Mapping of Irrigation Service Capacity by Remote Sensing in Batang Tampo Irrigation System-Lintau Buo

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Abstract. Batang Tampo Irrigation System (DI Tampo) area 1,437 ha, has 65 irrigation service are in Sub Basin Batang Tampo. Main river in Sub Basin is 25 km and a part of Sub Basin Kuantan-Inderagiri. This area lied on hilly terrain 350-2262 m above sea level. Normally, cropping intensity of rice farms is 2 to 2.5. But in dry period in downstream area it has 1 or failed because of water stress or dried. Even The rainfield area is not planted in the period of dry season. The area of rice field along the river or irrigation system show that it has better cropping intensity. It should have to know how is irrigation service capacity of Batang Tampo Irrigation System. Technology of Remote Sensing it can be used to evaluate of the capacity of irrigation service by using of information data satellite, like Digital Elevation Model (DEM) for topografi data, image, land level and Enhanced Vegetation Index (EVI) and rain (Herdianto dkk., 2010). This data usely combine with Geographic Information System (GIS) for spacial information data. This study aims to map the ability of DI Tampo service by utilizing remote sensing technology with a vegetation index as its main parameter, upstream - downstream variations, variations off the position rice farms land level (Hilly or Valley) or terrain land level, and distance of rice fields from irrigation water sources. The method to identification of the capacity irrigation service is EVI by remote sensing and survey by the farmers to vерьification data. Hydrology data is collected by the authority. Rice field area is identified by GIS and topography data by DEM. EVI value, which is a representation of photosynthetic activity and canopy density of paddy cropped or cropping intensity on paddy field each year. Average EVI data is collect for five years (2012 – 2017, excepted 2015). The result of this research shows: Irrigation service capacity influences by the topography of rice farms, mainly in the upstream. In upstream, some area of rice field was not cropped of paddy (different crop) because of water scarcity and different land level of rice farm (Hilly and river). In the downstream Irrigation service capacity influences by the distance of paddy field from the water resource.

Keywords: Irrigation, EVI, irrigation capacity

1. Introduction

Tampo Irrigation Area covers 65 irrigation systems from upstream to downstream with a total area is 1,437 ha with the main water resources of Batang Tampo, which is located in the Batang Tampo sub watershed with an area of around 26,450 ha. Thus the area of DI Tampo is 5.43% of the area of Sub watershed of Batang Tampo. Under normal conditions, the rice fields in Batang Tampo area have planting intensity 5 times in two years and some of them twice in a year. However, in certain conditions, part of the rice fields that near the downstream and in certain locations are only able to plant once in a year and sometimes crop failure due to lack of water and drought. With the discharge
of dry season around 300 liters/second, Batang Tampo water flow is unable to fulfill the needs of irrigation water for DI Tampo as a whole.

When the dry season begins to occur, the areas along the river and irrigation networks show higher planting index values than areas far from the network [8]. With the length of the main river reaching 25 km at an altitude between 350-2262 m above sea level, the form of Sub watershed of Batang Tampo is wavy and variations in steep altitude in the upstream section, ramps in the middle and somewhat flat in the lower part. The rice fields in sub watershed of Tampo also have height variation because they are along the main and undulating river paths according to the Batang Tampo cross section, so most of the paddy fields are near the upperstream and the middle are tiered, and slightly sloping and flat in the lower reaches.

With such shape of the watershed, the rice fields in the upstream and along the river flow have greater chance of getting water flow, especially in the dry season. The undulating shape of the land also indicates that there is lower chance of getting the water in higher areas on the ridge (hilly/guguak), water must be flowed from a place that is relatively further compared to rice fields that are in lower place in the valley (Lakuak) to raise water level. Thus Guguak rice fields require relatively larger water because some will be lost on the way. Another problem is the method of taking water and the amount of water for irrigation from a part of the irrigation area has not been measured properly. There are indications of users in the upstream section or those adjacent to water sources or irrigation channels using the water excessively.

From the description of this problem, it should to know: What is the ability of Batang Tampo Irrigation system to be able to serve rice fields along the flow of Batang Tampo river according to variations of: upstream-downstream, the distance from the channel irrigation and the location of rice fields according to variations of guguak-lakuak.

Technology that has been used to evaluate the performance of an irrigation system is remote sensing, which is using information provided by satellites such as the Digital Elevation Model (DEM) for topographic data, image, surface thermal (surface temperature), plant index (vegetation index), and rainfall [9]. The uses of satellite data can be combined with the Geographic Information System (GIS) to describe spatial information about the data that obtained. In the field of irrigation, GIS is used to visualize and explain the results of evaluations of irrigation performance and map theoretical irrigation water needs [5].

This study aims to map the ability of DI Batang Tampo service by utilizing remote sensing technology with a vegetation index as its main parameter, knowing the production, cropping intensity and according to upstream-downstream and variations in the distance of rice fields from irrigation water sources, variations in the position of rice fields and how farmers should handle the water limitations. The study was conducted with a five year times series data analysis of the vegetation index (2012–2017 excepted 2015) satellite MODIS-USGS (MODERATE resolution of the Imaging Spectroradiometer-United States Geological Survey). The vegetation index that used is NDVI and EVI which calculates and describes the condition of plants from a combination of electromagnetic waves in the red, near infrared, and blue spectrum derived from plant leaves. Observations of satellite data were verified in the field to see the accuracy of satellite data compared to conditions in the field. Field data also to know production, cropping intensity and irrigation and rice farms management. The research output will provide a map of irrigation service capabilities in Batang Tampo Irrigation System according to the variation of upstream-downstream rice fields, distance from channels or water sources and variations according to the height of the water source guguak-lakuak. The irrigation service capacity will indicate by: EVI value as reflection of cropping intensity.

2. Research Methodology
The research will be conducted at DI Tampo which is geographically located in the Sub watershed of Batang Tampo area and administratively is located in the North Lintau District and Lintau Buo District, Tanah Datar District, West Sumatra. Sub watershed of Batang Tampo is part of the Kuantan-Indragiri River which empties into the east coast of Sumatra Island. The shape of the Batang Tampo
Sub watershed extends from north to south, is at altitude between 350-2262 m above sea level, bumpy and variations in the height of the DAS steep in the upstream, ramps in the middle and somewhat sloping and flat in the lower reaches with the length of the main river Tampo Rod reaches 25 km.

Identification of geographic conditions and topography in Batang Tampo is done using primary and secondary data. Primary data is collected using the results of monitoring of satellite data using Information provided by the Digital Elevation Model (DEM) for ASTER GDEM topographic data with a resolution of 30 m which will provide topographic data in Batang Tampo and Batang Tampo Sub watershed. The elevation of benchmark points is measured by GPS Mapping, the results of this activity: a). Divide the Batang Tampo Sub watershed area into three land slope groups, which are: 1). Upstream with land slope> 15%, 2). Middle section with slope between 8% to 15% and, 3). Downstream with a small slope less than 8%. The identified areas are confirmed by maps of irrigation areas in the relevant agencies such as the agricultural service and the Public Works and Public Housing Agency (Dinas PUPR). The output of this activity is the Batang Tampo Sub Das map according to the upstream-middle-downstream region. b). Determine the location or path of the irrigation network. Based on the map the irrigation network is calculated and measured the distance of the nearest and farthest paddy fields. c). from topographic maps, you can find locations or grooves of the guguak rice fields and other rice fields. d). Based on the results of the identification of the three conditions above (a, b and c) the location and number of samples are measured cropping intensity and productivity of farmers' rice fields according to upstream-downstream, distance from the channel irrigation to the rice fields and the location of the guguak-lakuak.

The number and size of the sample will be determined based on the results of field observations taking into account the diversity of field conditions. The results of this mapping are: a.) Map of Irrigation Area according to topographic classification: Upper, Middle and Lower. b) Map of irrigation networks, C-Topographic map of rice field location by height. The results of the vegetation index analysis will show the highest to lowest vegetation index on DI Batang Tampo. The output of the vegetation index value is a map of the vegetation index IN Batang Tampo which will provide an overview of the level of planting intensity. The results of the mapping will show the locations of rice fields with a certain level of cropping intensity which are described in different colors that can be clustered. Planting intensity is one parameter that shows the level of irrigation services in that location. The clustering results are validated and verified in the upstream-downstream field, far from the source of the irrigation water and from the location of the guguak lakuak and will be classified into irrigation water: Good, lacking and poor and not available at all. Based on the results of regional identification and identification of water-deficient rice fields, a map of the water shortage area is obtained and the
area according to upstream-downstream, distance from the channel and location of the guguak lakuak. Furthermore, based on the above categories, data validation and verification is carried out on the map with the field on selected samples to obtain data: Irrigation service capacity, cropping intensity and rice productivity.

3. Results and Discussion
Vegetation index analysis will show the highest to lowest vegetation index on DI Batang Tampo. Vegetation index value is a map of the vegetation index in Batang Tampo which will provide an overview of the level of planting intensity. Normally: 0-1. On Batang Tampo Irrigation system EVI in rice farm is: 0.24-0.62. The results of the mapping will show the locations of rice fields with a certain level of cropping intensity which are described in different colors that can be clustered. By verification data EVI is clustered: < 0.20 (red) 0.21–0.4 (light green) 0.41–0.60 (green), 0.61–0.80 (light blue) and > 0.81 (blue).

Planting intensity is: 1–3, one parameter that shows the level of irrigation services in that location. The clustering results are validated and verified in the upstream-downstream field, far from the source of the irrigation water and from the location of the guguak–lakauk.

Based on the results of regional identification and identification of water-deficient rice fields, a map of the water shortage area is obtained and the area according to upstream-downstream, distance from the channel and location of the guguak lakuak. Furthermore, based on the above categories, data validation and verification is carried out on the map with the field on selected samples to obtain data: Irrigation service capacity, cropping intensity and rice productivity.

![Figure 2. EVI Value Cluster](image)

**Table 1. EVI Cluster rice field**

| EVI     | Color         | Cropping Intensity | %     | < 300 m from the river/canal | > 300 m from the river/canal | Guguak | Lakuak |
|---------|---------------|--------------------|-------|------------------------------|------------------------------|--------|--------|
| 0–0.2   | Red           |                    |       |                              |                              |        |        |
| 0.21–0.40 | Light green  | 1 – 2.0            | 73    | 25% by sample                | 75% by sample                | 67%    | 33%    |
| 0.41–0.60 | Green        | 2.0 – 2.5          | 25    | 73% by sample                | 25%                          | 33%    | 65%    |
| 0.61–0.80 | Light blue   | 2.5 – 3.0          | 2     | 2% by sample                 | -                            | -      | 2%     |
4. Conclusion
The analysis irrigation service capacity by remote sensing can be done for first step to identification irrigation system capabilities. The EVI index on rice field is 0.24 – 0.62. Furthermore, for accuracy measurement it have more land activities to verification data. The water scarcity in rice field in Tampo Irrigation System influences of topography and rice field level from the river or water resource.

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