 1.

The matrix which is shown in Table 1 presents two internal factor cells (strengths and weaknesses) as well as two external factor cells (opportunities and threats). Four other cells labeled as comparative advantage, mobilization, investment/divestment, and damage control are policy options resulted from a combination of its internal and external factors [16].

Comparative advantage cell represents a stable position to take advantage of specific opportunities. In “mobilization” cell, the organization may overcome the threats by mobilizing the existing resources. Investment/divestment cell describes expectant opportunity, despite the weaknesses circumstances. The organizations have choices to invest in turning the weak condition into strength, divesting the weakness circumstances, and maintain the status quo [15].

TABLE I. SWOT MODEL MATRIX

	Opportunities	Threats
Strengths	Comparative advantage	Mobilization
Weaknesses	Investment/Divestment	Damage Control

IV. DISCUSSION

A. *Existing Condition of Infrastructure Deployment and Set-Top Box (STB) Distribution in Border Areas*

The Indonesian broadcasting industry is still based on analog broadcasting since there is 61 million number of households watching analog television. Television digitalization is carried out for the efficient use of radio frequency and digital dividend for the public interest such as the need for disaster management, education, health, broadband, and increased connectivity and information access. The use of spectrum in Indonesia already increasingly critical as the market of mobile-based telecommunications and consumption data-based communication rises [17].

ITU launched analog-switched off worldwide in 2015. However, there are only five countries in the Asia Pacific that have completed ASO, namely Japan, Australia, Korea, New Zealand and Mongolia [18]. In the midst of low progression ASOs, countries in ASEAN have agreed to ASO at the latest until 2020 [19]. In ASEAN, Vietnam, Singapore, Thailand, and Malaysia have started the migration process. Singapore and Malaysia set ASO targets in Vietnam, Thailand and Malaysia set ASO targets in 2020. [20].

BPPPTI encourages accelerations of DTT in the border region by providing digital infrastructure and supporting devices consisting of DVB-T2 transmitter, tower optimization and upgrading electricity supply and provision of STB. This effort is carried out to disseminate information through LPP TVRI in the border area starting in 2016. BPPPTI has built transmitters in 10 border area locations includes Bukit Batu District (Bengkalis Regency, Riau), Nunukan District (Nunukan Regency, North Kalimantan), District Atambua Barat (Gelu Regency, NTT), Sekayam District (Sanggau Regency, West Kalimantan), District of Central Ternate (Ternate Regency, North Maluku), Padang Selatan District (Padang Regency, West Sumatra), Suwela District (East Lombok Regency, NTB) , Wangi-Wangi District (Wakatobi Regency, Southeast Sulawesi), Middle Tarakan District (Tarakan Regency, North Kalimantan), and Sanggauledo District (Bengkayang Regency, West Kalimantan).

The development of DTT infrastructure in the border area helps the process of digitizing LPP TVRI to all over Indonesia. At the end of 2016, TVRI's digital broadcasts were affordable in all provincial capitals in Indonesia with 43.2 percent broadcast coverage and 54.5 percent population coverage. From 2018 to 2019 the range of TVRI broadcasts is targeted to reach 72 percent, and the population reaches 88 percent [21].

BPPPTI has distributed 5000 digital broadcast receiving devices or STB to the public in 10 transmitter locations in 2016. Distribution of STB is needed to increase digital television penetration, especially during the transition from analog to digital. To evaluate the set-top box distribution that has been distributed, in 2018 BPPPTI surveyed the study of the effect of STB on the digital television broadcast service zone in 2016-2017. The survey was conducted on 466 respondents in 9 locations providing TVRI infrastructure and digital broadcasting devices for determining the effectiveness of the STB distribution and community interest in watching digital television broadcasts in border service zones. The survey results conducted by BPPPTI are shown in Table II:

TABLE II. SURVEY RESULT IN NINE LOCATIONS

Parameters	District							
	Sanggau dan Bengkayang, West Kalimantan	**Tarakan, North Kalimantan**	**Ternate, North Maluku**	**East Lombok, West Nusa Tenggara**	**Belu, East Nusa Tenggara**	**Bengkalis, Riau**	**Wakatobi, South East Sulawesi**	**Padang, West Sumatera**
Regional Economic Condition	Regional economy and infrastructure are developing well	The most developed city in North Kalimantan	Major city, the most developed economy in North Maluku	Medium city, tourist location	Directly bordering Timor Leste, low economy	Location on the island, bordering the sea with Malaysia and Singapore	Archipelago district area, marine tourism location	Provincial and city/ regency capital buffer
Set-Top Box Utilization	63,2% do not utilize the given set-top box	95% do not utilize the given set-top box	95% watch digital television when their cable television is problematic	90% do not utilize the set-top box since there are no usage instruction	90% utilize the set-top box and bought the antenna	43,6% utilize the set-top box	80% do not utilize the set-top box	95% do not utilize the set-top box
Survey Finding	STB is not equipped with the antenna, more channels on cable TV	STB is not equipped with the antenna, more channels and cheap subscription fees on cable TV	Limited STB channels, cheap cable TV with many channels	STB is not equipped with antennas, cheap cable TV and many channels, digital TVB STB channels	The satellite dish is only owned by a few residents, installation is assisted by officers, STB TVRI content and 5 local LPS	10-16 STB channels, STB is not equipped with antennas, public do not know how to use STB	STB is installed but not equipped with an antenna, the STB broadcast program is limited	Limited STB content, constraints in installing STB due to due to officer lack explanation

From the survey result in Table II, most of the distributed STB are not utilized. The recipients admitted that they lacked socialization about the procedures for installation and use. The majority recipient complained about the STB which was not equipped with an outdoor antenna. In fact, for some locations, the antennas are not available to buy. In half of the locations, people generally use satellite dishes or cable TV with affordable subscription fees and various broadcast channels. However, people who were given STB and had pay cable television only use STB when their cable television is problematic. Strength, weakness, threat, and opportunities from the existing condition of infrastructure deployment and STB distribution in border areas indicated by the SWOT matrix in Table 3.

B. SWOT Analysis

From mapping the conditions Strength, weakness, threat and opportunities in Table 3, strategies can be prepared by the government and relevant stakeholders related to public acceptance for DTT in border areas, which are divided into the comparative advantage, mobility, divestment/investment, and damage control. The illustration is shown in Table 3. The strategy described in Table 3 is a solution of a combination of strength or weakness with opportunities or threat, where S indicates strength, W is the weakness, T indicates the threat, and O represents opportunities. For example, S3, O1 in the mobilization column shows the combination strategy between the 3rd point of the cell strength and the first point of the opportunities cell.

1) Comparative Advantage

As in Table I, people in several survey locations have received broadcasts from paid cable television and satellite dish antennas, which are DTT competitors. When compared to its competitors, DTT has advantages in terms of cost efficiency. One channel can load some Free to Air (FTA) content so that no monthly fees are required such as subscription cable television.

Digitalization is needed in the world of broadcasting due to its benefit in term of spectrum efficiency, quality and reliability compare to the analog broadcast system [23]. In terms of quality aspect, digital television has the main advantages of a clearer picture and better sound quality compared to analog television. Thus, the government needs to implement a promotional strategy that highlights the advantages of DTT compared to its competitors so that it can increase demand for the use of DTT.

2) Divestment/Investment

People in several BPPPTI survey locations prefer cable television compared to DTT because the content is more numerous and varied on cable television [22]. Therefore, one solution in increasing public interest in DTT is to increase the number and variety of broadcasts, especially news and entertainment content which is the most desirable content in the survey location.

Furthermore, the STB is not utilized in several survey locations, among others due to difficulties in obtaining additional antennas and lack of information on how to install and use the STB and its supporting devices. The strategy that can be applied by the government to increase digital TV penetration is to offer a complete STB solution that is

equipped with antennas and other supporting devices coupled with installation in each house. The Singapore government has implemented this scheme, which has been called the Digital Television Assistance Scheme (DTVAS) since 2014 to eligible communities [20].

3) Mobilization

Danang City in Vietnam is one example of cities in ASEAN that have conducted ASO in 2015 [24]. In addition to Vietnam, Singapore is a country that is quite successful in carrying out digital migration, marked by 3 out of 4 people in Singapore having DTT [20]. There is a different approach between the Thai government and the Singapore and Vietnam governments in the STB distribution. The Thai government subsidizes STB through the provision of vouchers to all of its people while the governments of Singapore and Vietnam subsidize STBs for underprivileged people [20][24]. The Indonesian government can develop an STB distribution model that considers the lesson learned from the distribution models that have been implemented by neighboring countries in ASEAN.

In addition to the distribution of STBs, public awareness and support play an important role in the success of DTT migration. In addition to socializing digital TV through print and electronic media, the Government of Vietnam also involves local communities in the campaign to increase public awareness and support for DTT. Collaboration with the community of volunteers was conducted in Singapore to reach the elderly and disabled [20]. Local government involvement is needed in bridging policies from the central government to people in the regions because local governments better understand the conditions and culture of their communities.

4) Damage Control

The lack of assistance in the installation and operation of the STB was one of the reasons people did not install the STB which had been distributed by BPPPTI. To overcome this, the central government and local governments can coordinate the provision of Call centers and support centers, as has been done in Vietnam and Singapore, as a forum for people who want to ask questions and get digital TV assistance, including the obstacles faced in installing and the operation of the STB [20][24].

Table III SWOT Matrix

Internal \ External	Threat	Opportunity
	1. Cable television (DTH) and internet-based television as existing competitors	1. Some countries in ASEAN have started the migration process and develop certain successful migration models
Strength	Comparative Advantage	Mobilization
1. DTT coverage (LPP TVRI) has reached 43.2% and coverage population 88% 2. DTT is more cost efficient compared to cable television (DTH) 3. Digital television has clearer picture and better sound quality compare to analog television 4. The government has the commitment to align budget on DTT migration, including in border area	1. The government and relevant stakeholder promote the advantage of DTT compare to analog television and other competitors (S1,2,3, T2)	1. The government optimized the budget to develop ASO public awareness and supports, also STB distribution models, taking into account lesson learned from other countries (S3, O1)
Weakness	Divestment/Investment	Damage Control
1. The STB which has been distributed to the public was not fully utilized 2. Lack of socialization about installation procedure of DTT 3. Existing DTT broadcast has only a small number of channel 4. Additional auxiliary equipment (UHF antenna) is needed for locations where the TV transmitter is far enough	1. The government and relevant stakeholder encourage the increasing the number and variety of DTT to increase public interest, especially in the border region (W3, T2) 2. The government and relevant stakeholder provide STB and other supporting instruments (UHF cables and antennas) evenly throughout Indonesia to support DTT penetration, especially in border areas (W4, T2)	1. The government encourage public interest in using DTT by promoting on DTT benefit and assistance in DTT installation process, taking into account lesson learn from other countries which have experience successful migration process from analog to DTT (W1,2, O1)

V. CONCLUSION

The DTT infrastructure development program and distribution of STB in 2016-2017 by BPPPTI is an effort to accelerate the migration of analogue to digital technology as well as equal access to information for border communities. The BPPPTI program with LPP TVRI implemented in these 10 locations faces a number of obstacles. Most people who accept STB do not use devices that have been given in vain even though they receive them. The condition due to the absence of additional antennas. In addition, there is no user manual and the lack of socialization on how to install or operate causes people to have difficulty using STB. On the other hand, people also want digital channels with more diverse content.

Based on the SWOT analysis, the strategy to increase the public interest in watching DTT using STB devices is by increasing the number of channels and variations in content, especially news and entertainment. Provision of STB for border communities must be equipped with additional devices, namely the UHF antenna and installation. In addition, it is necessary to prepare consumer services to assist the mentoring process such as website, call center or support center. The dissemination of DTT devices needs to involve the local government and invite local communities for socialization and assistance, including for people with disabilities and the elderly.

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The Influence of Internet Information-Communication Skills and Overloads towards ICT Rural Adoption

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Abstract— **The integration of ICT development program in rural areas should not only focus on the physical infrastructure, but also non-physical ones. Adoption plays significant role in continuing the ICT development programs in rural areas. The existing models such as TAM, UTAUT, or RuTAM weigh heavily on technology characteristics that form individual perception towards technological usability and convenience. Since internet facilitates the exchange of information and user-to-user communications, so the information and communication skills play significant role to influence the ICT adoption behaviour. The more people engage on the internet, the more information and communication occurs and therefore information and communication overloads in inevitable. There are no many studies done in these topics particularly in the context of Indonesian rural. Therefore, this study explores information and communication skills as well as overloads as the influencing factors of ICT adoptions. Two hypotheses were tested in the study. This is a quantitative study with non-probability sampling method in Gubugklakah village, Indonesia. By using statistic-descriptive analysis, the study confirmed that Information and Communication Skills and Overloads in adequate manner. Two imperative findings: 1) the information overloads has no influencing force towards ICT adoption; 2) information internet skill dominantly influences ICT adoption.**

Keywords— Information and Communication Skills and Overloads, ICT adoption, Rural

I. INTRODUCTION

The information and communication technology (hereinafter "ICT") has highly penetrated in a developing country such Indonesia. Survey shows that the number of internet users in this country grows annually. The Indonesian ISP association (APJII) survey in 2017 shows that the number of internet users in the country reaches 143.26 million (54.68 per cent) which grows from 63 million internet users in 2012 [1]. Even so, digital divide remains an issue. According to the same survey, the internet penetration in urban area is higher than rural one (72.41% compare to 48.25%). Java Island is the most penetrated among other islands in the archipelago, which is 58.08 per cent of internet users. Whereas, the least percentage of internet penetration was Maluku and Papua regions (2.49%) in which geographically are located in the most Eastern part of Indonesia [1].

The ICT physical infrastructure development has become current government's main attention at least for the last four years. One of the Ministry of Communication and Information Technology's (the MCIT) five year strategic targets is telecommunication access and digital service available in more than five thousand villages in Indonesia [2]. The programs that include 4G refarming [3], Palapa Ring Project [4] to provide national broadband access in District level, and 'Desa Broadband Terpadu' program to provide broadband access infrastructure for underdeveloped rural areas [5]. Nevertheless, the ICT physical infrastructure development should be assisted by the development of non-physical infrastructure in order to achieve the sustainability of the program in the future.

Adoption is the crucial part when new technologies are being introduced. There are so many studies done on ICT adoption topic. Scholars has been introduced many models to explain the ICT adoption. However, most of the models has been used and developed within information system field of research. This paper argues that adoption is not merely about user's perception that the technology is easy to use or beneficial. Many scholars have paid attention to other determinant factors or dimensions to explain particularly rural people's behaviour towards ICT. Bourdieu's concept of habitus to explain external factors that motivate Australian indigenous to adopt ICT [6]. Daft and Lengel's media richness theory to explain the formation of media experience, task characteristics, and social interaction as antecedent factor of ICT adoption [7].

This study explores skills and overloads concepts to explain ICT adoption in rural areas. ICT facilitates the exchange of communication as well as production and distribution of information. A person who adopts ICT may have prior, and expect an increasing of, internet skill particularly information and communication. Therefore, informational and communication skills play important roles to form the adoption. The recent development of ICT technologies facilitates more people to people connected on the internet (e.g. social media and instant messaging). The more people engage on the internet, the more information and communication occurs and therefore information and communication overloads in inevitable. These overloads, in somehow, may influence the adoption process.

Domestic studies on internet information and communication literacies and overloads topic may be insufficient, particularly on theoretical framework. Hence, this study would elaborate some existing measurement scales to assess the communication and information internet skill as well as its moderating influence toward the ICT adoption. ICT in this study includes internet, gadget (e.g. 2G, smartphone,

computer, and tablets), and service/ applications (e.g. SMS, instant messaging, and social media)

This is a quantitative study which primary data collection done by survey in Gubugklakah village (desa in Indonesian). The village is located in foothills of the Mount Bromo, one the most active volcano mountains in Malang, East Java, Indonesia. There are at least 3734 inhabitants living in the area with the primary livelihood as apple farmers [8]. Since it is located near internationally known tourist destination place, the village designated as "tourist village" and therefore some of the villagers provide tourist needs such as accommodations, travel packages, and cars rental as their household income.

Telecenter was a program that initially funded by United Nations under its Development Program (UNDP) and managed by The Indonesian National Development Planning Agency (Bappenas) under the Partnership for e-Prosperity for the Poor (Pe-PP) in 2005 which destined to give internet access for rural people and at the end to reduce the poverty [9]. There were eight telecenters had been built in East Java, Sulawesi and Papua within 2005-2007. But, this program has been stopped as the funding project stopped. A study found that the most important dimensions to keep the program sustain in the future is financial and social factors [10]. Nevertheless, there are some telecenter that remain sustain until present time. One of those is in Gubuklakah village namely Desa Wisata Gubugklakah telecenter (DWG Sakti).

II. Conceptual Framework

A. *Information and Communication Literacies for ICT Adoption*

There has been progressive theoretical and conceptual development in explaining ICT adoption behaviour. The well-known and classic technological adoption model, such as Technological Acceptance Model or TAM [11], has been developed by other scholars in to several models such as the Unified Theory of Acceptance and Use of Technology (UTAUT) model [12] and Rural Technology Acceptance Model or RuTAM [13]. Nevertheless, these models weigh heavily on technology characteristics that form individual perception toward technological usability and convenience. For instance, "Computer Playfulness" is one determinant factor that constructs perceived ease of use [14]. The RuTAM framework may consider individual factors (e.g. individual characteristics, demographic, and social influence), however the model needs further scientific test.

Since internet facilitates exchange of communication and information, both informational and communication skills become crucial factors that may influence ICT adoption. Information internet skills relate to information literacy and digital literacy [15]. Traditionally information literacy is defined as know-how to write and read. The sophisticated definition of information literacy is skill to "find, locate, and evaluate" accurate and relevant to own-information needs [16]. Some studies found that telecenter will increase information literacy. Telecenter evidently promote e-literacy for rural people in China [17]. In addition, there is relation between intensity of telecenter usage with the information literacy particularly economy information among rural people [18]. By this means, the more rural people aware of their information needs and skill, the more likely that they will use ICT.

Its ability to connect people boundless in term of time and place makes internet becomes the preferable medium for social interactions, despite of its asynchronous communication environment. The growing usage of social networking sites makes it possible for rural people, particularly youth, to expand their friend networks online to get informal peer support [19]. However, a dystopian may see internet as a cause of disconnection from offline world. In clarifying this contradiction, time spent on internet (i.e. social networking sites) weakly lead to face to face communication reduction. But, the nature of interactions, the characteristic of the participants and social self-efficacy play important role to enhance online connection for community development [20]. By this means that communication skill is critical skill that needed to engage in online world. Communication internet skill refers to "the ability to cooperate" which includes the ability to respond adequately and identify appropriate participants in the communication process. Van Deursen and his colleagues (2014) add communication internet skill into the existing internet skills measurement framework [21] [15]. Adapting to their recent framework, this study explore informational and communication internet skills in the context of ICT adoption.

H1: the increasing of informational and communication skills may drive the ICT adoption among rural people.

B. *Information and Communication Overloads for ICT Adoption*

The increasing of internet usage may cause unprecedented information and communication overloads that may overwhelm the user who may influence his or her ICT adaptive behavior. Information overloads (IO) occurs when the number of potential information is abundant so that a user may not be able to use the information efficiently [22]. The increasing number of social media, emails and instant messaging platforms has increased the number of human to human engagement online. Conceptually, communication overloads (CO) is quite similar to information overloads. If IO refers a condition that a person unable to use potential information efficiently. The CO refers to a temporal condition when a person unable to handle the flow of information during the communication process [23]. CO may hinder a person to complete his or her tasks [24].

Karr-Wisniewski and Lu (2010) propose an idea of "technology overload" in which both information and communication overloads are part of the dimensions. It refers to the condition where users are distracted due to excessive number of information that may influence cognitive ability as well as attention [25]. Logically, these overloads may influence the adoption of ICT in negative way. When a person positively perceive that ICT will fulfil his or her information needs, but due to information and communication overloads that may cause her or him stress and reluctant to use ICT in the future. The perceived information and communication overloads, or refer as "ICT media technostress", is obstructing factors of adoption behaviour [7]. Adapting Karr-Wisniewski and Lu's information overloads [25] and Cho et al.'s communication overload [23], this study investigates how these overloads may influence ICT adoption. While ICT adoption measurement scale, this study adapts Islam's RuTAM scale [13].

H2: the increasing of informational and communication overloads may decrease the ICT adoption among rural people.

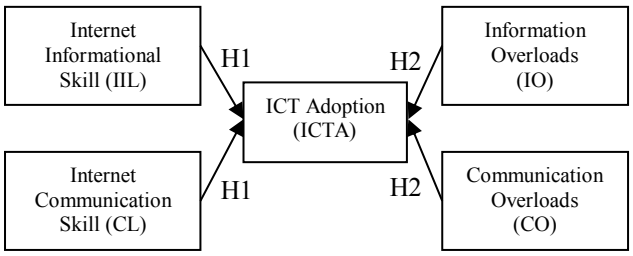

Fig. 1. The Research Framework

III. METHODOLOGY

The study uses quantitative method in which the primary data was gathered through a survey in Gubugklakah village, West Java, Indonesia. A questionnaire was developed based on five variables, which are four independent variables and one dependent variable (as seen at Fig.1.). The items of each variable were adapted from existing measurement scales which developed by scholars as mentioned earlier. Each variable has different items which in total 26 items with 5 points Likert scale (6 items of CL, 5 items of IIL, 6 items of CO, 4 items of IO and 5 items of ICTA). Each item was translated and modified in accordance to Indonesian language structure.

This study used a non-probability sampling where the samples derived from accidental sampling method. Accidental sampling is a method to select respondents who are coincidently or available in a location where the study was conducted [26]. The questionnaires were distributed in the Desa Wisata Gubugklakah telecenter (DWG Sakti) and Gubugklakah village office during 6 to 9 September 2017. There were 107 questionnaires were collected, but only 99 questionnaires were completed.

The statistic-descriptive analysis is applied by using regression analysis in SPSS version 22. A Pearson correlation technique was used to measure the validity of each item by comparing r-result with r-table [27]. All items of each variable were valid (CL= .769; .756; .751; .749; .748; .761; CO= .906; .802; .835; .776; .864; .909; IIL= .708; .705; .755; .744; .789; IO= .676; .775; .755; .717 and ICTA= .726; .691; .689; .720; .795). The alpha Cronbach (α) of all variables was above 0.6 which determined reliability (CL= .842, CO= .921; IIL= .792; IO= .706; ICTA= .773) [28].

IV. FINDINGS AND DISCUSSIONS

The respondents are consist of 48 males (48.5%) and 51 females (51.5%). The complete demographic profile of the respondent can be seen in the Table 1. Smartphone is the most owned gadget by the respondents which is 69.7%, followed by 2G hand phone (41.4%) and computer/laptop/PC (20.2%). In the last three months, the respondents have accessed smartphone (72.7%) and computer/laptop/PC (47.5%). Instant messaging is the most frequent activity whenever they use their gadget which is 33.3% followed by voice call (26.3%) and social media (24.2%).

The distribution of residual data is normal. It can be seen that one-sample Kolmogorov-Smirnov test shows Asymp. Sig. (2-tailed) is 0.2 which is more than 0.05. There was no correlation between each independent variable (multicollinearity test= tolerance >0.1 and VIF <10, CL=.748, 1.338; CO= .736, 1.358; IIL= .546, 1.830; IO= .748, 1.337). The Glejser test was used to measure heteroskedastic (sig. >0.05, CL= .114, CO= .892, IIL= .499, IO= .411). The correlation between independent variables toward independent variable was strong (R = + .649). However, the percentage of contribution independent variables toward dependent variable was only 39.7% (Adjusted R Square= .397). This means there is 51.3 per cent of other influencing factors that excluded in this study. The significant of each independent variable was measured by t-test. Only three independent variables have significant influence towards dependent variable (sig. <0.05. CL=.003; CO=.010, IIL=.008) [29]. However, IO did not influence ICTA (sig. =.901). Among these independent variables, the dominant influence was IIL (B=.283) which means that every time IIL's value increase a certain point, will increase ICTA 0.283 point.

TABLE I. DEMOGRAPHIC PROFILE

Demographic Information	Category	Freq.	%
Age	< 15 y.o.	15	15.2
	15-25 y.o.	39	39.4
	26-35 y.o.	24	24.2
	36-45 y.o.	19	19.2
	46-55 y.o.	2	2
The latest formal education	Students	85	85.9
	Bahelor	12	12.1
	Master/PhD	1	1
	No formal education	1	1
Occupation	Non public sector workers / enterpreneur	20	20.2
	Farmers/ fisherman	28	28.3
	College students	29	29.3
	Unemployement	6	6.1
	Others	16	16.2

The study confirmed that information and communication skills as well as information and communication overload influence ICT adoption in adequate manner. Two hypotheses are tested in this study. The first hypothesis (H1) is confirmed that information and communication skills have positive influence towards ICT adoption. So, the better rural people's information and communication skills, the more they would likely to adopt ICT in the future. However, the second hypothesis is not confirmed that the increasing information and communication overloads do not influence ICT adoption behaviour in negative way.

Even so, there are two prominent findings in the study that need to be explored more. First, information overloads influence ICT adoption insignificant way. It may contrary to the existing studies relating technology overloads particularly. Media technostress plays positive influence towards ICT adoption for rural people, although the information literacy may insufficient [7]. Other study, by Cao and Sun (2018), found that information overloads significantly cause exhaustion in which may lead to the discontinuing of social media usage.

The second imperative finding of this study is information internet skill found to be a dominant factor of ICT adoption,

rather than communication internet skill. This means that information seeking could motivate a person to use ICT. This could be interpreted that ICT is not used just for communication, but also for the exchange of information. Whitten and colleagues (2009) found that web based information service may increase social capital for rural youth in Michigan [30]. Information has been the essence of mentoring and/or training program for rural people in using ICT. A study in three Mexican towns found that there is growing need of poor community towards "infomediaries" which refers as actors who play role to train the community to use information. Youths in the family can be potentially become infomediaries who will induce the technology usage in the household [31].

V. Conclusion

This study confirmed that information and communication skills as well as information and communication overloads adequately influence the ICT adoption for people in *Gubugklakah* village. Internet information skills play dominant role in forming ICT adoption compare to other independent variables. In contrast, information overloads insignificantly influence ICT adoption.

The study has several limitations. First, this study cannot be generalized due to the limited scope of locus and also the non-probability sampling method that used in the study. Second, this study does not consider gender, education, daily time spent of using ICT as control variables for dependent variable. Future study can be carried out by considering other societal factors such as social influence and preferences as independent variables that effect ICT adoption in rural.

Acknowledgment

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Preliminary Work on Design Thinking: Addressing Challenges using Low-fidelity Prototyping with Rural Teenagers

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Abstract— **The strength of design thinking activity lies in the participation of users in contributing ideas in the process. In this paper, we report our findings from a preliminary work which was carried out with rural teenagers. Our aim is to inculcate the critical and creative thinking among them. Low-fidelity prototyping was used as a mean to illustrate their ideas into tangible solutions in a form of mobile application. The teenagers enjoyed the brainstorming and building the mock-ups using low-fidelity prototyping sessions. They reflected that the activity made them think about what mobile applications can do and elated on the fact on how they can actually design one. We take this work as a pilot study where in this paper we will also discuss the shortcomings that need to be addressed.**

Keywords— Design thinking, low-fidelity, rural teenagers, problem solving, creative and critical thinking.

I. INTRODUCTION

The explosion of information and communication technology (ICT), especially mobile phones, has transformed the development landscape of rural areas. Having mobile phones is a normalcy in any rural villages in Malaysia today, as the community mostly use the technology for communication, especially social media, where they often use this platform for marketing local businesses [1, 2]. Meanwhile, at about the same time, the Malaysian government launched the national blue ocean strategy (NBOS), to nurture and increase productivity, creativity and innovation by working collaboratively between the ministry, public servants and the civilians. One of the main focus is on the rural areas where initiatives must be of the ones that could increase the quality level of rural communities [3].

While many ICT developments in the past had looked into, and are still looking at providing services and infrastructures to the villagers [4, 5], this study taps into involvement of the rural villagers, particularly the teenagers, in the ICT development process. This approach can be seen as per described as co-creation according to [6], which by doing so, would aspire towards becoming smarter citizen. The design thinking approach will be used to realise this effort. The design thinking process, which consists of consists of empathize, define, ideate, prototype and test, [7] are used by many across multi-disciplinary domains and with various groups, as its techniques allow the participants to derive to creative solutions to address certain challenges or limitations.

This paper describes our effort in applying the adapted design thinking on rural teenagers to encourage creative and critical thinking. We will first present a brief background of the locality involved in our pilot study, then proceed with descriptions on how we carried out the activities with the teenagers.

II. BACKGROUND AND RELATED WORK

Rural transformation program (RTP) under NBOS is a continuous effort by the government to ensure rural regions could attract private investment, create job opportunities and economic activities, and encourage the youth generation to return to serve their communities [3]. Narrowing down to Johor state alone, the southeast of Johor, under the care of Lembaga Kemajuan Johor Tenggara (KEJORA) has set up six mini rural transformation centers (RTC) for the benefit of the villagers and the communities [8]. Each center is equipped with a room with computers, a space to sell products, which basically acts as a one-stop-center for various services. In our project, we aim to maximize the usage of computers in these centers by using a standalone low-fidelity prototyping tool in our activities.

The today's version of Design thinking (DT) was brought to mainstream by IDEO in the 1990s, though the history can go back to as far as 1970s [9]. The core idea behind DT as per stated by Kelley and Brown, the IDEO Founder and CEO, is, *"design thinking is a human-centred approach to innovation that draws from the designer's toolkit to integrate the needs of people, the possibilities of technology, and the requirements for business success*." [10]. Thus, it is no surprise that today, many big and giant companies such as Samsung, Google, IBM adopted DT in their business corporations.

DT has also been widely adopted in ICT development. To stay ahead in producing better innovative solutions and services, the development must be agile and rapid and tick all the boxes; from what users or clients wants (empathy) to validating by testing out the prototype. There is even a view to propose a profession of DT in ICT due to its potential in providing some real possibilities for improving software design when tying together with computational thinking. The fact that today's technology is dominated by software and technology, makes this point relevant [11].

As previously mentioned, the stages involved in DT are empathise, define, ideate, prototype and test, which this process is a continuous evolving process. According to [12], this is due to the repeatable steps undertaken, which can happen simultaneously or liner, until the best answers are discovered and selected. The elements of creative and critical thinking come into play, or integrated in DT, when performing each stage of the DT process. The repeatable and evolving blend of progressively integrated creative and critical thinking skills, is really what defined by Bloom's "critical thinking skills" in the Bloom Taxonomy [13]. These two elements fused really well together to create innovation in the DT process, as per mentioned before.

The approach of design thinking has proved to be a success in many projects in rural communities. This is true to areas mainly in India [14] and Africa [15], where in one example in India particularly, train the rural kids and youth to practice problem solving and critical thinking, as part of the design thinking, to solve problem [16]. The phase which usually gets people excited is the prototyping phase, where they get the chance to build mock working models, which carry onto building the real working prototypes. Prototypes can be of from low-, medium- to high-fidelity, with low-fidelity is close to mock working models, rough sketches, to high-fidelity which close to the end product [17].

III. Method

We scoped the design thinking to mobile application, as this is the closest example of the most recent ICT technology which they have access to and usually use. Furthermore, we carefully chose a software to facilitate the mock-up prototyping which uses the computer machines in the lab, to align with our aim to maximizes the usage of the computers provided at the RTC.

We sought the assistance of mini RTC officer to gather teenagers from the rural location. We mentioned that the criteria of the participants must be of teenagers and local to the place.

The questionnaires designed for this study serve several purposes. The pre-questionnaire was designed to get to know the teenager's background, the frequency they use the computers at the mini RTC, and on their exposure and usage of mobile phones. As the aim of the study is to also learn about the teenager's way of creative thinking in problem solving and critical thinking, the questions also asked, how often they come up with ideas, and what they do with the ideas. Meanwhile, for the post-questionnaire, the questions were designed to reflect as to whether the session has certain effects on them. The questions include whether the activity in some ways guided them to 'think' and properly address the 'idea'. The pre- and post- data were collected by using paper hand-outs. All recorded data were analysed and evaluated manually.

IV. Design Thinking Session

Twelve teenagers from various nearby schools participated in our program which was held at mini RTC Layang-Layang, with 9 boys and 3 girls. The session began with a short background questionnaire. In the introductory note, we briefed about what mobile applications today can do. The activities were proceeded with groups of three members, and each group is facilitated by one facilitator. We kicked off the session with a question, inspired by Alan Kay [18], *if you can build an application, what would it be?*

A. Emphathize

In a group, each of them was required to reflect their surroundings, daily tasks, and activities, that they find to be a challenge to kick start the empathize phase. Facilitator guided them that this can be anything from what they observe or what they actually experience.

B. Define, Ideate

Once a challenge is identified, each group then further defined what it was, before starting to think about what would be the best solutions their mobile application can offer to overcome the challenges. This was done using brainstorming and mind-mapping techniques, with post-it notes, colored pens and large papers (Fig. 1). The ideate phase adopted in this project has been slightly adapted to meet the mobile application concept.

Fig. 1. The teenagers worked in group, defining and brainstorming what and how the identified challenges can be solved

C. Prototype, Test

In order for them to be able to visualize their proposed mobile application, we used the low-fidelity prototyping approach to design and prepare the mock-ups. Pencil Project application [2] was used in this project as it is a standalone software which suits the condition of the computers at the mini RTC (Fig. 2). The teenagers took turn in creating the mock-ups, and completed at least one 'function'. They also had the opportunity to see what it is like by playing the 'function' they just created.

Fig. 2. One of the group member uses the low-fidelity prototyping to design the solution of their application

Once all phases are performed, we gathered all teams for quick pitching via brief presentation. Each group described

the challenge and their solutions, before demonstrating their prototype (Fig. 3 and Fig. 4). Other member from different teams also had the chance to try out the prototypes and gave feedback. The program ended with a quick survey on what they thought about the whole design thinking session.

Fig. 3. A group described the challenge, and their proposed solution

Fig. 4. Group members demonstrated how the prototype works

V. FINDINGS

The total of twelve teenagers whose ages range from the age 13 to 17 years old were involved (Fig. 5) in this event.

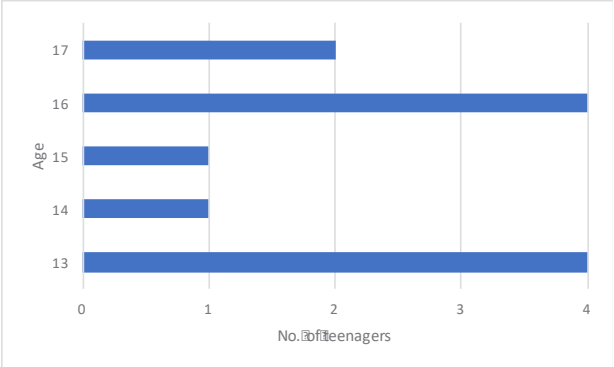

Fig. 5. Age details of the teenagers

From the pre-questionnaire gathered findings, all of them do not go to the mini RTC as often to use the computers. When asked about what they usually do if they have ideas, only 3 answered they will dwell on the ideas and thought about them further. Whilst the rest answered they never had any ideas apart from daydreaming. The survey also asked if they have smartphones, and what kind of applications they use. Out of 12, 7 said they have smartphones and they use them for social media applications such as WhatsApp, WeChat, Instagram, besides games and watching videos on YouTube (Fig. 6). Apparently, they are not aware of other types of applications with other specific purposes, for e.g. online shops, fitness, maps, learn new languages, etc. They were quite amazed and excited to know that applications are actually of various kinds to facilitate our daily chores and activities.

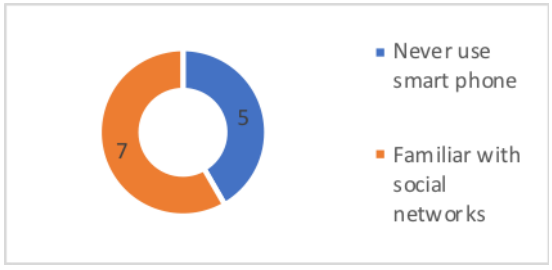

Fig. 6. Number of teenagers on smart phone usage

The post-questionnaire survey, meanwhile, shows promising results. Using a smiley-o-meter [7], all of them rated the program as good, very good and awesome! To them, this program gave them insights into something new and actually made them think – when they were asked to identify challenges and to find suitable solutions. They really enjoyed the hands-on activity to design the low-fidelity prototypes, and few mentioned they liked the work-in-group activity (Fig. 7).

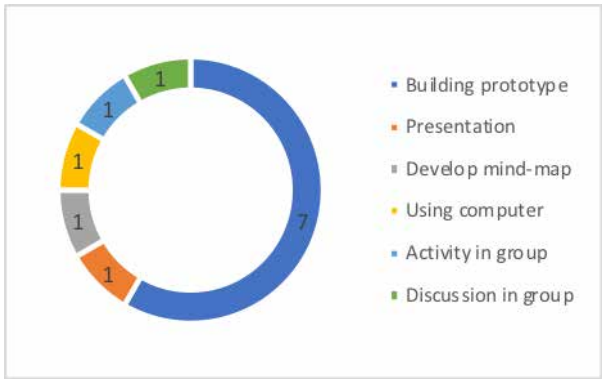

Fig. 7. Number of teenagers and their preferences on the activities

Meanwhile, when asked what they disliked throughout the program, 2 of them said it was during the pitching session. We asked again, if they would return to Mini RTC again to use computers after this - 2 said yes, and 9 said maybe. When asked about the program in general, 7 of them said they would like to repeat the same activities that involved thinking/brainstorming and designing the prototype (Fig. 8), which shows some potentials for them to hold on to their ideas and do something about it.

Fig. 8. The likeliness the teenagers to repeat the activity again

VI. REFLECTION

The motivation behind our program with the community is to nurture the creative and critical thinking skills among the rural teenagers. We do this by adopting and adapting the design thinking approach [1,6] in which we suited the prototyping with a low-fidelity prototyping tool to in line with the objective of the mini RTC, i.e. to fully utilize the computers which are already available at the center. For the teenagers to empathize, define and ideate, proved to be difficult or challenging, and it was totally the guidance of the facilitators that these can be overcome. Asking the teenagers to evaluate their surroundings or their daily routines to get some ideas for a proposed mobile application was not an easy task. This is due to the fact that they find their life satisfactory and there is no need for any mobile application. The facilitators then used creative approaches to spark some ideas.

From this preliminary study, in order to address the above shortcoming, a storytelling approach is deemed to be more suitable. Asking the teenagers to explicitly mention the challenges, or, to provide answers to the question posed earlier, proved to be quite overwhelming to them. Thus, training for the facilitators is deemed to be a necessity in order to familiarize with other techniques and approaches available in the design thinking process. Also, it is observed that some of the questions distributed before and after the surveys also need to be improved. After analyzing the answers, there are some answers that we thought might be understood differently. For instance, questions on would you like to do the activity again on (i) brainstorming (empathize and define) and design (ideate and prototype) (ii) would you use the tool again at mini RTC, could mean the same thing to some of them.

The findings that we obtained from this program will be addressed in order to improve the shortcomings. We treat this project as our pilot study in which we had obtained better insights into what suitable approaches to be used to gain and to measure how program such as this had impact in the lives of the rural teenagers.

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