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Digital Transformation of Subak Management in Bali Through GIS Implementation

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Abstract

Subak is a customary law society with socio-agrarian-religious characteristics, consisting of a group of farmers who manage the irrigation of rice fields or paddies. The agricultural irrigation system in Bali or Subak was officially recognized as one of the world's cultural heritages in 2012 by UNESCO. Many Subak data still rely on traditional recording systems, making it crucial to have a digital transformation using an information system platform capable of collecting data on Subak and providing related information about Subak in the Bali Province. To address this problem, a mobile-based Geographic Information System (GIS) that encompasses information about Subak is developed. The data collection method used in this research includes literature studies and questionnaires. The result obtained from this research is an Android mobile application tested using Black Box Testing. All tests were successfully met according to the testing criteria that have been established.

Keywords: *Android, Mobile, Subak, Geographic Information System, Black Box Testing, Digital Transformation*

1. Introduction

The management of agriculture in Bali has its uniqueness and distinctive characteristics in handling rice field irrigation. *Subak* is a customary law community with socio-agrarian-religious traits, a group of farmers managing land rice field irrigation [1]. The agricultural irrigation system in Bali, or *Subak*, has been officially recognized as one of the world's cultural heritages in 2012 by the United Nations Educational, Scientific and Cultural Organization (UNESCO) [2]. The *Subak* system applies the concept of *Tri Hita Karana*. *Tri Hita Karana* is a foundation originating from Hinduism that signifies three harmonious relationships: between humans and *Ida Sang Hyang Widhi Wasa* (the divine), between humans and humans (the community), and between humans and nature (the environment). *Tri Hita Karana* greatly influences the behavior of *Subak* and its members in carrying out agricultural development activities in rice fields. This *Tri Hita Karana* concept embodies traditional values that align with the advancement of science and technology [3].

According to data from the Bali Provincial Department of Culture in 2018, the number of *Subak* still exists, which is 2,726 in 1,493 traditional villages (*desa pakraman*). This data is a compilation of the Special Financial Assistance data 2018 from the Department of Empowerment of Village Communities in the department's region and the grant data 2017 from the Bali Provincial Department of Culture in the urban areas [4].

Information technology is developing rapidly, leading to an increase in the exchange of information [5]**.** Information technology has become a primary necessity for people in providing

and receiving information. The use of smartphone applications is one example of the development of information technology that supports information systems in delivering and providing information to users. Almost everyone owns a smartphone to support all their activities [6]. Smartphones allow people to access information more quickly, so the development of mobile-based information systems will facilitate *Subak* management villages in conducting data collection and enable the Department of Indigenous Community Development to monitor the *Subak* systems in Bali Province more easily.

Digital transformation is the strategic integration of digital technologies into various aspects of an organization or industry to revolutionize processes, enhance efficiency, and achieve superior outcomes [7]. Digital transformation or digital transition is part of a more extensive technological process. Digital transformation is a change related to adopting digital technology in all aspects of society. With GIS technology, data regarding the *Subak* area will become more detailed and precise. Also, *Subak* management, which was previously carried out conventionally, can now be done via mobile devices. It is hoped that with this digital transformation, *Subak* will be maintained and even preserved.

Previous research on the Geographic Information System (GIS)-based *Subak* Information System in Tabanan has resulted in an information system that can display the mapping of *Subak*. Still, the mapping of *Subak* is only available in the Kediri District of Tabanan Regency [8].

A similar study on the application of remote sensing and Geographic Information System (GIS) in Padanggalak's *Subak* has produced an application for building a remote sensing-based database and Geographic Information System (GIS) to create land ownership maps for *Subak*. The *Subak* data generated includes mapping *Subak* classified based on tenant farmers and landowners. Remote sensing is used to identify land ownership boundaries through imagery, while GIS is used for digitizing *Subak* polygons and land ownership polygons [9].

A similar study on remote sensing and Geographic Information Systems (GIS) for *Subak* resource mapping has resulted in a *Subak* resource database created using remote sensing and GIS technology. The *Subak* database contains land ownership maps of *Subak* Juwuk and *Subak* Lebo, providing information on the quantity and area of land ownership [10].

Based on previous research, *Subak* data collection has been limited to specific areas and has not encompassed comprehensive and accurate data collection from across the entire province of Bali. So far, information about *Subak* has not been conveyed in detail and clarity, even though this information is essential for planning, implementation, and monitoring by the Department of Indigenous Community Development to support the National Food Security program and the conservation of sustainable food land resources, which focuses on promoting food commodity production by building infrastructure and using technology. There is still much *Subak* data in other regions that use conventional recording methods, making it difficult for the government to monitor *Subak* activities as they have to visit the locations physically. It's also challenging to process the data because it is still written or typed on paper, and the data is not integrated. To initiate digital transformation from conventional data to digital services, developing a comprehensive and integrated digital platform that can streamline data collection, analysis, and dissemination of Subak-related information across the province is essential.

2. Research Methods

This chapter examined the research phases and methodologies employed in the conducted study. The subsequent content elaborated on research techniques addressing the development of the Subak Application.

2.1. System Overview

An overview of the system provides a general representation of the system in the form of a diagram illustrating the system's flow. An overview of the Subak Application that has been developed can be seen in Figure 1.

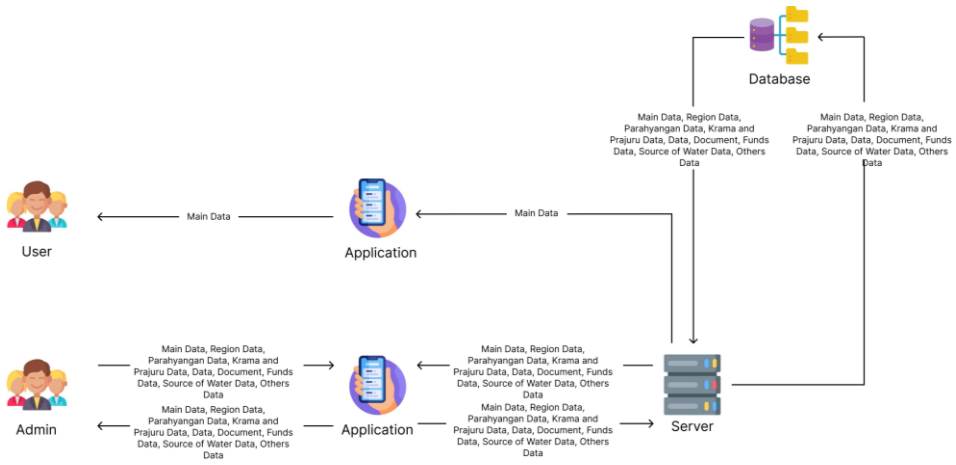

Figure 1. Subak Application Overview

Figure 1 represents the general overview of the mobile-based Subak Application on the Android platform. The system generally has two types of users: administrators and users. There are three types of administrators in the Subak Application, namely the Pemajuan Masyarakat Adat Administrator, District Administrator, and Village Administrator. Administrators have the authority to manage all the data within the application, while users can only view the general data of *Subak* in the Bali Province. The next application design stage was to create a context diagram for the Subak Application. A context diagram is a diagram that represents a large circle or bubble, which can mean the entire process within a system [11]. Context diagram consists of only one process, and the set of external entities and data flows [12]. The context diagram of the Subak Application consisted of four entities, as seen in Figure 2.

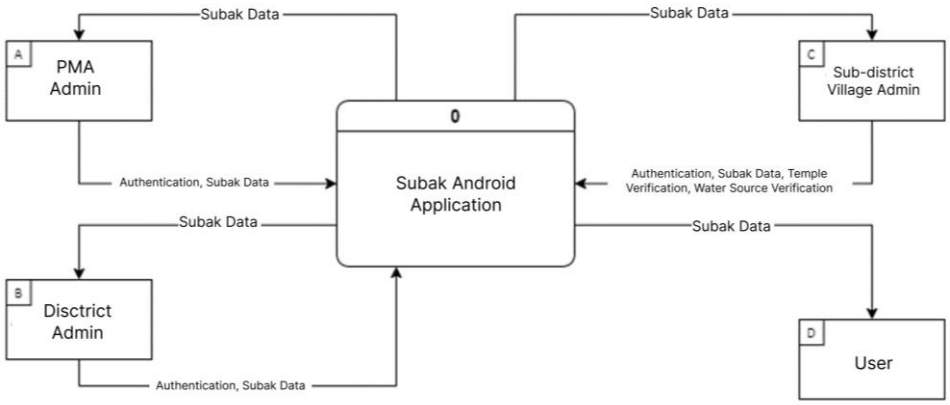

Figure 2. Subak Application Context Diagram

Figure 2 is the Context Diagram of the Subak Application. The diagram above illustrates four entities involved in the Context Diagram of the Subak Application: the Pemajuan Masyarakat Adat Department (PMA) Administrator, District Administrator, Village Administrator, and User.

2.2. Use Case Diagram

Use Case Diagram is a diagram that describes typical interactions between users of a system and a separate system through a story of how a system is used [13], [14]. A use case diagram also shows how the system or software interacts with its environment, depicted by actors [15]. The use case diagram of the Subak Application can be seen in Figure 3.

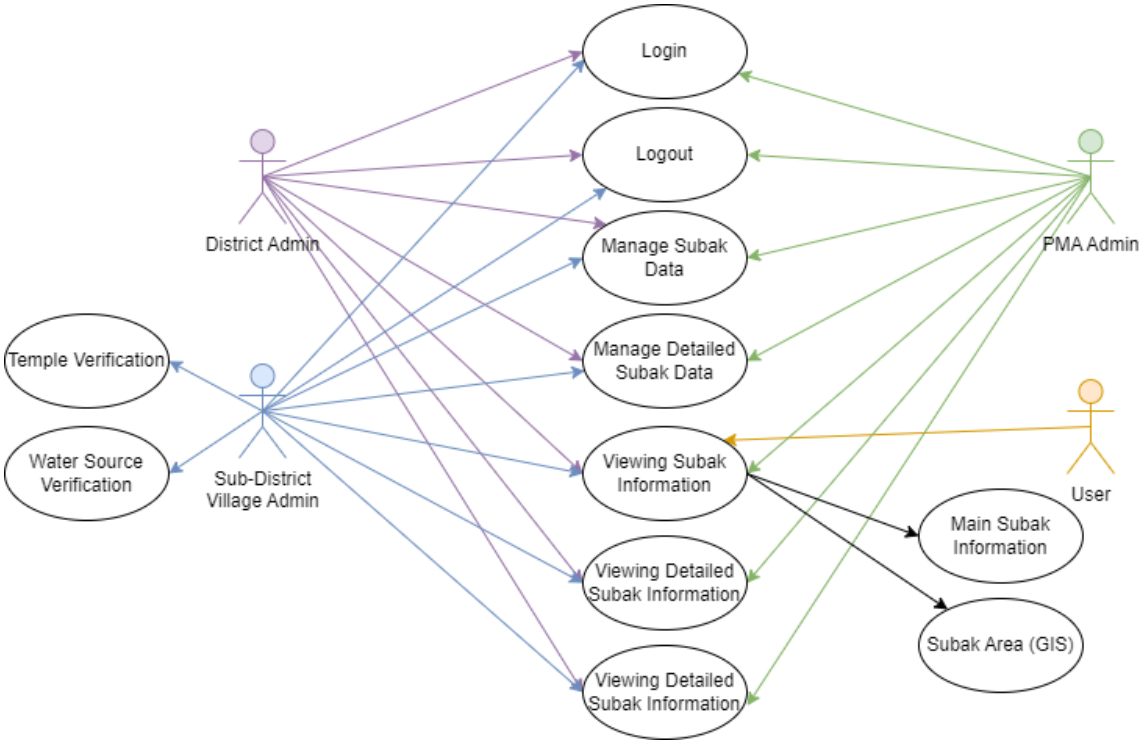

Figure 3. Use Case Diagram of the Subak Application

Figure 3 is the Use Case Diagram of the Subak Application. The diagram above shows that the Use Case Diagram of the Subak Application contains five entities: Pemajuan Masyarakat Adat Department (PMA) Administrator, District Administrator, Village Administrator, and User.

Sub-District Village Administrators manage *Subak* data, including creating, reading, updating, and deleting *Subak* records in their respective villages. PMA Administrators can manage *Subak* data throughout the Bali Province. District Administrators can manage *Subak* data within their respective districts. Sub-District Village Administrators can verify temples and water sources if they are located in their village.

2.3. Data Flow Diagram

DFD (Data Flow Diagram) is a logical representation of a system that is not dependent on hardware, software, data structures, or file organization [16], [17]. DFD is a graphical representation of how data flows among software components primarily used for modeling the functional properties of a system [18]. The level 0 Data Flow Diagram (DFD) of the Subak Application provides a more detailed overview of the modules, flow, and entities than previously discussed in the Context Diagram. The level 0 DFD of the Subak Application can be seen in Figure 4.

Figure 4 represents the DFD level 0 diagram of the Subak Application. The diagram above shows that the DFD level 0 of the Subak Application has four modules: the Authentication Module, the Main Data Management Module, the Detailed Subak Data Management Module, and the Subak Temple and Water Source Management Module. In the Authentication Module, the admin can input their usernames and passwords, which are then checked by the system. If the credentials entered are correct, the admin will receive an output indicating a successful login status and Profile Data. In the Main Subak Data Management, the admin can create, read, update, and delete processes on Subak Data. These processes will be recorded in the Main Subak Data Store. Users can only read data from the Main Subak Data. In Detailed Subak Data Management, the admin can create, read, update, and delete processes on Detailed Subak Data. These processes will be recorded in the Detailed Subak Data Store.

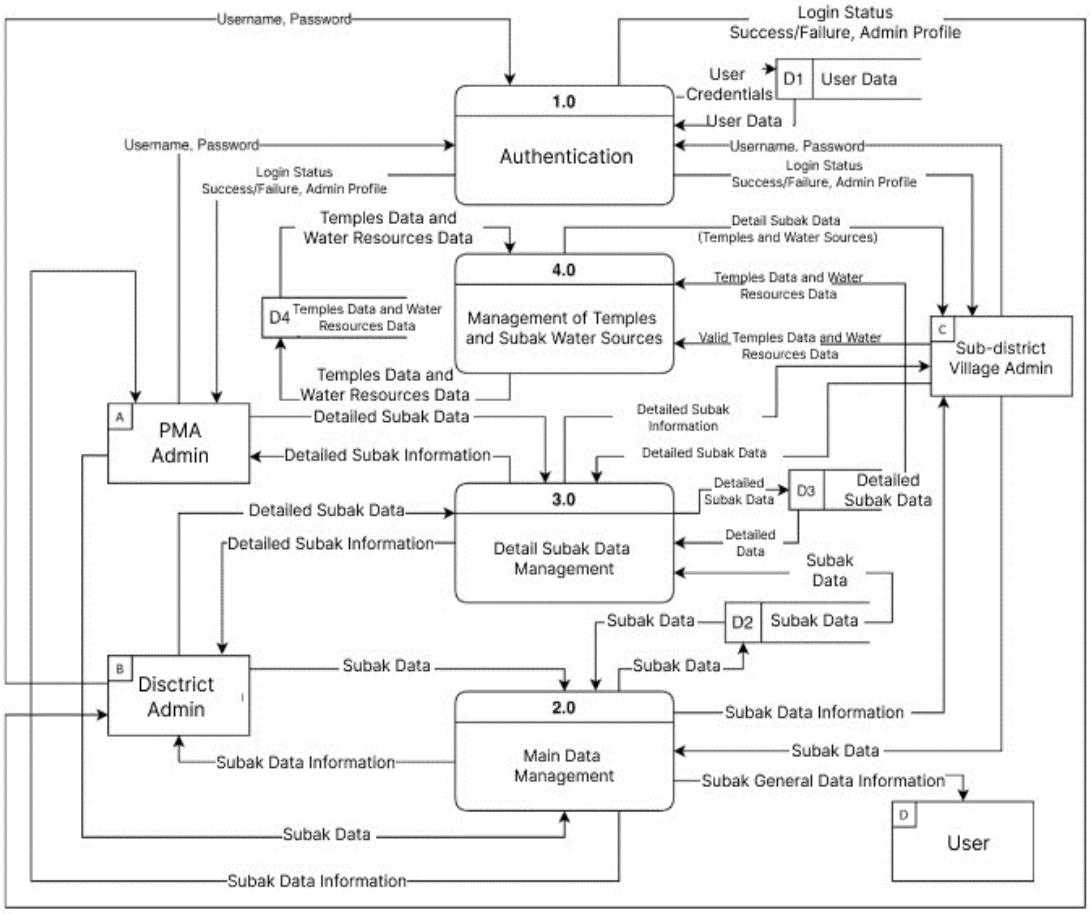

Figure 4. Data Flow Diagram Level 0 of Subak Application

2.4. Digital Transformation

Digital transformation is the strategic integration of digital technologies into various aspects of an organization or industry to revolutionize processes, enhance efficiency, and achieve superior outcomes [7]. Digital transformation or digital transition is part of a more extensive technological process. Digital transformation is a change related to adopting digital technology in all aspects of society. Digital transformation is a complex process involving various methods and approaches, depending on the context. One of the standard methods or approaches used in digital transformation is the implementation of new technologies, such as information systems, artificial intelligence (AI), the Internet of Things (IoT), big data, and cloud computing, to enhance efficiency and productivity.

2.5. Black Box Testing

Blackbox testing is one of the software testing techniques that focuses on the function of software to ensure all functions on the software have been running well [19]. According to Sukamto (2016), "Black Box Testing is testing the design and code of a program. Testing is intended to determine whether the software's functions, inputs, and outputs conform to the required specifications." The Black Box Testing method is used to test software without considering the software's internal details [20]. Black box testing is chosen because it is the most commonly used for testing applications, and its testing approach is easy to implement. With black box testing, software

developers can create input conditions that cover all functional requirements [21]. This testing is necessary to ensure the program operates according to the company's requirements.

3. Result and Discussion

This section discusses the results of the development of the Subak Application that has been created, as well as the discussion of testing and analysis of the results of the Subak Application development.

3.1. Digital Transformation Implementation

The digital transformation in this research involves implementing a mobile technology-based information system that manages S*ubak* data, which was previously recorded traditionally and conventionally. In the Subak Application, data can be digitally recorded, and it utilizes Geographic Information System (GIS) technology to map S*ubak* areas more accurately.

Figure 6. Conventional Subak Data

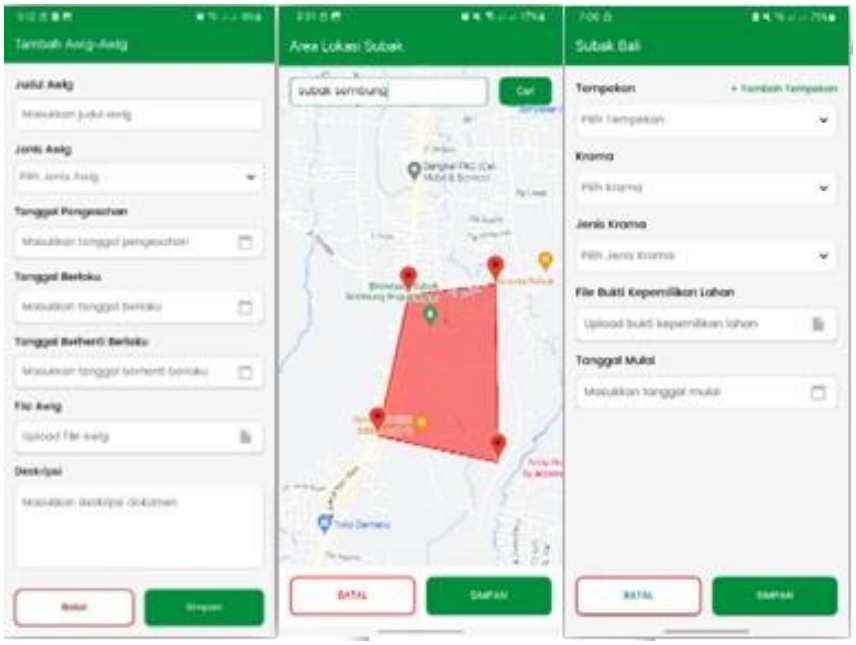

Figure 7. Digitalize Subak Data using the Android Platform

Figure 6 is an example of conventional S*ubak* data, where its use still involves printed media, limiting its coverage and making data management ineffective. With the implementation of digital transformation through an information system, data management becomes much more accessible, mainly when changes occur. Furthermore, the user base becomes broader through digital transformation, as anyone with a mobile device can access *Subak* data. The changes in conventional data can be observed in Figure 7.

Figure 7 represents the previously conventional data digitized using an Android platform. With this system, *Subak* managers can add or modify data in real time. Users can also instantly access the data that has been added or modified by *Subak* managers.

3.2. Subak Application User Interface

The application user interface is a visual display of an application that aims to connect users with the system [22]. The user interface is the appearance of a product that bridges the system with the user, where the UI design can include colors, shapes, and engaging text in mobile applications [23], [24]. The User interface for the Subak Application is developed with two types: user interface for admin and user. The visual representation of the Subak Application user interface can be seen in Figure 6.

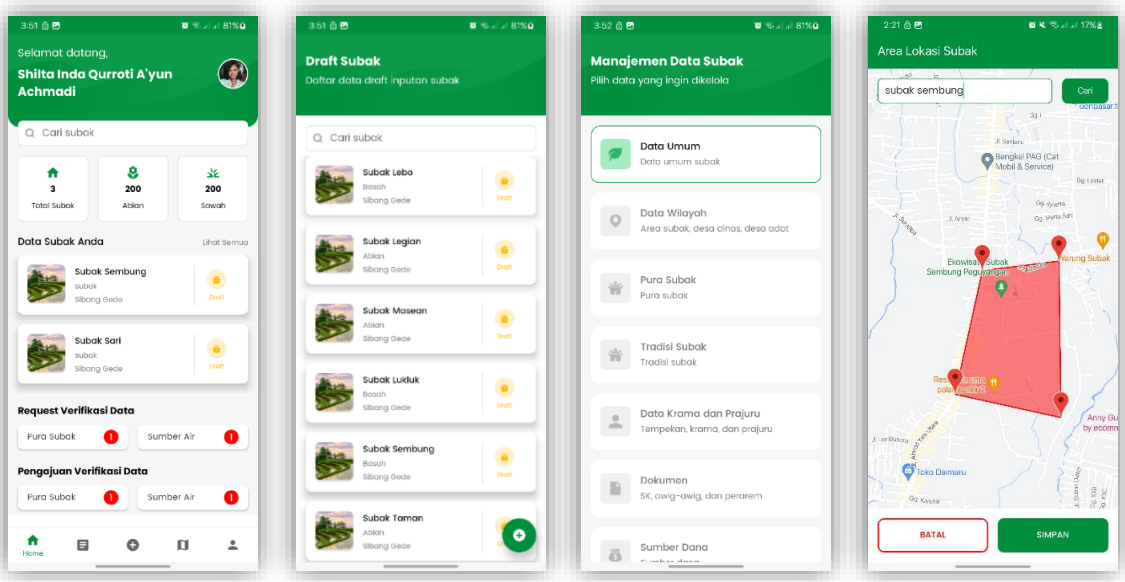

Figure 8. Subak Application User Interface

Figure 8 represents the user interface of the Subak Application. It includes a home screen displaying the total number of *Subak* in the village, *Subak* data that have been recorded, and notifications for temple or water source verifications. The Subak Application features a bottom navigation bar with five options for different functionality. Selecting "data" from the navigation will display the master data of the Subak Application. Choosing the "*Subak*" menu from the master data will show all draft *subak* data that has been input, which can be viewed, updated, or edited. Admin can also add *Subak* data, consisting of primary and detailed information. The Subak Application also enables selection for *Subak* areas, which will be displayed as a Geographic Information System.

3.3. Black Box Testing

Using predefined test cases, system testing using the Black Box Testing technique will involve testing 61 pages of the Subak Application from both the admin and user perspectives. The aim is to ensure that the application functions correctly and efficiently. Here are some examples of Black Box Testing conducted on the Subak Application.

Table 1 is an example of Black Box Testing conducted on the Subak Application based on the test scenarios prepared for testing the entire application. The test results have been met and are in line with expectations. Several differences from previous research were identified in the development of the Subak Application, which can be seen in Table 2.

Table 1. Testing the Subak Main Data Entry Page

Testing Activity	Testing Scenario	Expected Results	Explanation
Adding Main Data	- Entering the subak name - Selecting the subak type - Entering the subak area - Entering the northern, southern, eastern, and western boundary of the subak - Selecting the subak district - Selecting the subak sub-district - Selecting the subak village - Tapping the map thumbnail - Determining the subak's location point - Saving the subak's location point - Pressing the "Continue" button	The application will direct the admin to the "Add Region Data" page, and a pop-up message will appear saying "Data Successfully Added."	Fulfilled
Selecting the Subak Location Point	- Pressing the "Data" bottom navigation button - Pressing the "Subak" menu button - Selecting one of the draft *Subak* from the list - Pressing the floating action button at the bottom right of the page - Pressing the "Add General Data" menu - Tapping the map thumbnail - Determining the Subak location point - Saving the Subak location point	The application will display the Subak location point on the map thumbnail.	Fulfilled
Not filling out all the forms	- Pressing the "Data" bottom navigation button - Pressing the "Subak" menu button - Selecting one of the draft Subak from the list - Pressing the floating action button at the bottom right of the page - Pressing the "Tambah Data Umum" menu - Pressing the "Continue" button	The application will display a red icon next to each empty form	Fulfilled

Table 2 represents a comparison between the Subak Application and previous research. The first two comparisons relate to data concerns; one is its coverage, and one is the type of data being dealt with. The Subak Application covers the entire province of Bali, while in the previous research, *Subak* information was limited to just one district; for example, *Subak* data was only available in the Kediri sub-district, Tabanan Regency. Additionally, the Subak Application contains more data, not limited to general *Subak* information alone.

Third, the Subak Application is built on the Android platform, giving consideration to the fact that mobile phones (along with downloadable applications) are much more accessible and easier to navigate to a broader range of users. The previous research used a website-based platform, inherently at risk of having web issues and requiring a strict internet connection to have access

to the data, giving a disadvantage to those areas that have difficulties in having a reliable connection to the internet.

Table 2. Comparison of the Subak Application with Previous Research

	Subak Application	Previous Research
Data Coverage	Covers the entire province of Bali	Covered S*ubak* data in only one district rather than the whole province.
Data Types	It includes a broader range of data, not limited to general *Subak* information, but also contains data on temples (*pura*), water sources, committees (*krama* and *prajuru*), and other detailed information.	The data primarily consisted of GIS visuals and some general *Subak* information without a wide variety of data types.
Platform	The application is built on the Android platform	The research utilized a website-based platform
Interface	The user interface is designed to be user-friendly	The interface was not user-friendly
Data Input	Village administrators across the entire province of Bali can input data	A single administrator carried out data input

Fourth, the Subak Application offers a user-friendly, informative, and easily understandable interface, while the previous research had a less informative and less user-friendly website interface. In the final comparison, village administrators across the entire province of Bali can input data into the Subak Application. In contrast, in the previous research, users could not input data and could only view data inputted by administrators.

The Subak Application optimizes the digital transformation from previous research, where subak data was initially recorded conventionally and traditionally, then digitized and made accessible through a website. Now, it can be accessed through a mobile device with broader user coverage and more comprehensive data than the previous research.

4. Conclusion

In comparison, based on the previous research where *Subak* data was only available in one district and had incomplete details, deploying the developed Subak Application can now encompass the *Subak* data for the entire Bali province. This includes the primary *subak* information, wherein detailed data such as *subak* areas are shown as a collective Geographic Information System. Additionally, it also contains data on temples (pura), committee data (*krama* and *prajuru*), document data, funding source data, and *Subak* water source data. This detailed data is integrated, making it easily accessible to users.

Furthermore, the application is built on the Android platform. This creates an expansion in the number of user reach as Android is much more accessible given that it is a commonly used device among the general public.

The Black Box method aided the process of preparing test scenarios and testing functionality to find error gaps that can be detected if there are input or output errors. Upon testing scenarios on 61 application pages, it can be concluded that the *Subak* Application found no functional errors in any features. Therefore, the *Subak* application runs effectively.

This development complements the shortcomings of the previous research, such as the Subak Application, which provides a more detailed database covering all of Bali. It is also an Android-based software integrated via a mobile platform, which allows many users more access.

Ultimately, with the help of the Subak Application through digital transformation, *Subak* management will now accomplished with much more ease and accuracy, along with a broader range of data and its in-depth representation.

References

[1] W. Windia, S. Pusposutardjo, N. Sutawan, P. Sudira e . S. S. Arif, “Sistem Irigasi Subak dengan Landasan Tri Hita Karana (THK) Sebagai Teknologi Sepadan dalam Pertanian Beririgasi,” *SOCA: Jurnal Sosial Ekonomi Pertanian,* vol. 5, 2012.

[2] I. G. A. M. R. Jayantiari, A. G. O. Parwata e I. G. N. D. Laksana, “Orientasi Kesejahteraan dalam Pengaturan Subak Sebagai Warisan Budaya Dunia,” *Jurnal Kertha Patrika,* vol. 43, pp. 82-92, 2021.

[3] I. M. Geria, Sumardjo, S. H., Sutjahjo, Widiatmaka e R. Kurniawan, “Subak Sebagai Benteng Konservasi Peradaban Bali,” *AMERTA,* pp. 39-54, 2019.

[4] Anonymous, “2.726 Subak Berusaha Bertahan,” NusaBali.com, 4 November 2018. [Online]. Available: https://www.nusabali.com/berita/40970/2726-subak-berusaha-bertahan. [Acesso em 8 September 2023].

[5] P. Diamandis e S. Kotler, The Future Is Faster Than You Think: How Converging Technologies Are Transforming Business, Industries, and Our Lives, 2020.

[6] L. A. Rabho, P. Awondo e D. Miller, The Global Smartphone: Beyond a Youth Technology, 2021.

[7] S. Kraus e N. Roig-Tierno, "Digital Transformation: An Overview of the Current State of the Art of Research," *SAGE Open,* pp. 1-15, 2021.

[8] N. M. Trigunasih, A. A. I. A. Pramesti, N. B. K. Sari e P. Y. Pribadi, “Sistem Informasi Subak Berbasis Web GIS (Geography Information System) dalam Menunjang Pertanian Berkelanjutan di Kecamatan Kediri, Kabupaten Tabanan,” *Nandur,* vol. 1, pp. 196-204, 2021.

[9] F. Cahyaningrum, I. Lanya e N. M. Trigunasih, “Aplikasi Remote Sensing dan Sistem Informasi Geografis untuk Menunjang Database Lahan Pertanian Pangan Berkelanjutan di Subak Padanggalak,” *Jurnal Agroekoteknologi Tropika,* vol. 10, pp. 366-277, 2021.

[10] A. T. V. Sitepu, I. Lanya e I. G. P. R. Adi, “Pemetaan Sumberdaya Subak Berbasis Remote Sensing dan Geographic Information System di Subak Juwuk dan Subak Lebo, Kecamatan Sukawati, Kabupaten Gianyar,” *Jurnal Agroekoteknologi Tropika,* pp. 561-569, 2021.

[11] L. Sari e G. Y. K. S. S. Siregar, “Perancangan Aplikasi Pendataan Data Kepegawaian Negeri Sipil pada Dinas Komunikasi dan Informatika Kota Metro,” *Jurnal Mahasiswa Ilmu Komputer (JMIK),* vol. 1, pp. 115-135, 2021.

[12] D. . R. Kulkarni e M. P. P. R. Prasad, "Novel Approach to Abstract the Data Flow Diagram from Java Application Program," *International Journal of Intelligent Systems and Applications in Engineering,* vol. 11, pp. 394-404, 2023.

[13] A. Y. Aleryani, "Comparative Study between Data Flow Diagram and Use Case Diagram," *International Journal of Scientific and Research Publications,* vol. 6, nº 3, pp. 124-127, 2016.

[14] T. B. Kurniawan e Syarifuddin, “Perancangan Sistem Aplikasi Pemesanan Makanan dan Minuman pada Cafetaria no Caffe di Tanjung Balai Karimun Menggunakan Bahasa Pemograman PHP dan MySQL,” *Jurnal TIKAR,* vol. 1, pp. 192-206, 2020.

[15] E. R. Aquino, P. d. Saqui-Sannes e R. A. Vingerhoeds, "A Methodological Assistant for Use Case Diagrams," *SCITEPRESS - Science and Technology Publications,* pp. 227-236, 2020.

[16] K. O. Putra, M. Jannah e E. Yubarda, “Aplikasi Penjualan Alat Tulis Kantor pada Alif Photocopy,” *Jurnal Jaringan Sistem Informasi Robotik (JSR),* vol. 6, pp. 114-121, 2022.

[17] A. R. Atmala e S. Ramadhani, “Rancang Bangun Sistem Informasi Surat Menyurat di Kementerian Agama Kabupaten Kampar,” *Jurnal Intra Tech,* vol. 4, 2020.

[18] H. Alshareef, K. Tuma, S. Stucki, G. Schneider e R. Scandariato, "Precise Analysis of Purpose Limitation in Data Flow Diagrams," *Association for Computing Machinery,* pp. 1-11, 2022.

[19] M. Y. P. Mahendra, I. N. Piarsa e D. P. Githa, "Geographic Information System of Public Complaint Testing Based On Mobile Web (Public Complaint)," *Lontar Komputer - Jurnal Ilmiah Teknologi Informasi,* vol. 9, pp. 95-103, 2018.

[20] N. M. D. Febriyantia, A. A. K. O. Sudana e . I. N. Piarsa, "Implementasi Black Box Testing pada Sistem Informasi Manajemen Dosen," *JITTER- Jurnal Ilmiah Teknologi dan Komputer ,* vol. 2, 2021.

[21] E. Hartati, A. Irawan, Fatmariani e W. Yunifa, "E-Archive Based on Web for Plaju Ulu Sub-District," *Sinkron : Jurnal dan Penelitian Teknik Informatika,* vol. 8, pp. 1747-1752, 2023.

[22] O. Sudana, I. W. W. I. M. J e D. P. S. P, "Implementation Of Tree Model In The Development Of E-Mantram Android Application," *Lontar Komputer - Jurnal Ilmiah Teknologi Informasi,* vol. 13, pp. 117-127, 2022.

[23] H. Thimbleby, User Interface Design, Assn for Computing Machinery, 1990.

[24] W. Buana e B. N. Sari, "Analisis User Interface Meningkatkan Pengalaman Pengguna Menggunakan Usability Testing pada Aplikasi Android Course," *DoubleClick: Journal of Computer and Information Technology,* vol. 5, pp. 91-97, 2022.