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Spatial Technology Based Participatory Digital Database for Village Potentials

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Abstract. Geodatabase or digital spatial database is one of the GIS applications with an integrated database that has become a data source center that can be accessed for information and analysis needs by various existing applications. Participatory digital database has the potency to be used for inventoring and collecting a complete, comprehensive, and detailed village/sub-district potentials spatial data. This research aims to provide knowledge as well as skills to the community, especially sub-district officials about a standardized spatial-based digital database of village potentials. The study took place in Langnga village, Mattiro Sompe District, Pinrang Regency, South Sulawesi, Indonesia. Methods used in this research are UAV Data Processing, Geodatabase System Compilation, Census and Cadastre Surveys, and Integration of Non-Spatial Data with Spatial Data. By compiling village potentials geodatabases, we constructed a Langnga village's potentials map which can be used as a reference for planning and development of the village.

1. Introduction

The Geodatabase is a concept of relational data management in a table form, which contains spatial and non-spatial data that helps the process of storing and managing geographic information in data management systems. This geodatabase or digital spatial database is a GIS application with an integrated database that has become a data source center. It can be accessed by various existing applications for information and analysis needs. It is built from Unmanned Aerial Vehicle (UAV) data and can be used in the processing and storing of data for the planning and development of villages / sub-districts. This system is expected to display a village / sub-district profile with standardized geographic information. The application of UAV technology in scientific research for mapping has been widely applied in various fields of science such as monitoring in agriculture [7], [3]; Archeology [4]; and Meteorology [5].

According to the Ministry of Villages, Development of Disadvantaged Areas, and Transmigration, there are currently 74,954 villages in Indonesia. Out of this number, 14,000 are very remote and 33,000 are underdeveloped with indicators of the absence of major infrastructures, such as electricity, roads, and public service facilities (public health center and schools). Based on this circumstance, a village map in a form of geospatial data and information would be an urgently required instrument for regional development planning. With this geospatial information, the development in the village can be expected to be more focused and synergized between the central and regional governments. However, there is a lack of trained-know-how human resources in almost all villages and sub-districts in Indonesia, one of which is Langnga Village, Mattiro Sompe District, Pinrang Regency. This village is located in the coastal area of South Sulawesi with some promising potency in fishery and agriculture. Nevertheless, it does not yet have a detailed, standardized database of its potentials. Therefore, this study aims to provide knowledge as well as

skills to the village community, especially the village officials, about a standardized spatial-based digital database of village potentials. By assisting them in constructing geodatabase, a map of Langnga village and its potentials was produced. This map can be used as a reference in planning the development of the village.

2. Materials and Methods

2.1 Study Site

Field and UAV data were collected in April - June 2020, in the Langnga village area, Mattiro Sompe District, Pinrang Regency, South Sulawesi, Indonesia, covering an area of 585.95ha (Figure 3).



Figure 1. Study site in Langnga village, Mattiro Sompe District, Pinrang Regency, South Sulawesi, Indonesia

2.2 UAV Data Processing

Nowadays, the use of Unmanned Aerial Vehicle (UAV) technology for mapping objects on the earth's surface has been growing [1], [6]. This platform offers several flight modes such as manual, semi-automatic, and automatic mode (Mitch and Salah 2009). The UAV data processing stage consists of (1) the preparation stage, (2) the acquisition stage, and (3) the data processing stage. In the **preparation stage**, we identified which area to be mapped in hectares, and determined the desired pixel resolution or ground sample distance (GSD). For a height of 150 meters, the GSD is 5.25 cm. The amount of overlap between photos was determined to be 80%. The vehicle being used was the DJI Phantom 3 and DJI Phantom 4 type drones with a camera resolution of 12 MP and 12.4 MP with the ability to fly for 15 - 28 minutes per battery. Furthermore, Pix4D Capture was used, which is an Android-based application to estimate the number and duration of flights based on the parameters. The **acquisition stage**, includes the time of photoshoots, which was between 08:00 to 10:30 and 14:00 to 16:30, with the assumption of sunny weather and a gentle wind.

Data Processing Stage which includes :

- Selection from the captured aerial photos. Photos that were blurry, tilted, or did not have an upright 90° angle were set aside. Aerial photo data processing was done using the trial version of Pix4D Mapper software.

- Photos aligning, dense cloud building, texturing, ortho-mosaicking, DSM building, and exporting ortho maps. Photos aligning is the process of aligning or straightening photos before combining multiple photos into a single photo. In the dense cloud building, the aligned photos were processed into many points with their height or depth value. Texturing changes data form from dots to the earth's surface texture or roughness. Ortho-mosaicking is the process of combining photographs based on reference coordinates and pixel depth values. The Digital Surface Model (DSM) is a model of the level of objects towards the earth's surface from the ortho-mosaic process, which then being exported into tiff format.
- Compressing and exporting the resulting map into .ecw format using an image processing software.
- Geometric correction of the resulting map from ortho-mosaic based on the 2017 One Map Policy Data (KSP) from BIG using the Orde 2 method.
- Land use classification process of corrected aerial photo data using visual interpretation by on-screen digitizing.
- Topology checking process was carried out on the results of digitization to correct its errors

2.3 Construction of The Geodatabase System

A literature review was performed to determine elements and indicators contained in the village potential map database information. Some of those were referred to related laws and government regulations regarding villages and community welfare. Other aspects considered in the preparation were the convenience of data acquisition, data collection time, and user-friendliness. Based on the analysis, we obtained four parameters that would be used to construct the spatial database of the village's map, which are Settlement, Infrastructure, Agriculture, and Fishery. The data structure in each feature class that would be inputted into the spatial database was compiled based on the database structure that has been stipulated in regulations such as the Catalog of Indonesian Geographical Elements (KUGI) (Ministry of Public Works and Housing, 2017).

2.4 Census and Cadastral Surveys

The census was conducted in a participatory manner, accompanied by a volunteer team to collect detailed data of each house, rice field, and pond. A numeric code was provided to facilitate the survey team. The next step was providing the codification that appears on the aerial photograph. This codification was given as a benchmark in filling the attribute data of the database system and the village potentials map. Data recording tools in the field are audio recorders and cameras.

2.5 Integration Process of Non-Spatial Data with Spatial Data

After the spatial database system was made, the recapitulation of non-spatial data was conducted based on the codes created at the beginning. The results were then integrated with the detailed spatial data of land use that had been compiled previously.

3. Results and Discussion

3.1 Digital participatory database

A spatial database is one of the important elements in map creation. Maps that do not have information in their attributes only provide a location and an overview of the area, needless to say, it would be of less use. In this case, the participatory digital database could be utilized for a complete, comprehensive, and detailed village potentials spatial data inventory and compiling. For this purpose, the staff and the community of the

village were taught to use a mobile-based survey and mapping application, Avenza, to facilitate the census and ownership survey. Village officials were also told to participate by contributing the village's potentials data through this app. These data could then be used to construct the geodatabase of Langnga Village's potentials. The types of data obtained from this census and cadastral survey were administrative boundaries, road networks, settlements, infrastructure, agriculture (rice fields), and ponds (Table. 2).

Table 1. Parameters used for the construction of the spatial database of the village's potentials maps, consisting of main elements and indicators

Main Elements	Indicators
Administrative Boundaries	Village Code, Village Name, Village Area Size, Type of administration, Status, Boundary Characteristics, Type of Boundary.
Road Networks	Id, Name, Function, Authorization, Class, Material, Position, Region, Condition, Number of Lines, Length
Settlements	ID Number, Family Card Number, Number of Family, Status, Age, Occupation, Gender, House Size
Infrastructure	Land Status, Land Size, Building Size, Wall Type, Floor Condition, Floor Type, Roof Type, Year of Construction, Sanitation, Electricity, Telephone / Mobile, Internet Connection, Television
Agriculture (Rice fields)	Ownership Status, Plant Type, Crops Yield, Area Size
Aquaculture (Fish ponds)	Ownership Status, Cultivator, Type of Cultivation, Yield, Luas

There are several people who participate by sending their respective census results such as home ownership (Figure 2).



Figure 2. Some of Avenza app survey data send by the village community

Besides the app, there was also participation from several community leaders based on printed maps. In Figure 3, the head of households from the Langnga village identified land ownership using secondary data of land and building tax payment.



Figure 3. Participation of the Head of the Langnga Households and the results of interpretation

3.2 Integration of spatial and non-spatial data

The result data of the census and cadastral survey recapitulation was integrated with detailed-scale land use spatial data. The spatial databases were collected from each house, ponds and rice fields as in Figure 3-5. Therefore, community service activities were carried out again in Langnga village in the following year to collaborate and assist the community, especially government officials to build a database of village potentials.

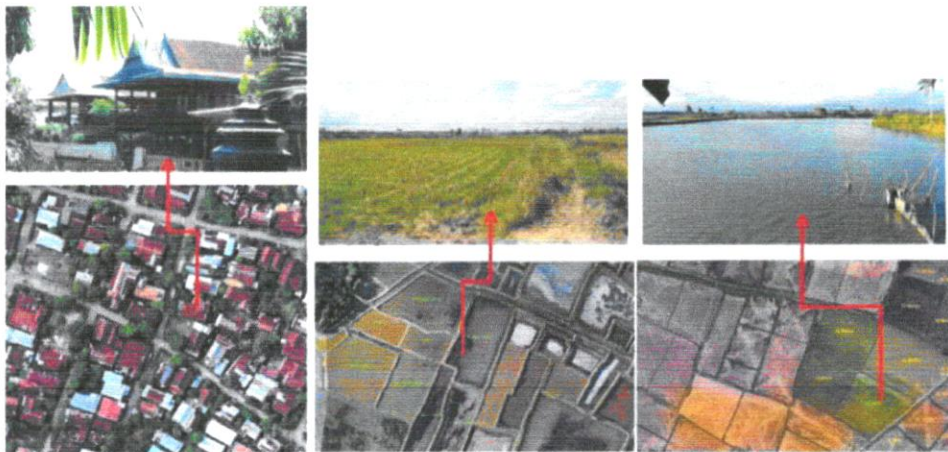


Figure 4. Households, ponds and rice fields ownership survey on July 16, 2020

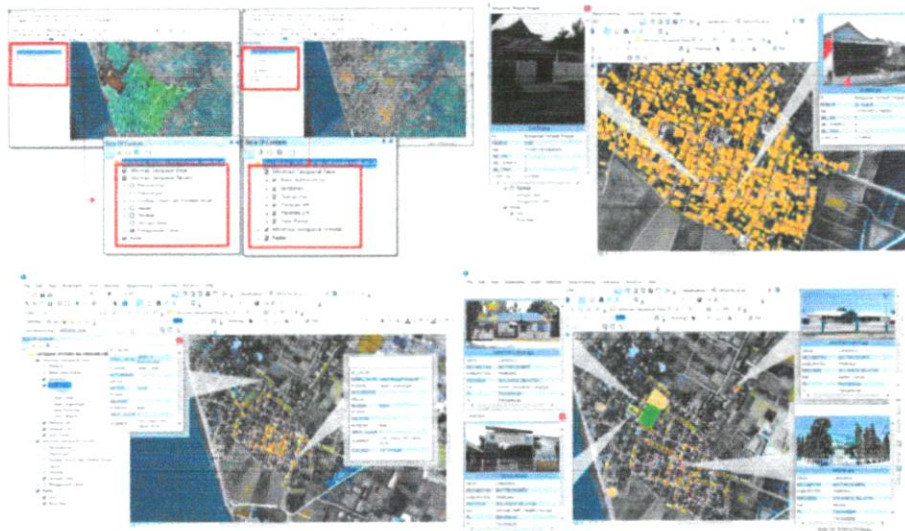


Figure 5. Basic and Thematic Geospatial Information layer structure. Geodatabase Display for Road Networks, residential areas, public and social facilities. The number of settlements in the Langnga village is around 1392 residential buildings.



Figure 6. The geodatabase view of rice fields and ponds. The number of ponds in Langnga Sub-district is around 471 plots and the number of rice fields is around 801 plots.

3.3 Village's Potentials Geodatabase

The village's potentials geodatabase is a relational data management concept that contains spatial and non-spatial data. Geodatabase helps the process of storing and managing geographic information in a standard data management system. By using the geodatabase, users will get several benefits at once. Among other things, all appearances and their attributes have a centralized storage location, the ability to group features into subtypes, and create spatial and attribute validation rules. Geodatabase consists of feature classes (spatial) and tables (non-spatial). Feature Class is a collection of several features that have the same geometric shape and attributes. Feature classes in the geodatabase can be single or individual features and can also be organized into feature datasets. All feature datasets in a geodatabase use the same coordinate system. The geodatabase view of the potential of Langnga Village can be seen in Figure 5-6.

A geodatabase is a form of geospatial data, which is needed in regional development planning. With this geospatial information, development in the village becomes more focused and there is a synergy between the central and local governments. To mobilize community participation in building a geospatial-based database at the village level, the Geospatial Information Agency (BIG) has issued guidelines for the preparation of a geodatabase system. Therefore, villages can carry out thematic mapping independently according to the standards issued by BIG. This village boundary map becomes the boundary of the Village area to build a standardized database of village potentials.

4. Conclusion

The participatory digital database could be utilized for a complete, comprehensive, and detailed village potentials spatial data inventory and compiling. By assisting the village officials in constructing geodatabase, a map of Langnga village and its potentials was produced. The types of data obtained from this census and cadastral survey were administrative boundaries, road networks, settlements, infrastructure, agriculture (rice fields), and ponds. Community of the village is participated by sending their respective census results such as homeownership. Participatory digital database has the potency to be used for inventoring and collecting a complete, comprehensive, and detailed village/sub-district potentials spatial data.

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