Analysis of Damage Levels of Primary and Secondary Irrigation Channels in Suradadi Sub-district, Tegal Regency, Indonesia Based on Geographic Information Systems (GIS)

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Abstract. Irrigation channels fulfill agricultural water needs by channeling water from various sources. Suradadi Sub-district has great agricultural potential, so irrigation infrastructure is a supporting factor for sustainable agricultural productivity. Agriculture depends on irrigation, the sustainability of the water supply is a priority. Water shortages in irrigation channel areas become a problem for farmers every year. Limited information on the condition of irrigation channels is an obstacle in repair and monitoring efforts. Incomplete data and information result in errors in the policy making process. This research aims to identify irrigation channels using Landsat images, identify the level of damage to irrigation channels, and analyze the priority of follow-up repair of irrigation channels. The sampling method used was purposive sampling and the data analysis method used was spatial analysis. The results obtained primary irrigation channels have a total length of 5,344 meters in the southern part of Suradadi Sub-district and secondary irrigation channels have a total length of 18,388 meters scattered in Suradadi Sub-district. Most of the conditions of primary and secondary irrigation channels have mild-moderate damage, the cause of this damage involves several factors. There are 4 locations of primary and secondary irrigation channel damage that are prioritized for follow-up repairs.

Keywords: Irrigation Channels, Damage, Image, and GIS

INTRODUCTION

Irrigation channels can be divided into three levels based on the way water flow measurements are arranged and their completeness, namely simple irrigation channels where water flows without special measurements or arrangements, and the water supply are relatively abundant. Semi-technical irrigation channels include intake and measuring structures downstream, with dams on the river. Some permanent structures were also built within the aqueduct system. Technical irrigation channels where irrigation and water disposal are separated, allowing the channels to function optimally according to their respective purposes [1]. Technical irrigation channels have several types of carrier channels, including primary, secondary, tertiary, and quaternary channels [2]. Primary irrigation channels take water from primary sources such as rivers and direct it to the main areas of agriculture. Secondary irrigation channels are branches of primary channels that distribute water to smaller agricultural areas. Tertiary irrigation channels are smaller channels that distribute water to individual farms or small groups. Lastly, quaternary irrigation channels are very small and are used to water crops precisely. It is an efficient system that supports agriculture by ensuring water is available and well distributed. Irrigation utilizes water from rivers or other sources using irrigation networks that distribute water to meet agricultural needs [3]. Use of irrigation channels to support sustainable agriculture. Limited water availability and erratic rainfall patterns are challenges in agriculture, so the existence of irrigation channels can help overcome these problems.

Suradadi Sub-district has an area of 5,573 Ha with rice fields in Suradadi Sub-district covering an area of 4,440 Ha consisting of 4,245 Ha of irrigation-type rice fields and 195 Ha of rain-fed rice fields. Agriculture is one of the main sectors in the economy of Suradadi Sub-district, with various types of crops and agricultural businesses managed by residents. Irrigation channels help distribute water to agricultural fields. Regional governments and related agencies are working to develop irrigation infrastructure to increase agricultural productivity, such as improving irrigation networks, expanding irrigation networks, building dams, and rehabilitating irrigation channels. Suradadi Sub-district has great agricultural potential with extensive agricultural land and various types of crops planted, this makes irrigation infrastructure a key factor in supporting sustainable agricultural productivity. Agriculture in Suradadi Sub-district depends on irrigation so the sustainability of irrigation water supply is a priority. The development of lowland rice is very dependent on the availability of irrigation water, so data is needed on the condition of the irrigation network and related information [4]. The non-functioning of one of the irrigation structures will affect the performance of the existing irrigation system, resulting in decreased irrigation efficiency and effectiveness [5]. The problem of water shortages in the hair irrigation network area (Cipero Dam) is a problem faced by farmers every year in Suradadi Sub-district [6]. Information regarding the condition of irrigation channels in the Suradadi Sub-district is still lacking, which has an impact on efforts to repair and monitor irrigation channels. Without complete data and information, it will result in errors in policy making.

The condition of the irrigation channel is slightly damaged, namely, there are small cracks in the building. Irrigation channels are moderately damaged, namely, significant deterioration in the building and changes in its dimensions, requiring quick repairs, some cracks or breaks are not too serious. Meanwhile, irrigation channels are seriously damaged, that is, there is significant physical damage to the irrigation channel, such as the collapse of parts of the channel, large cracks, and other structural damage that hinders water flow. There are severe levels of erosion and sedimentation in or around irrigation channels. Wild vegetation obstructs the flow of irrigation channel water [3]. Remote sensing is a method that has great potential in utilizing technology to continuously monitor various appearances or phenomena that occur on the earth's surface [7]. Through the use of remote sensing sensors, it is possible to capture detailed data and information from a distance, providing advantages in continuous monitoring of changes that occur in various locations. Remote sensing data in the tropics is often affected by widespread cloud cover, resulting in difficulties in obtaining optical remote sensing data that is free from cloud interference [8]. Remote sensing imagery is an effective technology in capturing information on various features of the earth's surface without direct contact, but validation tests are needed between objects resulting from interpretation and objects in the field [9]. There is damage to the channel walls, channel floors, sediment buildup in the channels and some tertiary channels are not flowing with water resulting in uneven distribution of water to the rice fields. Apart from that, there is rubbish and wild plants in the channels which obstruct water distribution [10]. A geographic information system is a system that can be used as a tool to organize, analyze, and display spatial data that can be adapted to needs in various fields [11]. Geographic information systems (GIS) utilize spatial data to represent objects on the Earth's surface [12]. The advantages of geographic analysis using maps make information systems (GIS) unique when compared to other information systems. GIS provides significant added value to society or individuals by providing in-depth explanations of certain events, projecting future events, and planning strategies more effectively [13]. Within the scope of GIS, information technology has a crucial role in the process of storing, processing, analyzing, managing, and visualizing data. The SAS Planet page is used to access high-resolution image data, such as Landsat TM images with a spatial resolution of 30 meters which have been geometrically adjusted so that objects recorded in the image can be seen clearly [14]. Utilization of remote sensing technology such as imagery to obtain data about appearances on the earth's surface which produces information quickly and accurately. This effectiveness can be further improved by applying adequate data processing techniques [15]. Based on the background that has been described, this research has several objectives, namely to identify irrigation channels in the Suradadi Sub-district using SAS Planet imagery, identify the level of damage to irrigation channels, and analyze priority follow-up actions for repairing irrigation channels.

METHODS

Study Location

Suradadi Sub-district is located in Tegal Regency, Central Java. Geographically, this sub-district is located in the eastern part of Tegal Regency, with regional boundaries between 6° 54' - 7° 03' South Latitude and 109° 09' - 109° 16' East Longitude. This area has an area of 5,573 Ha. To the north, the northern part of Suradadi Sub-district borders the Java Sea, the eastern part borders Warureja Sub-district, the southern part borders Kedungbanteng Sub-district, and the western part borders Kramat Sub-district and Tarub Sub-district. Suradadi Sub-district is an agricultural area dominated by agricultural land and residential areas. Agriculture with rice, corn, and various types of secondary crops are the main commodities grown by farmers in this region. The study location can be seen in Fig. 1 below:

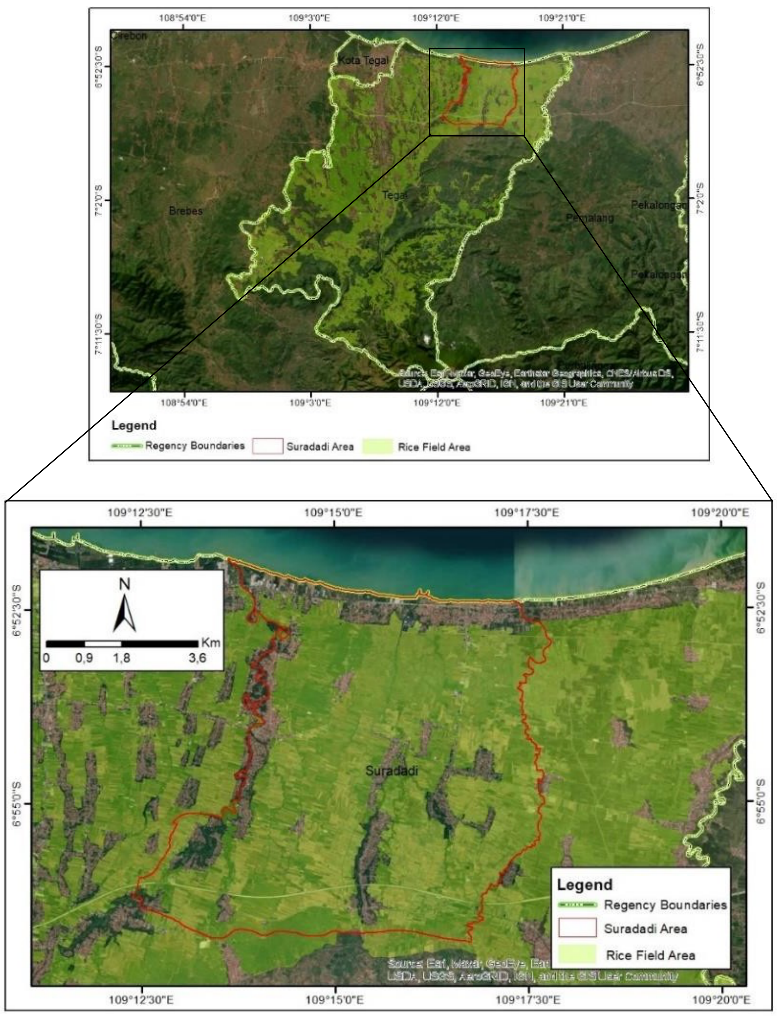

FIGURE 1. Research Location Map

Tools and Materials

The tools and materials used in this research can be seen in Table 1 and Table 2. The satellite images used were downloaded via SAS Planet software with a fairly high resolution so that the appearances in the images were quite clear. The downloaded image will be processed in ArcGIS by inputting spatial data obtained from several trusted sources for its accuracy, such as irrigation shapefiles, roads, administrative boundaries, land cover, and rivers. In conducting research, the Avenza Maps application was used during validation in the field to show the location of primary and secondary irrigation channels. In addition, the timestamp application is used during validation to obtain location coordinates and documentation of the location conditions of primary and secondary irrigation channels.

TABLE 1. Tools Used in Research

Tool's name	Function
ArcGis 10.8	Processing spatial data into maps
Software SAS Planet	Download satellite imagery
Avenza Maps	Shows the location of primary and secondary irrigation channels
Timestamp	Provide coordinate information and document the condition of primary and secondary irrigation channels

TABLE 2. Data Used in Research

Data Name	Function	Source
Citra SAS Planet	Describe the location of primary and secondary irrigation channels	SAS Planet
Land cover shapefile for 2022	Displays the paddy field cover area	BAPPEDA Tegal Regency
Irrigation channel shapefile in 2019	Identify the location of primary and secondary irrigation channels	Geoportal
Tegal Regency administrative boundaries shapefile for 2022	Displays the administrative boundaries of Suradadi Sub-district and its surroundings	BAPPEDA Tegal Regency
Tegal Regency road shapefile in 2022	Displays road-related information	BAPPEDA Tegal Regency

Data Processing and Analysis Stages

Secondary data used in ArcGIS software are images from SAS Planet, administrative boundary files in shapefile format, land cover files in shapefile format, and irrigation channel files in shapefile format. The data processing process in this research can be explained as follows:

Identification of Agricultural Area

Identifying agricultural areas in the study location to identify agricultural areas and assist in the identification process of primary and secondary irrigation channels is done by overlaying SAS planetary imagery with land cover shapefiles.

Identification of Primary and Secondary Irrigation Channels

Identification of Primary and Secondary Irrigation Channels involves digitizing the image to distinguish between the two. In this process, each channel is identified and marked whether it is a primary or secondary channel.

Damaged Irrigation Channel Orientation

The orientation of damaged irrigation channels in the image is carried out to determine the characteristics of damaged irrigation channels in the appearance of the image so that it makes it easier to identify damage to irrigation channels to be carried out.

Identification of Damage to Primary and Secondary Irrigation Channels

The division of segments every 500 meters on primary and secondary irrigation channels aims to facilitate the identification of damage. Each segment of primary and secondary irrigation channels is then analyzed to identify damage, and damage samples are taken using a nonprobability method, namely purposive sampling. In this method, samples are taken by considering certain criteria by the research objectives on primary and secondary irrigation channels.

Field Validation

Field validation is conducted as an important step to assess the extent of damage that occurs in primary and secondary irrigation channels. This process involves a series of steps that include direct observation in the field and data collection.

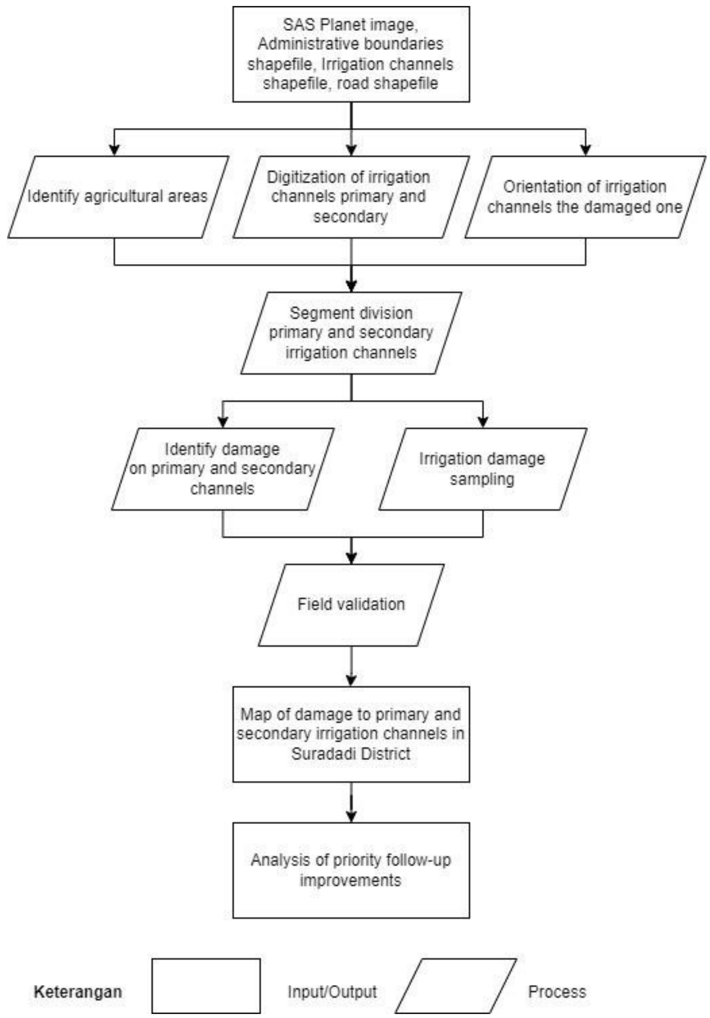

FIGURE 2. Research Flow Chart

RESULTS AND DISCUSSIONS

Based on the objectives of this research, the results obtained are primary and secondary irrigation channel maps, maps that show the location of primary and secondary irrigation channels, providing information about the distribution of these channels. The second result is the condition map of primary and secondary irrigation channels, a map that visualizes the condition of irrigation channels, ranging from good to severely damaged. The last result is an analysis of the priority of follow-up repair of primary and secondary irrigation channels that are damaged. Not only does this study provide a comprehensive overview of the condition of irrigation channels, it also provides a strategic perspective that can be the basis for policy development and implementation of optimal improvements.

Irrigation Channels

In identifying irrigation channels in the Suradadi Sub-district, the data obtained can be seen in Table 3 and Fig. 3. Irrigation channels in Suradadi Sub-district are divided into two types, namely primary and secondary irrigation channels with different channel lengths. The identification results show that the length of the secondary irrigation channel is longer than the length of the primary irrigation channel. This means that secondary irrigation channels have a longer distance for water to travel before reaching agricultural land compared to primary irrigation channels.

TABLE 3. Length of Irrigation Channel

Irrigation Channels	Length (m)
Primary Channel	5,344
Secondary Channel	18,388

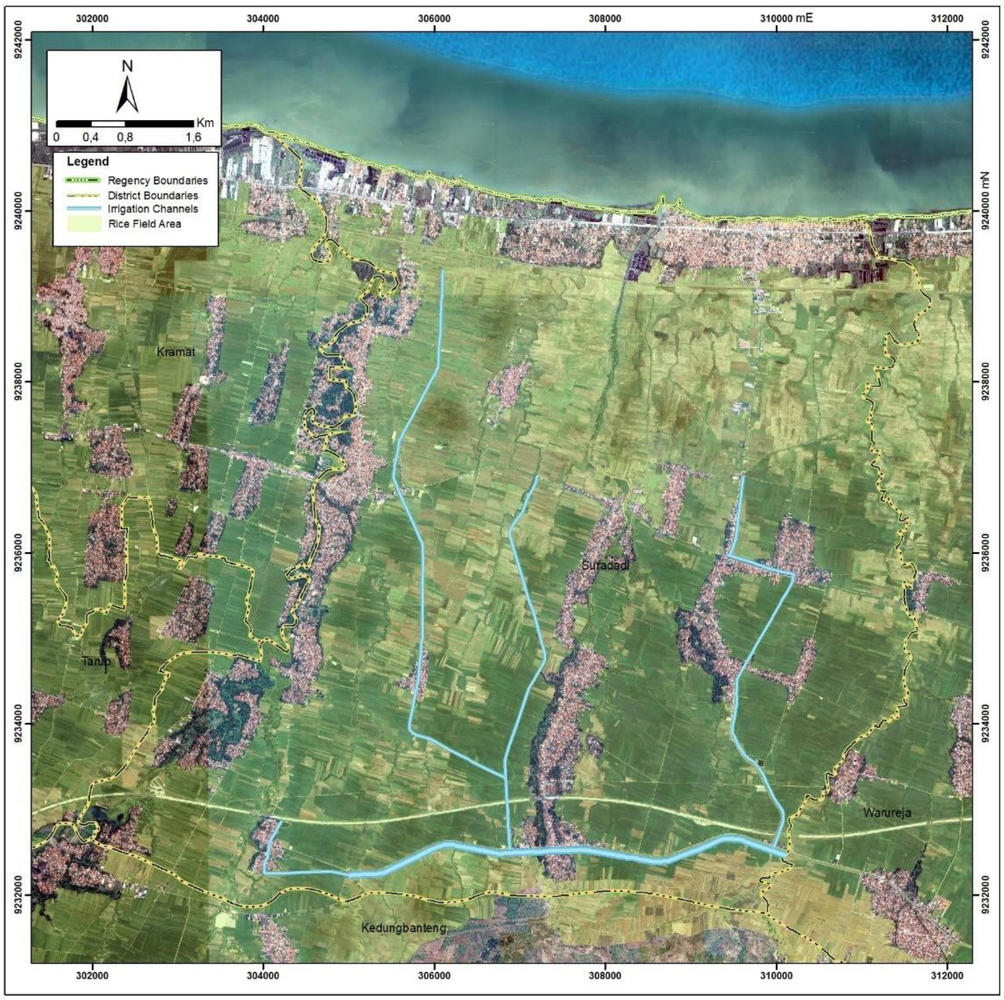

FIGURE 3. Irrigation Channel Location Map

Fig. 3 displays a map of the location of primary and secondary irrigation channels to provide an overview of the distribution and relationship between primary and secondary irrigation channels and rice fields in the Suradadi Sub-district. Primary irrigation channels as the main supplier of water for agriculture are visible in the map which includes their length, path, and relationship with secondary channels. Secondary irrigation channels as supporting channels that channel water to smaller agricultural land can be seen on the map. Apart from that, the large area of rice fields and their distribution in the Suradadi Sub-district is also clearly presented on a map that includes the location and shape of agricultural land.

Identifying irrigation channels in images can show the characteristics of irrigation channels in the form of water flowing in a straight pattern or with slight bends. This is because irrigation channels are generally man-made structures designed to convey water efficiently and follow a parallel pattern to agricultural land [16]. Irrigation channels have the characteristics of straight lines with few bends, in contrast to rivers which are meandering. This is because the process of human development which creates irrigation channels and rivers is formed by natural processes. When an irrigation channel meets a road, it usually passes under the road. Along irrigation channels, there are often small bridges that are used as transportation access for farmers [15]. Several aspects to pay attention to are width, shape, location, and objects related to irrigation channels such as rice fields, bridges, and roads. Distinguish between primary and secondary irrigation channels through imagery by paying attention to several factors. Primary irrigation channels are wider, located at higher elevations, carry larger volumes of water, have connectivity to multiple secondary channels, and pass through large agricultural areas. Meanwhile, secondary irrigation channels are spread across smaller agricultural land. Irrigation channels in Suradadi Sub-district have characteristics that reflect differences in irrigation water supply. Primary irrigation channels with a total length of 5,344 meters are located in the southern part of the Suradadi Sub-district area. This indicates that the primary irrigation channel functions as the main water source serving agricultural land in the region. Suradadi sub-district only has one primary irrigation channel due to the topography of the area which is located on the coast and includes lowlands. This area is only passed by a small river as the main water source, because the main source from Mount Slamet is very far away. As a result, the river flow in Suradadi Sub-district is small, causing limitations to the available water resources. Secondary irrigation channels with a total length of 18,388 meters are spread throughout the Suradadi Sub-district. The presence of a major river in the southern part of the sub-district allowed the construction of primary irrigation channels with shorter lengths, while secondary irrigation channels had to be adapted to the more complex geography. The need for equitable distribution of irrigation water throughout the sub-district encouraged the construction of secondary irrigation channels with longer networks to reach a wider area of agricultural land. Therefore, the difference in length between primary and secondary irrigation channels in the Suradadi sub-district can be attributed to a combination of the need for more equitable water distribution and the demands of the region's diverse geography.

Level of Damage to Irrigation Channels

Observation of the condition of irrigation channels is carried out through imagery. The results of the observations carried out showed that there was some damage spread across the primary and secondary irrigation channels in the Suradadi Sub-district. Irrigation damage visible in the image is characterized by shifts or breaks in the physical structure of the irrigation channel which can indicate structural damage, changes in the pattern or direction of water flow which can indicate an obstacle or blockage in the irrigation channel, and the irregular shape of the irrigation channel indicates the presence of changes in the shape of irrigation channels. The total number of damages in primary and secondary irrigation channels was 27 damage locations. The samples used to carry out field validation were 17 samples of irrigation damage locations spread across primary and secondary irrigation channels. The number was chosen to cover the overall condition of the irrigation channels concerning diversity. Although limited, the use of this sample is expected to provide sufficient information to evaluate the general condition of the irrigation channels. The site selection process was random, covered a wide range of damage types, and took into account the time constraints of data collection. The results of field validation show that 13 sample locations are in damaged condition and 4 sample locations are in good irrigation condition. 3 locations of damage and 1 location of good irrigation are located in the primary irrigation channel which is the main channel for channeling water to agricultural land. 10 locations of damage and 3 locations of good irrigation are found in secondary irrigation channels which have a role in distributing water from primary channels to smaller agricultural land.

The condition of primary and secondary irrigation channels is grouped into 4 categories, namely good, slightly damaged, moderately damaged, and heavily damaged. Primary and secondary irrigation channels in the Suradadi Sub-district are divided into two types based on the structural characteristics of the irrigation edges, namely irrigation channels with edges in the form of cement or rock structures and channels with edges in the form of soil. The classification of damage based on the type of edge is described in two separate tables, Table 4 which is used to classify damage to irrigation channels with cement or rock edges, and Table 5 which is used to classify damage to irrigation channels with soil edges.

TABLE 4. Classification of Irrigation Channel Conditions

Condition of Irrigation Channels	Classification
The channel walls are intact without significant cracks, there is no structural damage that could hinder water flow, and the basic structure of the channel is still strong and stable.	Good
The condition of the channel walls is quite good, there are small cracks on the surface of the channel walls, and only need minor repairs such as crack repair or surface coating.	Lightly damaged
Quite large cracks, and structural damage to the walls but the basic structure of the channel is still there, enough to hinder the flow of water.	Moderately damaged
There is significant physical damage to irrigation channels such as the collapse of most or all of the walls, large cracks, and other structural damage that impedes the flow of water.	Heavily damaged

Source : [3]

The condition of primary and secondary irrigation channels that use cement irrigation edges experience a level of damage that tends to be mild to severe, although most are categorized as mild damage. The main damage is seen in the form of small cracks on the surface of the channel walls, which require minor repairs such as crack repair or surface coating. The use of cement material on irrigation edges provides sufficient structural strength, but remains vulnerable to water pressure, temperature changes, and other environmental factors that can cause cracks. The impact of this damage is not only localized to the physical structure of the channel, but also has a direct impact on the flow of irrigation water. Cracks in the channel walls can lead to water leakage, reducing the efficiency of water distribution to farmlands. In addition, severe damage can significantly impede water flow, affecting the productivity of farmlands that depend on the availability of smooth irrigation water.

TABLE 5. Classification of Irrigation Channel Conditions Without Irrigation Edges

Condition of Irrigation Channels	Classification
The earth walls are intact and there is no significant soil surface erosion.	Good
Earth walls are generally still quite intact and there is soil surface erosion or loss of soil which can be repaired with light repairs such as leveling the wall surface.	Lightly damaged
There is structural damage to the walls or significant erosion in some parts of the channel. More intensive repairs such as wall repairs and new coatings.	Moderately damaged
There are many sections of walls missing or collapsing, water retaining structures missing, and channels that cannot be used to drain water effectively.	Heavily damaged

The condition of primary and secondary irrigation channels without cement irrigation edges showed mild to severe damage, but the majority experienced mild damage. The condition can be identified from the presence of soil erosion on the walls of the irrigation channel, although the overall structure of the channel is still quite intact. This level of damage can be addressed through corrective measures, especially by equalizing the surface of the irrigation channel walls. The presence of soil erosion in primary and secondary irrigation channels without cement irrigation margins can be caused by rainfall intensity, high water flow, or other factors that damage the soil layer. In addition, soil loss on the channel walls can also be affected by other materials or natural processes that damage the integrity of the channel walls. Irrigation channels without cement irrigation edging are more susceptible to soil erosion than those with cement edging. This factor is related to the ability of soil as a wall to more easily collapse or disappear when exposed to water or other materials. The direct impact of this level of damage to irrigation channels is a reduction in irrigation water flow efficiency, which can negatively impact agricultural productivity in the areas served by the channels.

Both primary and secondary irrigation channel linings, whether cement linings are used or not, are dominated by minor damage. It should be noted that the form and cause of damage are significantly different. Irrigation channels with cement edging are more prone to cracks in the channel walls. The contributing factors are changes in temperature and water pressure against the cement structure which can cause cracks. This condition indicates the need for planned maintenance to maintain structural strength and prevent further damage. Irrigation channels that do not use cement edging suffer minor damage in the form of erosion caused by environmental factors, such as heavy rainfall or uncontrolled water flow. Therefore, structural repair and protection measures focused more on strengthening the ground surface and effective drainage.

Each damage location has different characteristics, including varying damage lengths and levels. More detailed information about the length and level of damage at each damage location can be seen in Table 6 as follows:

TABLE 6. Condition of Irrigation Channels

Sample	Length (m)	Irrigation Conditions
1	22	Moderately damaged
2	52	Moderately damaged
3	68	Good
4	20	Lightly damaged
5	6	Moderately damaged
6	8	Heavily damaged
7	6	Moderately damaged
8	9	Heavily damaged
9	26	Lightly damaged
10	33	Moderately damaged
11	24	Moderately damaged
12	44	Good
13	91	Heavily damaged
14	27	Lightly damaged
15	42	Good
16	24	Heavily damaged
17	38	Good

Irrigation channels with moderate and severe damage have a length of 6 m - 91 m, indicating the need for special attention to repair and maintenance to optimize their functionality. Meanwhile, several irrigation channels with light levels of damage have lengths of 20 m, 26 m, and 27 m which, although relatively better, require maintenance measures to prevent damage to the condition of the irrigation channels. Irrigation channels that are in good condition with lengths of 68 m, 44 m, 42 m, and 38 m respectively require regular monitoring and maintenance to maintain the quality and sustainability of the irrigation channels. With most irrigation channels showing moderate to severe levels of damage, it is important to implement more intensive repair and maintenance measures on irrigation channels. Priority for repairs should be given to channels with serious damage to avoid serious impacts on water distribution to agricultural land. Even if irrigation channels are in good condition, regular maintenance is still required to prevent more serious impacts on water distribution to agricultural land. Heavy damage with a length of 91 meters was in the secondary irrigation channel, this damage was the worst and longest damage compared to other damage. Meanwhile, medium damage with a length of 6 meters was the shortest damage compared to other damage, this damage was in the secondary irrigation channel. The condition of the damaged sample location can be seen in Fig. 4 and Fig. 5 as follows:

FIGURE 4. Irrigation Channels Heavily Damaged

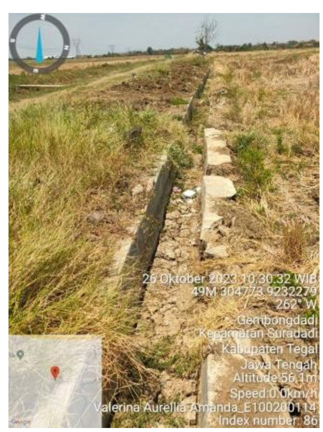

FIGURE 5. Irrigation Channels Are Moderately Damaged

Based on the documentation from Fig. 4 and Fig. 5 taken during the field validation process, it can be observed that there is quite a significant condition of damage to the irrigation channel which experienced heavy damage. The physical damage that occurred involved the collapse of most of the walls, large cracks, and structural damage that significantly hampered the flow of water in the irrigation channels. Meanwhile, for irrigation channels that experienced moderate damage, there were quite large cracks and structural damage to the walls, even though the basic structure of the channel was still there. Even though this damage is enough to hinder the flow of water, it still allows the flow to take place.

A more detailed visualization of the location of damage in Fig. 4 is presented through a map that clearly shows the location of damage to primary and secondary irrigation channels in the Suradadi Sub-district. This map not only shows the location of damage but also shows the percentage of damage by segment in primary and secondary irrigation channels. The information in this map provides a clear picture and makes it easier to recognize and respond to damage that occurs to primary and secondary irrigation channels in Suradadi Sub-district.

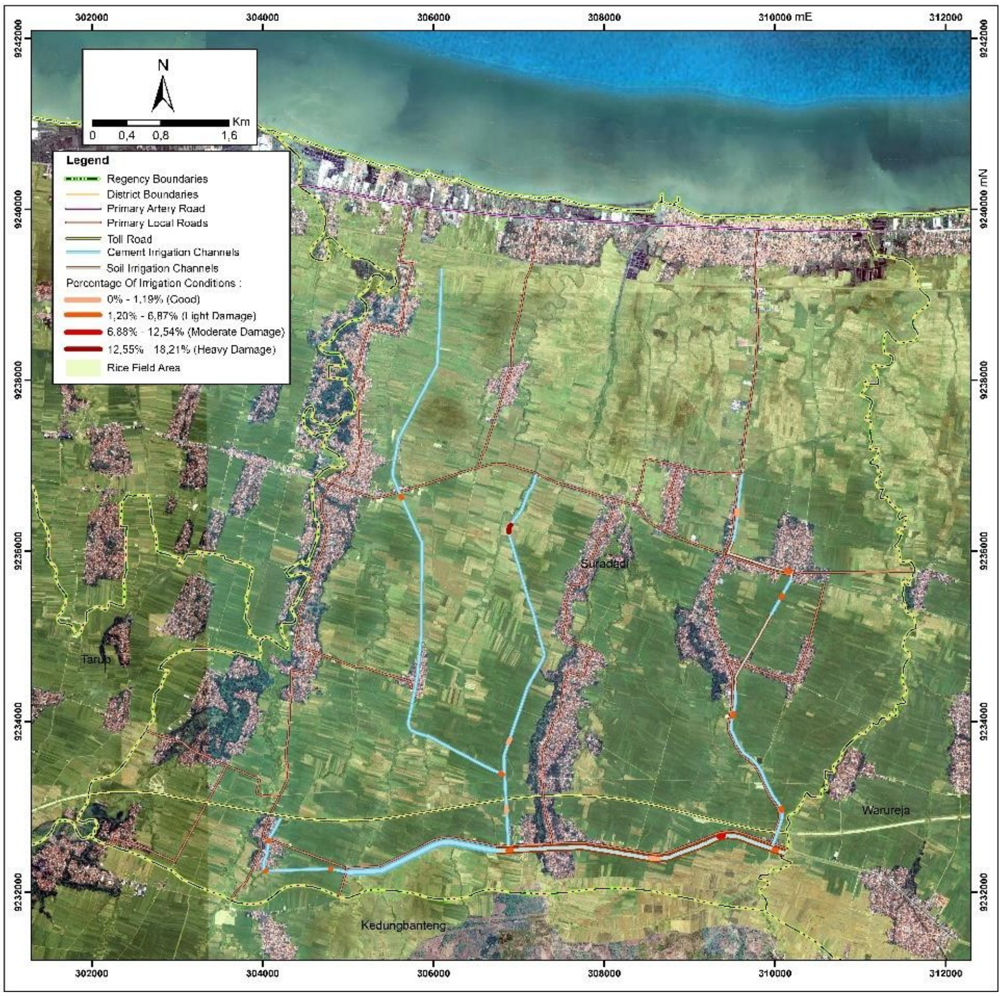

FIGURE 6. Map of Irrigation Channel Conditions

The discrepancy between the initial number of samples for image observations (17 samples) and the number of accurate samples in field validation (13 samples) is due to changes in the environment around the irrigation channel, such as plant growth, land use changes that can affect channel conditions, and water flow conditions in the channel irrigation is different during image observation and field validation. Limitations in the resolution or quality of satellite imagery used for initial observations may affect the ability to correctly identify damage. The condition of irrigation channels will decline over time and the function of irrigation channels will decrease according to irrigation conditions [17]. Various factors influence the performance of the irrigation network so that it does not reach optimality, such as sedimentation at the bottom of the channel, the loss of some channel walls, seepage, damage to tapping gates, and damaged conditions in other water structures [18]. As a result, the function of irrigation channels is disrupted resulting in a decrease in agricultural productivity and the potential for drought. Damage to irrigation channels in primary irrigation channels and secondary irrigation channels in Suradadi Sub-district in the form of irrigation channel walls containing small to large cracks, collapse of most or all of the walls, and structural damage. The existing damage is influenced by several factors, including expansion of the soil which puts pressure on the channel walls, causing small cracks, soil erosion around the irrigation channels causing shifts in the soil around the walls, plant roots growing around the irrigation channels causing cracks, excessive load from the flow. water or other materials cause damage, construction of roads close to irrigation channels causes changes to the structure of the surrounding soil, and agricultural activities cause damage to the structure of irrigation channels.

Analysis of priority follow-up improvements

Analysis of priority follow-up actions for irrigation channel improvements has an important role in improving understanding and management of irrigation channel infrastructure in the Suradadi Sub-district. Irrigation channels can increase food crop production, especially rice. By implementing effective irrigation, agricultural productivity per hectare can be increased, so that farmers can earn higher incomes [19]. The results of identifying the condition of irrigation channels include 4 categories, providing information to stakeholders to categorize damage according to the level of urgency of repairs needed. The aim is to facilitate the prioritization of corrective actions to address damage of a certain level of severity, especially those that can have a significant impact on agricultural land. Determining priorities for irrigation repairs is based on the level of damage to irrigation channels and how big the impact may be due to delays in repairing the damage [20]. Based on the classification of irrigation conditions during validation, there were 4 locations with heavy damage that were prioritized for follow-up repair. Meanwhile, in the percentage classification of irrigation channel conditions based on segments, there are 2 locations with heavy and moderate damage which are priorities for follow-up repairs. These 2 locations include locations that are prioritized for follow-up repairs based on the classification of irrigation conditions during validation.

The map of the location of irrigation channel conditions in the Suradadi Sub-district shows the location of damage and the percentage of irrigation channel conditions based on segments of primary and secondary irrigation channels. The information available in this map provides an overview of the location of damage to irrigation channels and can assess the level of damage in certain segments so that it can be identified whether the damage is only limited to one segment or spread across several parts. Damage percentage information helps determine repair priorities. Locations with a high percentage of damage are the main focus for repairs because significant damage to irrigation channels can have a major impact on the performance of the irrigation system as a whole, while locations with a low percentage of damage require lighter maintenance because the damage that has occurred has not reached a level that significantly threatens system performance. Locations that are prioritized for follow-up repairs can be seen in Fig. 7 as follows:

FIGURE 7 . Map of Priority Locations For Follow-Up Repair of Irrigation Channels

The analysis is carried out to determine priorities for irrigation repairs by considering the level of damage to the channels and the impacts that may arise due to delays in repairs [21]. After field validation, 4 locations experienced heavy damage as priority follow-up repairs. In addition, the assessment is not limited to the level of physical damage to irrigation channels. By paying attention to the condition of each segment through percentage calculations, only 2 locations were identified that experienced heavy and moderate damage, which were also priorities for follow-up repairs. This shows that priority assessments are not only based on the level of damage but also on locations that have a major influence. The 2 priority locations for improvement follow-up identified from the percentage have the same location as the 4 locations based on the classification of irrigation conditions during validation. So the total number of damage locations that are prioritized for follow-up repairs is 4 locations shown in the black box area in Fig. 7. Improvements are focused on areas that require immediate attention and provide comprehensive solutions to increase irrigation system efficiency. Irrigation channel maintenance is a step to maintain and ensure that irrigation channels always operate optimally, facilitate smooth operational implementation, and maintain the continuity of their function. This is done through a series of actions, such as regular maintenance, repairs, prevention, and security efforts which are carried out on an ongoing basis [22].

CONCLUSION

The primary irrigation channel has a total length of 5,344 meters located in the southern part of the Suradadi Sub-district area which functions as the main source of water for agricultural land in the area. Secondary irrigation channels have a total length of 18,388 meters and are spread throughout the Suradadi Sub-district. This difference in length and distribution shows that secondary irrigation channels have a broader role in distributing irrigation water to various smaller agricultural areas throughout the Suradadi Sub-district area. Damage to primary and secondary irrigation channels in the Suradadi Sub-district consists of cracks ranging from small to large, collapse of part or all of the channel walls, and structural damage. The causes of this damage involve factors such as expansion of the soil which creates pressure on the channel walls, erosion of the surrounding soil, growth of plant roots, excessive loads from flowing water or other materials, construction of roads adjacent to irrigation channels, and agricultural activities that can damage the structure. irrigation channel. Repairs are focused on 4 locations which are priorities for repair follow-up with a priority assessment that is not only based on the level of damage but also considers locations that have a major impact. It aims to provide a comprehensive solution and increase the efficiency of irrigation systems in areas that require immediate attention.

The outline of the results of this research includes conclusions, this research has the following solutions or recommendations for establishing a regular maintenance program schedule and carrying out periodic inspections to actively monitor the condition of the primary and secondary irrigation channels in the Suradadi Sub-district. Using construction technology that is resistant to soil expansion, including anti-crack material and structural reinforcement on the channel walls. Prevent erosion and coordinate with farmers to prevent structural damage due to root growth and excessive loads. Involve the community and related parties in repairs using civil engineering methods appropriate to the damage at each location. Develop training programs for irrigation officers and local farmers to increase understanding of sustainable irrigation management.

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