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Geographic Information System (GIS) for Salt Management in Madura Island

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Abstract— **Madura Island is known as Salt Island because it has many salt fields, produces a high volume of salt, and is the main contributor to national salt production. There are some salt fields in Sampang, Pamekasan, and Sumenep districts. It is essential to manage, control, improve, and decide Salt production in Madura island. There is still limited research about GIS for Salt Management for the case study in Madura Island. Therefore, this paper aims to capture and design a Geographic Information System (GIS) for Salt Management in Madura. The system will map salt fields, storage, production, marketing, and other places. Hopefully, it contributes by providing a GIS model for Salt mapping, management, and decision-making in Madura. The novelty of this research is the developed system based on the case study in Madura Island. This paper is developed based on progress research about GIS for Salt Management based on the Scrum model in Madura.**

***Keywords**—Geographic Information System (GIS), Salt management, Madura Island, Model*

I. Introduction

Madura Island is known as Salt Island because it has many salt fields, produces a high volume of salt, and is the main contributor to national salt production. In 2017, Indonesia produced 1,020,925 tons of salt. East Java province contributed 372,728 tons of salt, and Sumenep, as one of the districts in Madura, had 126,662 tons of salt. Therefore, Sumenep was the highest salt producer in East Java province and the second-highest producer in Indonesia. In 2018, Sumenep produced 190,007 tons of salt, and Pamekasan had 2,749 tons of salt. [1] presented salt fields in Madura island's Sampang, Pamekasan, and Sumenep district in Madura island.

Furthermore, GIS is needed to map, analyze, manage, control, improve, and decide salt fields, storage, production, and marketing data. These data will be visualized in the system using geospatial data. It will be helpful for field utilization management of salt, natural resources, environment, transportation, region facilities, and other public services.

It is vital to manage, control, improve, and decide on Salt production in Madura Island. Many researchers have conducted research related to geographical information systems (GIS). There is still limited research about GIS for Salt Management for the case study in Madura Island. Therefore, this paper aims to capture and design a Geographic Information System (GIS) for Salt Management in Madura.

The system will map salt fields, storage, production, marketing, and other places. The novelty of this research is the system is designed for the case study in Madura Island. This paper is developed based on progress research about GIS for Salt Management based on the Scrum model in Madura. Scrum is a framework to provide stages for organizing and controlling software and product development process. Furthermore, Scrum combines iterative and incremental models as it has consecutive and incremental features related to object-oriented software development. Moreover, Scrum is designed to improve development speed, organization, and individual alignment, define a culture that focuses on performance, support value creation from shareholders to have good communication about performance at all levels, and improve individual and quality of life [2]. Scrum contributes as a framework to develop the Salt GIS based on agile characteristics. Therefore, the developer does not have to wait for all the development processes to make changes, updates, and improvements.

This paper contains an introduction, literature review, research methods, analysis and discussions, and conclusions. The introduction section captures the Madura island as a high volume salt producer, gap, aim, contribution, the novelty of the research. Furthermore, the literature review will explain GIS and Salt management kinds of literature. Moreover, the analysis and discussion result will present analysis, design, and discussion about GIS for Salt management. The conclusion section will provide a summary, conclusion, and future research.

II. LITERATURE REVIEW

GIS has assisted in describing the analysis results, such as soil salinity modeling [3], agro-hydrological modeling [4], research opportunity [5], big data [6], power system [7], education [8], Undergraduate Academic Curriculum [9], decision support system [10], enterprise geographic information system [11], developing countries [12], big data

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problem [13], and also marketing information system [14]. [15] created a virtual GIS to navigate, analyze, and visualize complex and dynamic area databases and models. The data contains elevation and spatial data, buildings, vehicles, and other objects. The system is window and virtual reality-based, [16] employed GIS with spatial data processing for natural resources management, as well as environmental assessment and monitoring, [17] examined GIS has been utilized in urban planning and design, for example, Canadian Geographic Information System (CGIS) in 1963 to map the natural resources in a land inventory project. GIS is also applied in many fields, such as transport and logistics, urban architecture, engineering networks, military planning, real estate, urban planning, and environmental protection. This research presented a data model as shown in Fig. 1 and abstraction level in GIS as captured in Fig. 2.

Furthermore, [18] conducted topographic structure extraction from digital elevation data for GIS examination, [14] captured GIS application to support Marketing Information System (MKIS). This research presented capabilities alignment with components of MKIS. Also, the GIS has the capability for information integration from various sources and multiple decision aspects.

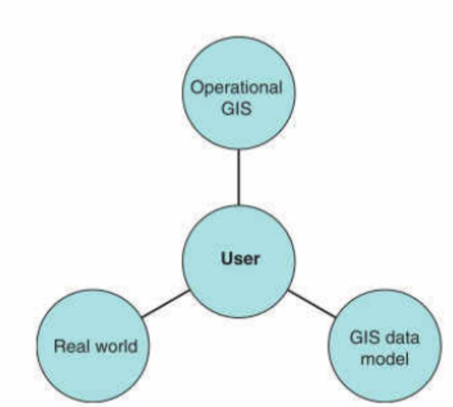

Fig. 1. Data model in GIS [17]

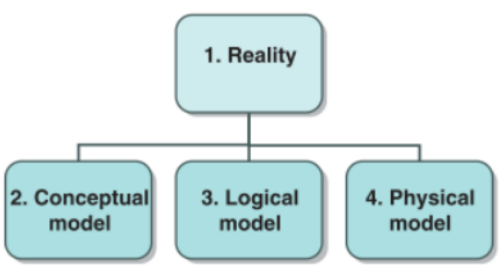

Fig. 2. Abstraction level in GIS [17]

Furthermore, much research about Salt Management has been conducted: [4] applied the agro-hydrological model SWAP to enhance water and salt management in Northern Iran. This model has been used for Voshmgir irrigation and drainage network, [19] implemented a Decision support system for environmental including seasonal wetland salt management in a river basin, [20] examined a system method for coupled mine site water and salt balances. This research aims to analyze the implications of desalination or dilution implementation and evaluate the cost and benefits, [21] captured salt management strategy related to mangrove tree species with the stem and hydraulic leaf details, [22] examined water and salt management in the Yanqi Basin, China.

Also, many systems have been developed by a software company as the result of the research. Unfortunately, the system was not equipped with graphical, remote sensing, and geomatics science as well. However, several researchers have been tried to conduct it, such as integration remote Sensing and geographical information system to manage salt [23], modeling and mapping of the soil salinity based on remote sensing and geographical information system [3], dust event assessment using GIS and MODIS satellite imagery to evaluate the dust storm [24], land use and land cover (LULC) changing pattern based on the remote sensing technology [25]. Features of the graphical information model will assist top management person in making the best decision. [23] has integrated geographical information systems and remote sensing to serve many fields in Jordan. The research results have been utilized to yield and assist in decision-making flexibly, easily, and simply. GIS model can assist in extracting region topography, area boundaries, and road network as well. They use ENVI 4.3 to visualize the images. In this case, the ENVI 4.3 has combined and integrated package of image processing with spectral tools. The ENVI 4.3 could be used to analyze information of the hyperspectral images adaptively, simply, and easily. [3] has succeeded to model and mapping the soil salinity using remote sensing and geographical information system. The authors have determined remote sensing feasibility using spatial modeling, regression model, and also remote sensing. They use the irrigation farm of the Wonji sugar cane as the material of the experimental data, Ethiopia. They have modeled a location map of the area for research. They also conduct image enhancement as pre-processing before model generation and validation. The regression model was used to describe spatial variation of the soil salinity. The results show that the research results can be used to predict soil salinity. [24] has conducted research to describe the effect of the dust based on the GIS, MODIS, and statistical model. They have determined sampling points based on random data sampling as experimental data. They have selected thirty areas to observe the loss of dust. They can conduct analysis easily based on the GIS and result in analysis, such as "changes in dust, for both spatial and temporal." The results also described that low green space, wind blowing direction, Sistan wind, marginal and urban densities could affect the changes in dust for both spatial and temporal.

Based on the research results, some papers show that using the geographical information system model can assist us in visualizing, assessing, evaluating, and analyzing the results. In this research, we proposed a method to manage salt in Madura based on Geographical Information systems: salt field mapping, storage area, salt production, marketing network, and supply chain of the salt.

III. RESEARCH METHODS

This paper is a part of our research about GIS for Salt Management. The stages of research can be shown in Fig. 3.

The stages of research consist of designing research, conducting literature reviews about GIS and Salt Management from various sources, such as reputable journals, proceedings, and books. Furthermore, we identified spatially and attributed data about salt fields, storage, production, marketing, and other places related to Salt management. After that, we conducted early analysis and designed GIS for Salt management. Moreover, we reviewed the GIS design and identified a plan of improvements. Data identification and collection will follow stages in Fig 4: planning, preparation, transfer, editing, and assessment.

Fig. 3. Reseach methods

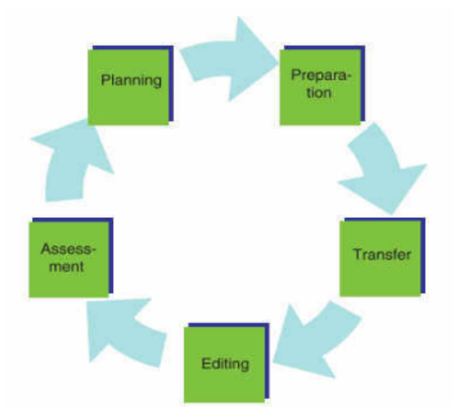

Fig. 4. Data Collection Steps [17]

IV. DESIGN AND ANALYSIS

We have identified data requirements as presented in Table I. The required data contains spatial and attribute data about Salt fields, processing and production, storage, and marketing. in from Bangkalan, Sampang, Pamekasan, and Sumenep. The data is gathered from Bangkalan, Sampang, Pamekasan, and Sumenep in Numbers 2021 documents produced by Statistics Centre Board (Badan Pusat Statistik – BPS). Also, we are still approaching the Department of Marine Affairs and Fisheries in Bangkalan, Sampang, Pamekasan, Sumenep, and PT. Garam in Sampang and Sumenep to collect those data.

TABLE I. DATA REQUIREMENTS

Spatial and Attribute Data	Location	Sources
Salt fields	Bangkalan, Sampang, Pamekasan, Sumenep	Bangkalan, Sampang, Pamekasan, and Sumenep in Numbers Document by BPS Department of marine affairs and fisheries in each district. PT. Garam in Sampang and Sumenep.
Salt processing and production	Bangkalan, Sampang, Pamekasan, Sumenep	Bangkalan, Sampang, Pamekasan, and Sumenep in Numbers Document by BPS Department of marine affairs and fisheries in each district. PT. Garam in Sampang and Sumenep.
Salt storage	Bangkalan, Sampang, Pamekasan, Sumenep	Bangkalan, Sampang, Pamekasan, and Sumenep in Numbers Document by BPS Department of marine affairs and fisheries in each district. PT. Garam in Sampang and Sumenep
Salt marketing	Bangkalan, Sampang, Pamekasan, Sumenep	Bangkalan, Sampang, Pamekasan, and Sumenep in Numbers Document by BPS Department of marine affairs and fisheries in each district. PT. Garam in Sampang and Sumenep.

Furthermore, the users of this system will be an admin who can access all menus and features, including add, remove, and update data. The second user type will be public users, who can access and view menus and features without updating data. Table II shows user requirements for the GIS.

TABLE II. USER REQUIREMENTS

User	Facilities
Admin	All menus and features
Public	View menus and features without data update and remove

Moreover, Fig 5 captures the use case diagram of the GIS. The admin public can view spatial and attribute data in the system. Furthermore, public users can log in, input, add, delete, and change spatial and attribute data.

The design has been reviewed, and Table III shows the plan of improvements, such as the database should consist of map, text, and numbers. The user interface should be simple and easy for the user, and the map should be visible.

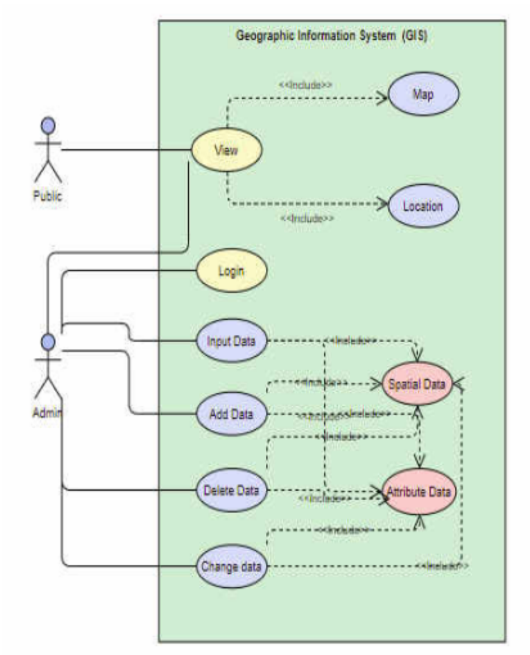

Fig. 5. Use Case of GIS

TABLE III. REVIEW AND IMPROVEMENT PLAN

Review	Plan of improvement
Database	Data consist of map, text, and numbers
User interface	Simple and easy for the user
Map	Visible

Moreover, the database design has been developed using Physical Data Modelling (PDM). The database contains tables: regencies, provinces, districts, public users, villages, salt lands, salt-land owners, and salt land attributes (Fig. 6).

As discussed above, this research-in-progress shows how the complex task in salt farming activity can be effectively managed by using a GIS-based application. For this purpose, this research describes the design process of such GIS, including requirement engineering, use case design, database by the Scrum model. While the result is preliminary and based on region-specific, some general lessons learned and design principles can be drawn from this study. Especially for similar projects that aim to design and develop a GIS salt-related application, this research-in-progress suggests that the Scrum model has been useful in guiding the development process. Moreover, the business process design, use case design, and the database design proposed in this study can be a reference for those building a GIS salt-related application for any region

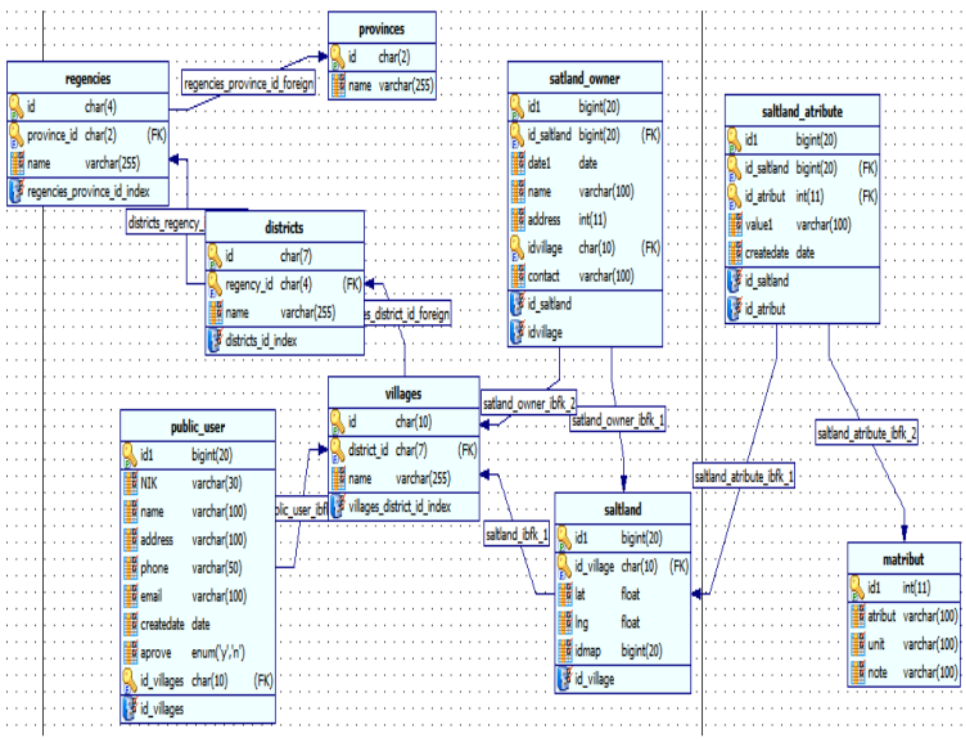

Fig. 6. Database design

other than Madura Island. Finally, since this is research in progress, more research is needed to continue the development process.

V. CONCLUSIONS

This is in-progress research of GIS-based on Scrum model for Salt management in Madura. This paper captures literature review, data identification, analysis, and GIS design and reviews and improvement of the design. The system contributes by providing a GIS model for Salt mapping, management, and decision making in Madura so that the volume of salt production in Madura can be improved. The future research will be GIS based on the Scrum model for Salt management in Madura.

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