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Modeling Architecture with the TOGAF Framework to Support the Smart Village in Indonesia

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***Abstract*— In an agricultural nation like Indonesia, where villages are one of the key regions for economic growth, Jatisura Village in the Cikedung district of Indramayu has the potential to grow into a smart village. This is because Rosalia Food MSMEs (Micro, Small, and Medium Enterprises) that have sold their products to the Asian level and reputable communities like Situ Bolang as a tourist attraction both have potential in Jatisura village. Realizing smart village development is a program that requires cooperation from all parties since it is in line with the government's priority program, which is to construct Indonesia from the periphery to minimize the inequity between cities and rural areas. Therefore, a model of architecture that aligns with information technology architecture is required to implement the construction of smart villages. This study intended to build an architecture that aligns with information technology to facilitate the implementation of smart villages based on information and communication technology in Jatisura village, Indonesia's Indramayu regency. To promote digital inclusion and more excellent employment prospects, this study focuses on smart village architecture and methods leveraging ICT initiatives. The TOGAF framework was the foundation architectural concept used. The framework generated business and organizational architecture models, information system and technological architectures, and migration, implementation, and change management architectures. All these architectural models help carry out the process of constructing a smart village, enabling it to do so in a way that effectively carries out the vision and mission of the regency.**

***Keywords*— Information systems architecture; TOGAF framework; village; smart village; jatisura village.**

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I. INTRODUCTION

Indonesia is an agricultural country where villages are one of the strategic areas in economic development. However, the reality shows that many villages in Indonesia still have a status lagging. Referring to the Village Development Index (IPD) from 2015 to 2022, according to data from the Ministry of Villages, the most underdeveloped villages have decreased by 8,471 villages, from 13,453 villages in 2015 to 4,982 in 2022. Meanwhile, underdeveloped villages have decreased by 24,008, from 33,592 in 2015 to 9,584 in 2022. Afterward, the number of developing villages rose from 22,882 in 2015 to 33,902 in 2022 (an increase of 11,020 villages). Then, advanced villages increased by 16,641 villages, from 3,608 in 2015 to 20,249 in 2022. There was a rise of 6,064 in independent villages, from 174 in 2015 to 6,238 in 2022 [1]. One of the challenges of village development lies in the lack of access to electricity and the internet. There are still 433 villages without electricity and 13,577 villages without internet access [2].

The sustainability agenda has arisen where ICT access is widely recognized as a crucial development indicator [3], [4]. Smart cities and villages are the results of a society powered by technology. To investigate the impact of Smart Villages on national economies, it is crucial to collaborate with scholars and professionals globally. Scholars should consider using baseline studies and long-term effect assessments to help governments, ICT access, cloud storage, and adopt cutting-edge agricultural technology. Every part needs to be rebuilt according to the requirement to allow steadily more for a smart life if smart villages and smart cities are to be realized. Every sector needs to be examined with SMART goals (Specific, Measurable, Attainable, Realistic, Timely) in mind [5].

The smart city's environment is quite good, and quick advancement is being constructed toward creating a smart village to improve the standard of living, local economic

prospects, education, and health [6]. The smart village initiative aims to identify opportunities and problems that can be solved by digitally transforming operations and services in rural regions [7]. The presence of smart villages is expected to provide space for the creation of a democratization process in the village because it will promote transparency and accountability as well as community participation. The existence of smart villages is motivated by two factors, namely 1) an increase in information and communication technology usage and 2) the need to realize democratization in the village. The two factors are interrelated in achieving the creation of smart villages. As it relates to smart villages, information, and communication technology usage, in general, can be seen as a medium for governance stakeholders to optimize their role and potential to participate in governance.

Many researchers have researched information system architecture using the TOGAF framework [8], [9]. Still, no one has done research explicitly focusing on modeling information system architectures aligned with information technology architecture to support the development of smart villages. In general, in researching village information systems, researchers directly design without paying attention to the architectural model so many village information systems are not in harmony with the information technology used. As a result, the author's research is expected to help build and develop smart villages while avoiding risks. Some research results are used as references for researchers in the literature review. The previous research used as references has similarities, such as the use of the TOGAF framework, but what distinguishes them is that researchers have created an aligned information system architecture model with the information technology used to assist in creating smart villages.

Alhari et al. [10] studied that it is crucial to transform village authority utilizing the enterprise architecture smart village design model to actualize integrity values according to the SDGs sustainable development goals. The study adopts the TOGAF ADM 9.2 framework. The output of this study takes the shape of a smart village architecture on the e-government dimension in the form of multiple platforms for applications that manage many aspects of public administration, objectives for public development, and management.

Darmawan et al. [11] performed research that the idea of a "smart city" is now the go-to trend for enhancing the standard of public services, and it is anticipated to solve issues that arise in metropolitan areas that are getting more complicated by providing an idea for a city government based on integrated ICT. The conceptions of Regency and City differ significantly in terms of social organization, geographic location, types of livelihoods, population, and economic and cultural factors. As a result, when applied to the district, the "Smart City" approach is not necessarily realistic and sound. This project intends to develop a Smart Regency Framework Model that differs from the widely used Smart City Framework Model. The meta-ethnography approach was applied in this study to establish an information system architecture model and synthesize the qualitative results of the regency building factors. It's anticipated that the findings will lead to a new model for the architecture of information systems and aid in creating service models for smart districts.

Qurratuaini [12] initiated an investigation that shows that the growth of information technology in daily life, both in terms of development and application, has been rapid. As a result, organizations and businesses have a wide range of options when choosing the information technology that will be used within them. Enterprises must consider their culture, current state, and information technology capabilities while implementing information technology solutions to guarantee that they can effectively assist businesses in resolving their challenges. Additionally, it should be possible for the solution to integrate the organization's data and systems, benefit from its current capabilities, and guarantee that its resources are prepared to convert a state from the present to the targeted one. According to the needs statement, enterprise architecture is businesses' best information technology solution. Because of its comprehensiveness, integration of processes, and adaptability, the TOGAF framework was decided to be the enterprise architecture framework for this article. The enterprise architecture's final goal, an evaluation of the existing format of the goals, and a project roadmap are all presented to help businesses achieve the intended goal and address their present issues. These are anticipated outcomes from the enterprise architecture's development in this article. In this study, an Indonesian state-owned business (BUMN) will have its enterprise architecture designed using the TOGAF framework.

Kornyshova et al. [13] researched frameworks for enterprise architecture (EA) and demonstrated the effectiveness of organizational performance enhancement by offering an in-depth analysis of a company that fits its overall approach. However, these concepts are frequently extensive and not utilized entirely since they are currently inappropriate. They advocate utilizing an EA framework vision based on components to address this issue. We aim to find a group of EA elements that may be employed independently of one another and in different contexts. This strategy might be utilized to establish the entire EA technique to gradually integrate specific components into an organization or to enhance a current EA, including the missing components. Our suggestion was given the name SEA (Situational Enterprise Architecture) strategy. In this investigation, they provide a formalization approach for EA components and use the TOGAF framework to explain it.

Oberle et al. [14] revealed that a critical component of smart manufacturing and Industry 4.0 is the use of IT systems to assist company operations. IT systems shouldn't be viewed as a goal in themselves. The company goals and strategy must align with the enterprise IT architecture. Current methodologies for developing enterprise IT architectures offer limited advice for greenfield systems with few preexisting boundaries, such as operational procedures. This is difficult in smart manufacturing because of how complicated the factory floor is, which includes IT and OT. The IEC 62264 manufacturing operations management standard and the TOGAF architectural development technique are combined to fill this gap. The design of the Fraunhofer battery manufacturing research line, an enterprise IT architecture using the TOGAF phases architecture vision, business architecture, information systems architecture, and

technology architecture for manufacturing, is used as an example in the paper to explore this combination.

Jatisura Village, Cikedung district, Indramayu, has the potential to be developed into a smart village. This is because Jatisura village has the potential for reliable villages such as Situ Bolang as a tourist attraction and Rosalia Food MSMEs (Micro, Small, and Medium Enterprises) that have marketed their products to the Asian level. In line with the government's priority program, which is to build Indonesia from the periphery to reduce inequality between villages and cities, smart village development is a program that needs to be supported by all parties. To achieve sustainable development, however, all parties involved in its intricate socio-economic processes must work together [15]. The involvement of stakeholders on the part of regional and local governments has an impact on an increasing number of local and international towns and cities [16].

This paper focuses on proposed smart village architecture and strategies using ICT initiatives to foster digital inclusion and guarantee that rural kids have better employment opportunities. Therefore, for the creation of smart villages to be effectively implemented, it is necessary to have an architecture model that aligns with the information technology architecture. This study aims to model architecture in line with information technology to assist the application of smart villages based on information and communication technology in Jatisura village, Cikedung district, Indramayu regency. The framework used to create this architectural model is the TOGAF framework. This framework produces an integrated model that includes business and organizational architectures, information and database architectures, and application and software architectures. All these architectural models are useful for creating and developing information systems so that they can run effectively and avoid unwanted risks.

II. Materials and Method

A. Village

The village can be defined in two prevalent ways. Firstly, a village is regarded as a sociologically homogeneous social group that relies on the goodness of nature. Second, due to its affiliation with the state government, a village is seen politically as a unit of authority with specific rights or powers [17]. The village is a unitary division of a community entity with a unique character and heritage, where the community serves as the primary impetus for growth and is recognized as a legal community unit. The village also functions as a straightforward unit of social uniformity with uniform means of subsistence[18]. The village is the lowest level of government in Indonesia. Surprisingly, 65% of Indonesia's population resides in rural areas, according to the National Socio-Economic Survey [19].

B. Smart Village

Indian scholars, Viswanadham and Sowmya Vedula created the “Smart Village” concept in 2010 to illustrate a village’s ecology and integrated design map processes for creating a smart village [6]. Smart village programs typically revive rural communities through the agricultural sector or deal with the shortage of fundamental infrastructure, supplies, and services (such as water, energy, food, education, and jobs) in underdeveloped and developing areas [20]. This smart village concept was established by outlining a village's environment and the unified form processes to establish a smart town. In the contemporary global period, the approach of the smart village has emerged as an option for the advancement of rural communities. The "smart village" was a possible answer to raising rural residents' lifestyle standards [21]. SMART village (SMART-V) framework includes several aspects, including technological infrastructure, an adaptable society, a manageable economy, and a sustainable environment [22].

Modern and traditional networks and services in smart villages are improved for locals’ and companies' benefit using innovation, digital technologies, and greater knowledge utilization. For the formation of smart villages, the environment is highly crucial. The fundamental premise underneath the establishment of smart villages is that quick technological advancement, when appropriately aimed and connected to developing regions, generates novel possibilities. It may result in improved services, earnings, and expanded social prospects. These can significantly enhance rural communities' quality of life [23].

The term "smart village" refers to a community where information technology systems and innovation are used to support and integrate the work of residents and institutions to benefit the surrounding area. Most of them were rural residents who lived a long way from growth hubs. Their connection to the modern network, which gives accessibility to the most recent developments in mobile healthcare technologies, information and communication technology (ICT), finance, and biotechnology, was out of their reach [24].

Three aspects indicate the advancement of the Smart Village. The economic element comes first and consists of local government and financial variables. Governance models, mobility, internet networks, entrepreneurship, cloud computing, and other topics will be covered. The second is the environmental element, which covers local infrastructure and resource availability concerns. This can include more environmentally friendly technologies, public transportation, alternate modes of green areas, transportation, smart growth, and others. The third is the social element, which is an element that can address issues about social innovation, people's lives, services, participatory democracy, and others [25].

C. Study Area

One of the regencies in West Java Province, Indonesia, is Indramayu. Administratively, Indramayu Regency comprises 309 villages, 1689 RW, and 6,202 RT and covers a region of 209,942 km2 within the boundaries of West Java Province. One of West Java's top 10 contributors to GRDP is Indramayu Regency, which is noted for its agricultural hubs and rice barns. One of the essential products in the plantation industry is mango.

This research selected Jatisura village. The village was incorporated both de facto and de jure in 1985. Jatisura Village is physically situated in Cikedung District, Indramayu Regency. Five hamlets, each with five RW and 32 RT, comprise Jatisura Village. 5080 people were living in Jatisura Village as of May 2022, including 2,373 men and 2,707 women. According to their line of work or means of

subsistence, about 742 people are employed in the private sector, including 54 private employees, 160 traders, 584 farmers, 1,625 farm laborers, 14 small industries, 1855 students or college students, 3 retirees, and the remaining 13 civil servants (TNI/POLRI/PNS) [26].

Because of its 343.9 ha of mango orchards, which include *gedong gincu, sweet fragrant, cengkir*, and *elephant mangoes*, Jatisura hamlet is well known for growing mangoes. The village of Jatisura offers several assets that could sustain tourism, including rice fields, livestock, canting wells, great-grandfather sand, mango plantations, agrimania agrotourism, sugarcane plantations, and good deep swamps. Managing mangoes in various meals and beverages is now handled by numerous Micro, Small, and Medium Enterprises (MSMEs). Of course, it is precious economically and competitively and can even be exported internationally. The growth of the mango harvest has dramatically risen from year to year.

D. TOGAF

TOGAF (The Open Group Architecture Framework) [27] is an architectural framework. It offers the procedures and equipment to support an enterprise architecture's creation, operation, and upkeep. It is founded on a model of iterative processes with support from best practices and a valuable collection of existing architectural resources. The TOGAF Standard is made to accommodate each of the following four architecture domains, which are generally recognized as parts of an overall Enterprise Architecture:

- Business architecture describes business strategy, management, structure, and essential business procedures
- Data architecture outlines the physical and logical assets, as well as the data management resources, of an organization.
- Application architecture offers a roadmap outlining how each application will be used, interface with other applications, and relate to the organization's primary business activities.
- Technology Architecture specifies the standards and logical hardware and software infrastructure service needed to offer data, business, and application services. It also describes digital architecture. Internet of Things (IoT), cloud services, IT infrastructure, networks, middleware, social media infrastructure, processing, communications, standards, etc. are all included in this.

An established and repeatable procedure provides its services for producing architectural designs named the TOGAF Architecture Development Method (ADM). The ADM consists of constructing an architectural framework, developing architecture content, and managing and transitioning the realization of architecture. The execution of each of these tasks occurs within an iterative cycle of architectural continuity creation and realization, enabling firms to modify their businesses in a managed way to address business objectives and opportunities [27]. Figure 1 demonstrates how this works.

Fig. 1 Architecture Development Cycle with the artifacts [28]

These are the ADM phases [27]:

- The Preliminary Phase outlines the preparatory and initiation steps necessary to develop a capacity of architecture, such as defining architectural fundamentals and customizing the TOGAF framework.
- Phase A: Architectural Vision outlines the first stage of an architectural growth cycle. It contains details on developing the architecture vision, deciding the project's scope, securing consent to move on with the architecture creation, and locating the stakeholders.
- Phase B: Business Architecture discusses the creation of a Business Architecture to assist the Architecture Vision consensus.
- Phase C: Information Systems Architectures outlines the creation of Information Systems Architectures to assist the Architecture Vision consensus.
- Phase D: Technology Architecture details the creation of the Technology Architecture to assist the Architecture Vision consensus.
- Phase E: Opportunities and Solutions identify possible benefits for the architecture developed in the earlier phases and conduct initial planning for implementation.
- Phase F: Migration Planning completes a detailed Implementation and Migration Plan to address how to move from the Base point to the Objectives Architecture.
- Phase G: Implementation Governance offers a structural check on the execution
- Phase H: Architecture Change Management creates methods for handling changes to the new architecture.
- Requirements Management oversees the ADM's architecture specifications management process.

The TOGAF Standard explains how an extensive Enterprise Architecture landscape can be created iteratively using the ADM. The ADM graphic is best understood as a reference model that defines what must be done to deliver solutions in an architect-planned manner and identifies interdependent components across the enterprise and their linkages instead of being seen as a process model. The iterative usage of the ADM to create a thorough Enterprise Architecture landscape is described in the TOGAF Standard. Instead of viewing the ADM graphic as a process model, it is helpful to consider it a reference model that specifies what must be done to deliver solutions in an architected approach and identifies interdependent components across the enterprise and the interactions between them.

III. Result and Discussion

A. Preliminary Phase

As of September 3, 2022, the research team has been working to identify problems and seek needs related to the information system architecture and information technology architecture to support the development of a smart village in Jatisura village. The identification was carried out through a focus group discussion (FGD) with five village officials, two village community leaders, and representatives of village communities. The results achieved from the FGD were that village heads, village community leaders, and village community representatives agreed that Jatisura village was used as an example of technology-based smart village information development. The next step after the FDG was carried out was the research team assessing the existing condition of the information system and information technology owned by the Jatisura village government.

The preparation and initiation of EA will be explained in this phase, along with the definition of identity organizational structure, the organizational objective, the EA organization structure, and architectural guidelines[29]. Architecture principles are guidelines for conducting architectural work according to the TOGAF framework. Enterprise architecture is developed, managed, and used according to architectural principles, which control the process. The four domains of enterprise architecture—business principles, data, applications, and technology—will be used to organize the discussion of architectural concepts[12]. In Table 1, specific guidelines are shown.

TABLE I
PRINCIPLE CATALOG

Principle Architecture Domains	Principle
Business Principle	Service continuity adherence to the law provide advantages support business process
Data Principle	integrated data accessible data secure data availability data consistency data
Application Principle	reliable application provide usefulness ease of use
Technology Principle	data and resource-sharing capabilities interoperability easy to maintenance

B. Architectural Vision

The TOGAF ADM phase's first stage, Architecture Vision, aims to align the value of enterprise architecture inside a business. In this instance, it makes it simpler for the designer to outline the intended scope of the investigation this investigation, the e-government component in constructed villages, which has as one of its missions “Realizing Governance that serves, protects, clean, free of corruption, collusion, nepotism, transparent, accountable, professional and democratic, with 3 (three) priority programs, namely: 1) Improvement of Apparatus Facilities and Infrastructure, 2) Capacity Building of Apparatus Resources and 3) Development and Supervision of Local Government Implementation with technology-based public services” and as its vision “Sincere and Transparent government in Management and Governance” [30]. The government has set aims and implemented initiatives to accomplish these objectives through Le-Dig [31]. Le-Dig (lebu digital) program is a satellite-based digital village ecosystem that serves to digitize all villages that do not have terrestrial infrastructure. This value chain artifact explains how village government functions are grouped based on the primary activity and support activity to create value and competitive government success.

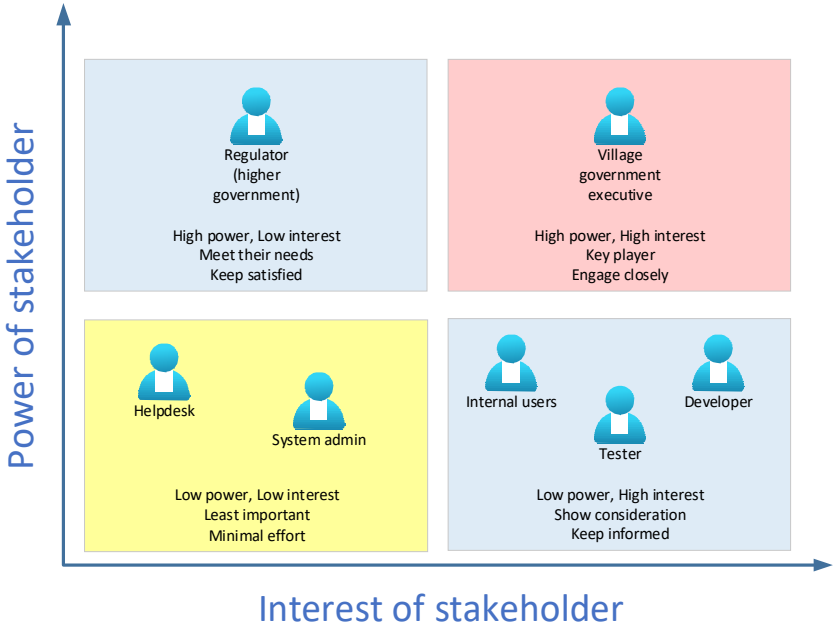

Fig. 2 Stakeholder Map Matrix

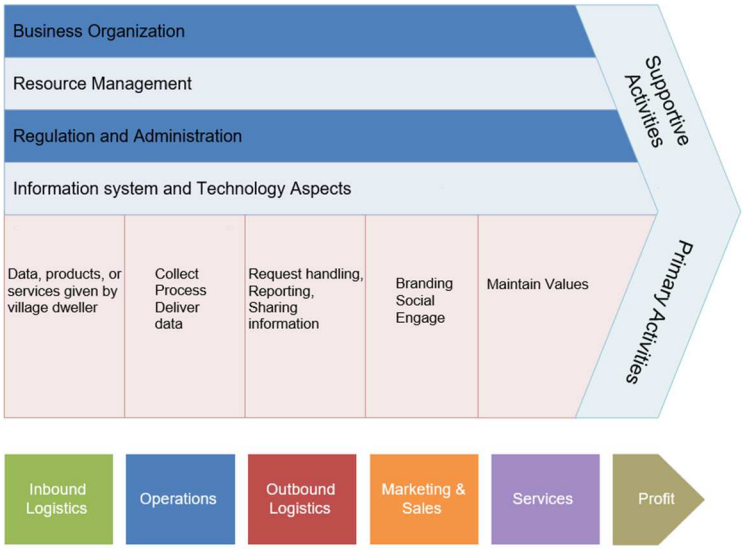

Fig. 3 Value Chain Diagram

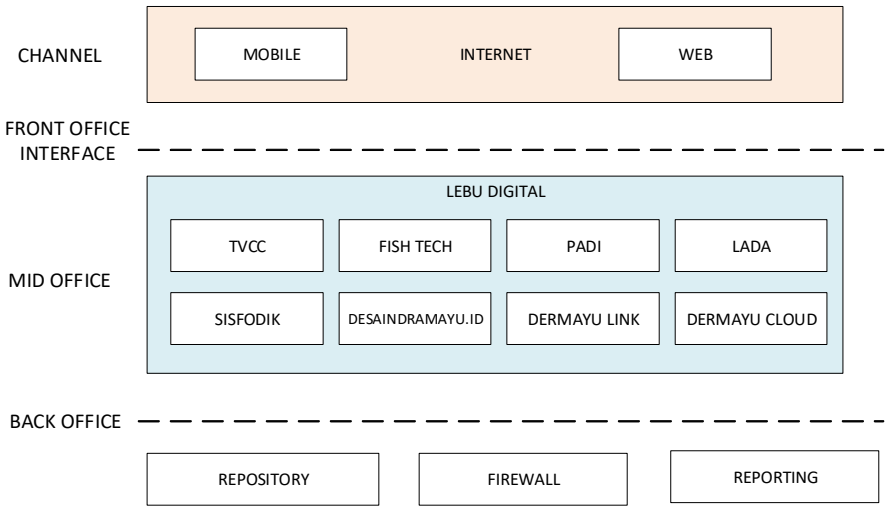

Fig. 4 Solution Concept Diagram

C. Business Architecture

The process of modeling steps was used to create business architecture models that adhered to standards and used the BPMN notation. Due to its simplicity of comprehension, the BPMN, a standard for graphically describing and modeling business processes and workflows, seems especially appropriate. Therefore, it was decided to use BPMN to design the business architecture models for the smart village service process in advance. Fig. 5 shows a BPMN model as an illustration. The software package Bizagi Modeler was employed to create a BPMN smart service process.

D. Information Systems Architectures

The planned application architecture supports both the business architecture and the architecture vision. We will use an application of portfolio catalog (Table II) and an application communication diagram to demonstrate how applications communicate (Figure 6).

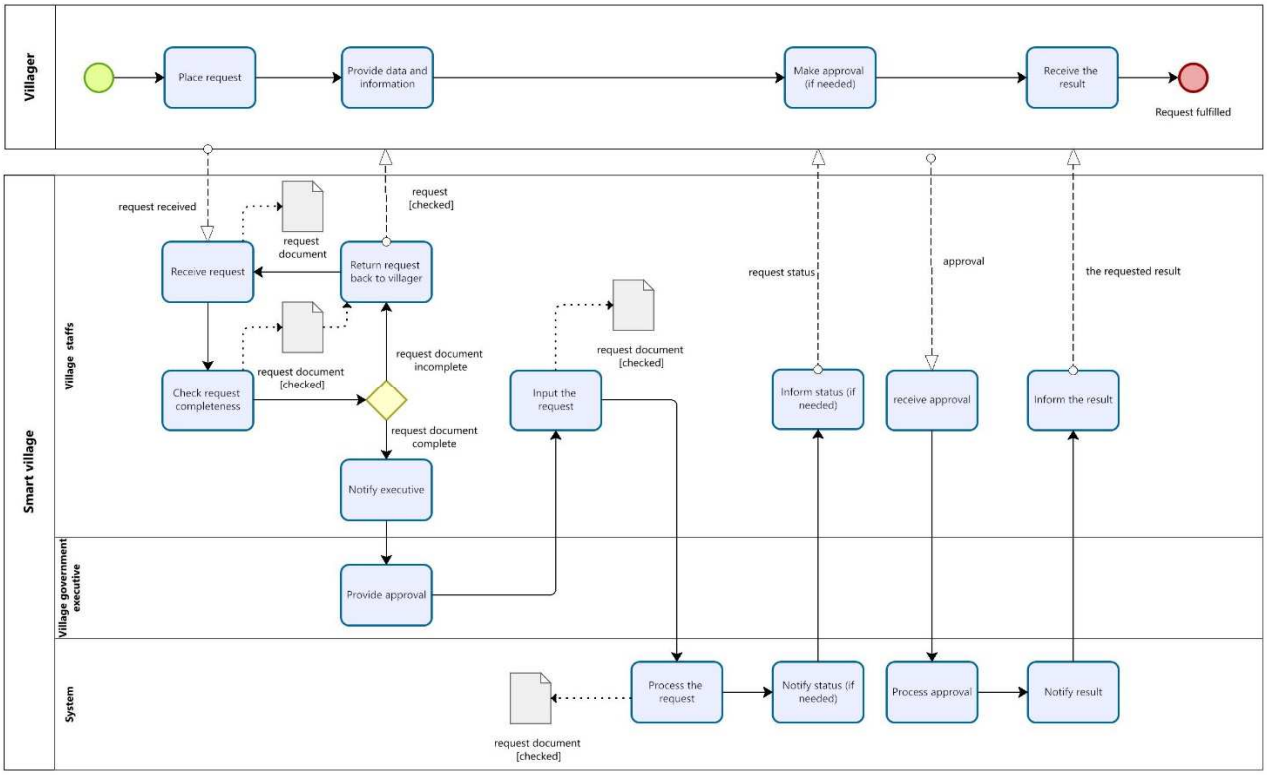

Fig. 5 Business Model Diagram

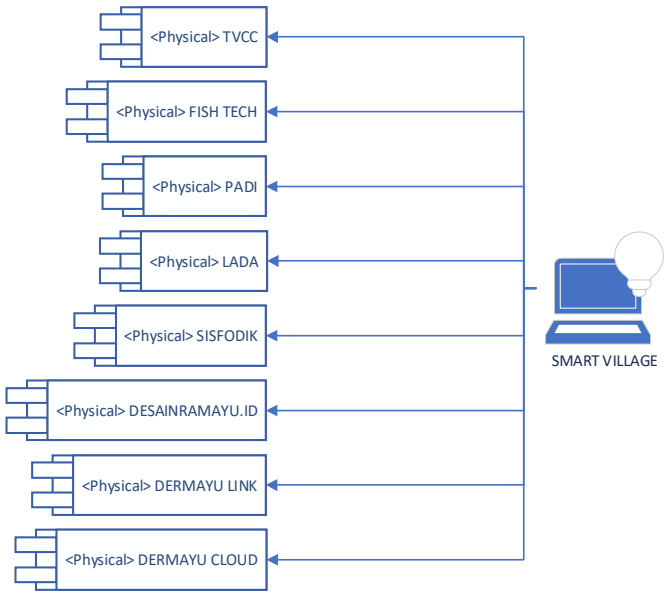

Fig. 6 Application of communication diagram

Its goal was to analyze each depiction to depict how the various programs or pieces of software interacted with one another. The ultimate architectural team was created by project architects working at the enterprise level. Each member was responsible for a different area of the business, integration, applications, infrastructure, and data across the organization. This team also developed architectural standards, principles, global roadmaps, and other paperwork pertinent to the field.

TABLE II
APPLICATION OF PORTFOLIO CATALOG

Information system service	Logical app component	Physical app component
Le-Dig (lebu digital) to digitalize all village service	e-government	TVCC FISH TECH PADI LADA SISFODIK DESAINDRAMAYU.ID DERMAYU LINK DERMAYU CLOUD

E. Technology Architecture

This stage aims to create a directed technology architecture that delivers architectural knowledge, directed business components, data components, and application development components utilizing technology-based services [32]. The environments and locations diagram demonstrates which sites host which applications, indicates which technologies and/or applications are employed, and then pinpoints where business users are situated and commonly interact with the applications. Office of Communication and Informatics (*Diskominfo)* to find the most essential programs and gadgets. Devices (servers, workstations) in this diagram are embedded in (deployed) locations. Additionally, the devices contain embedded components for applications.

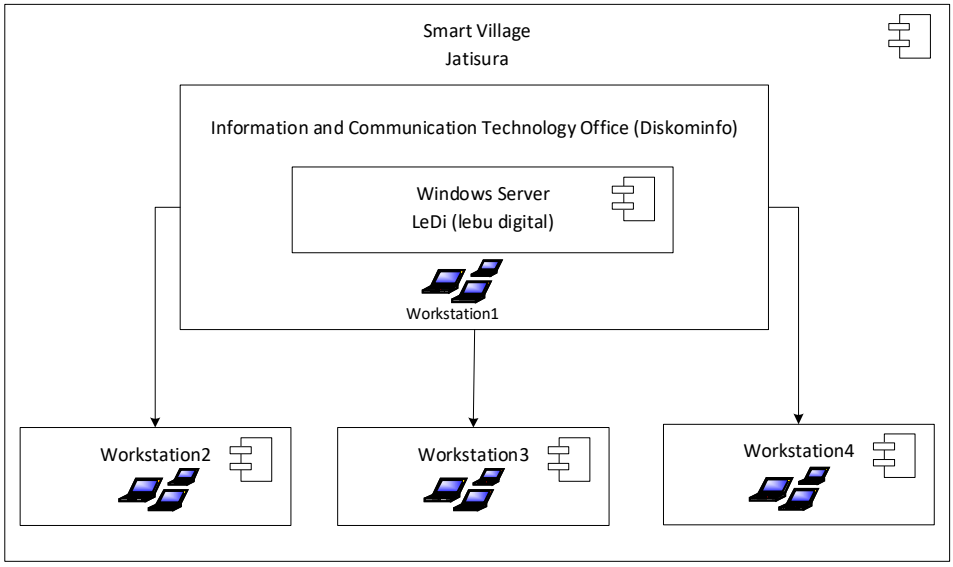

Fig. 7 Environments and locations diagrams

F. Opportunities and Solutions

The Benefit Diagram demonstrates the possibilities noted in the architecture definition. Three groups can be observed in the image below: social, environmental, and economic. The social benefits include improved service quality, Integrated service, Transparency, and Local service availability. Then, the main environmental benefits were expected for enhanced resource management, infrastructure improvement, integrated application, and decreased dependency. The last is economic benefits, namely innovation and competitiveness, business process improvement, paperless, and improved productivity.

G. Migration Planning

This phase's goal was to select an implementation project with various priorities. It was based on how the project's potential and benefits were interpreted and will be used to inform the creation of implementation and migration plans. It meant that the planned project would be based on the village government's business goal of improving performance, which would align with its vision and mission[32]. The planned project's work in the sequence is organized according to the results of the priority decision as follows: Business Application Development Project, Business Application Integration Project, Business Function of Data Center Maintenance Project, Backup System Development for Overall Information System Project, Business Function of Data Evaluation Realization Project, Information Technology Infrastructures Quality Evaluation Project [12].

H. Implementation Governance

Application system implementation is equated to implementation governance. The system implementation took time. The implementation governance should employ Project Time from the Project Management technique based on the Project Management Body of Knowledge (PMBOK). Project

time can describe how the entire scope of work is turned into a work breakdown structure and results in a Gantt Chart that tries to show the steps of the scope of task completion. A well-known chart (developed by Henry Gantt) used to plan and track the progress of a project is a Gantt Chart (GC) planning approach [33]. A GC is a kind of bar chart that shows a project schedule. The Gantt charts show how comprehensive process planning and scheduling was done [34]. A Gantt chart is the finest tool for improving timetable comprehension [35]. Realistic production plans can be made using Gantt charts[36].

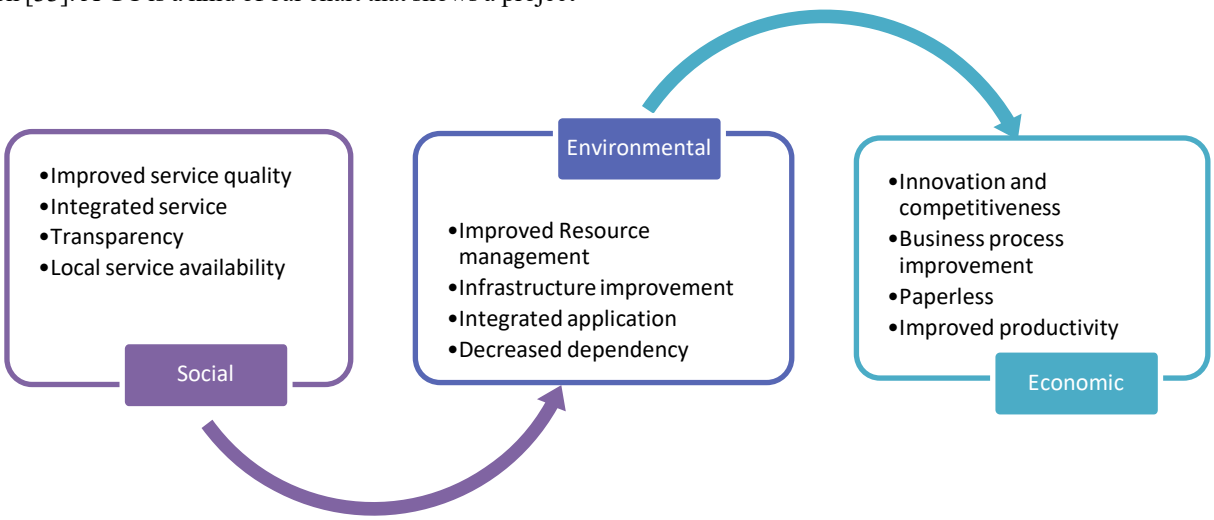

Fig. 8 Benefit Diagram

TABLE III
GANTT CHART

No	Task	2023 Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
1	Business Application Development Project				
2	Business Application Integration Project				
3	Business Function of Data Center Maintenance Project				
4	Backup System Development for Overall Information System Project				
5	Business Function of Data Evaluation Realization Project				
6	Information Technology Infrastructures Quality Evaluation Project				

I. Architecture Change Management and Requirements Management

Gaps between the target architecture and the previous phase's output were identified to create "improvement actions" or "projects" that should be carried out. However, the village lacked a distinct function or role endowed with the necessary job and authority to constantly supervise the implementation of this improvement on an operational level. According to a subsequent examination of the job description and current business procedures, the degree of coverage and authority for the implementation was not adequately aligned. As a result, it must consider important factors like autonomy (in various departments and units), adaptability, and the particular necessity for locally tailored systems [37].

The village executive will be a responsible actor and the project sponsor for change management. The remaining village employees will be responsible for creating programs and projects, with the Quality Committee validating and recommending success criteria (indicators) for each (villager representative). Each Head of the relevant unit will be responsible for the subsequent activities of directing the execution, activating the resource, managing stability, and handling change management (locally - as an impact of implementation). After that, the head of the pertinent unit will take over the project to the IT Operation team once the implementation of each project has been completed.

IV. CONCLUSION

Following the realization and implementation of the architecture, it can be deduced from the analysis and design of the smart village that was done in Jatisura village that the village may provide better service to the villagers. TOGAF ADM offers the respected village a set of inputs, stages, and outputs that must be followed for the roadmap to be developed, which will analyze the values in the migration planning phase and aid in providing direction and assistance for implementing the target architecture. It can be stated that digital development design strategy references have been produced relying on the research outcomes from creating a Blueprint Smart village Jatisura architecture using the TOGAF ADM framework. Sustainable development from the initial stages to requirement management as a complement to later facilities and the appropriateness of the village for putting the smart village approach into practice is necessary to achieve the outcomes of this study.

All stakeholders must support and commit to achieving the goals of the Indramayu district government program, namely the initiative to establish digital villages, including creating smart villages based on information technology. As a result, researchers recommend that: 1) The local government of Indramayu district, especially relevant officials, pay special attention to the villages targeted by smart villages; and 2) The village government, especially the village heads, are expected to support the Indramayu district government's program to realize and get the advantage of the development of smart village.

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