Planning For Development Of The Way Tulung Buho Irrigation Area, Lambu Kibang District, West Tulang Bawang Regency

Wan Abbas Zakaria[1], Muhammad Fahmi Rizaldy [2], Teguh Endaryanto[3]

[1,2,3] Study Program of Masters in Urban and Regional Planning, Postgraduate, University of Lampung, Lampung, Indonesia
Correspondence: Muhammad Fahmi Rizaldy
(email: frizaldy17@gmail.com)

Abstract

Irrigation development in the Way Tulung Buho area, Tiyuh Kibang Yekti Jaya, Lambu Kibang District, West Tulang Bawang Regency, Lampung Province aims to increase production and productivity of rice farming so that farmers' income increases. This research aims to examine the impact of irrigation development in the Way Tulung Buho Irrigation Area on increasing production, productivity and farming income and examine the development potential of the area. This research uses a survey method, data is analyzed using farming analysis and the AHP method. The research results show that irrigation development in the Way Tulung Buho Irrigation Area has an impact on changing the function of farmers' land from rainfed lowland rice fields, rubber and cassava plantations to technically irrigated rice fields with increased productivity and farming income. There are four potential locations to be developed into irrigation areas, namely Tiyuh Kibang Yekti Jaya, Tiyuh Kibang Tri Jaya, Tiyuh Agung Jaya and Tiyuh Gunung Agung with a total area of 1,927.34 Ha which is expected to become one of the rice production centers in West Tulang Bawang Regency

Keywords: Kawasan Irigasi, Pengembangan Wilayah, dan Pendapatan Usahatani.

Introduction

The development of irrigation areas is very necessary to support the supply of food in order to realize sustainable national food security. Therefore, the Indonesian Government places irrigation development as a priority in developing National Food Security. Availability of land for agricultural businesses is an absolute requirement to realize the role of the agricultural sector in a sustainable manner, especially in its role in realizing independence, resilience and national food sovereignty. (Subroto and Susetyo 2016). The use of irrigation areas will have an impact on regional development where the agricultural sector, especially the food crop sub-sector (rice), is the main source of livelihood for people in Indonesia. Indonesia itself has a total irrigation area of 7.2 million ha, which contributes to national rice production of 84%, the remaining 16% is from tidal swamp rice fields (0.49 million ha), groundwater irrigation networks 0.09 million ha, and others (rain-fed rice fields, village irrigation and fields) covering an area of 1.4 million ha (Marshella Febriani and Setya Putra 2022).

The Way Tulung Buho Irrigation Area is located in Tiyuh Kibang Yekti Jaya, Lambu Kibang District, Tulang Bawang Regency which was built in 2021. The planning area covers an area of 40 ha consisting of rice fields, cassava and rubber plantations where the source of irrigation water comes from the Way Tulung Buho River .Water is channeled through irrigation channels 1,240 m long. In 2023, only 18.25 hectares of technically irrigated rice fields will be realized, previously consisting of rain-fed rice fields (5.50 hectares), rubber plantations (4.00 hectares) and cassava (8.75 hectares). Of the 18.25 ha, there is an area of lowland rice with a planting intensity of 300% a year covering an area of 9.50 hectares and an intensity of 200% a year covering an area of 8.75 ha.

Potential land that can be developed into an irrigation area is spread around the Way Tulung Buho Irrigation Area, namely in Tiyuh Kibang Yekti Jaya and Tiyuh Kibang Tri Jaya. Apart from that, there are two other locations with similar conditions outside Lambu Kibang District, namely Tiyuh Setia Agung, Gunung Terang District and Tiyuh Agung Jaya, Way Kenanga District. Most of the land in these locations is mixed farming land and rubber plantations which are similar to the commodities that existed in the Way Tulung Buho Irrigation Area before irrigation

construction. Apart from that, there are two rivers that cross this location, namely the Way Tulung Buho River which divides Tiyuh Kibang Yekti Jaya and the Way Pidada River which divides Lambu Kibang, Gunung Terang and Way Kenanga Districts. Therefore, it is necessary to plan the development of the Way Tulung Buho Irrigation Area, Lambu Kibang District, West Tulang Bawang Regency in the potential locations above.

This research aims to examine the impact of irrigation development on production, productivity and farming income and examine the potential for developing the Way Tulung Buho Irrigation Area in Lambu Kibang District and its surroundings from a spatial aspect. By carrying out this research, it is hoped that it can become a consideration for the West Tulang Bawang Regency Government and related parties in regional development planning in the short, medium and long term. In this way, regional development based on irrigation areas in West Tulang Bawang Regency can be carried out well and on target.

Literature review

Regional development is defined as an effort to harmoniously combine natural resources, human resources and technology by taking into account the carrying capacity of the environment itself (Alkadri 2001). Regional development is a strategy to utilize and combine internal (strengths and weaknesses) and external (opportunities and challenges) factors that exist in a region to increase regional production and productivity of goods and services which are a function of needs, both internal and external to the region. (Friedmann and Alonso 2008).

Internal factors are in the form of natural resources, human resources and technological resources, while external factors are in the form of opportunities and threats that arise along with interactions with other regions. In general, rural area development refers to changes in regional productivity, which are measured by increases in population, employment opportunities, income levels, and the added value of processing industries. Apart from the economic definition, regional development also refers to social development, in the form of health, education, environmental quality, welfare and others (Friedmann and Alonso 2008).

In this research, regional development at the research location was designed based on the development of the Way Tulung Buho Irrigation Area which was built in 2021 in Tiyuh Kibang Yekti Jaya, Lambu Kibang District, West Tulang Bawang Regency, Lampung Province. According to FAO (1996) yields for most food crops increased between 100% and 400% along with improvements in irrigation networks in the area. Thus, regional development based on irrigation areas is needed to increase food production in West Tulang Bawang Regency, Lampung Province. Based on the results of field analysis, this development is proven to encourage regional development with the economic feasibility of the development which has a positive impact on rice production and socio-economics at the research location. Therefore, the development of irrigation areas can be developed in locations around the Way Tulung Buho Irrigation Area based on almost similar internal and external factors.

These locations are spread across several sub-districts which directly border the Way Tulung Buho Irrigation Area, namely Tiyuh Kibang Yekti Jaya and Tiyuh Kibang Tri Jaya (Lambu Kibang District), Tiyuh Gunung Agung (Gunung Terang District), and Tiyuh Agung Jaya (Way Kenanga District). According to the West Tulang Bawang Regency Spatial and Regional Planning Map, the land use of these locations is wet and dry land agricultural locations, bushes and fields. Accessibility of land is also assessed as the ease of location to reach transportation networks.

Determining these locations can be based on the criteria required for opening new rice fields. Several variables that can influence the determination of sustainable agricultural land include land slope, water availability, road access and land area (unit area) (Subroto and Susetyo 2016). According to the Directorate of Land Expansion and Protection of the Ministry of Agriculture (2018), the criteria for suitable locations for creating new rice fields are the availability of water, an area of more than five hectares and a land slope of less than 8%.

The ease with which a location (accessibility) is connected to other locations via the existing transportation network, in the form of road infrastructure and transport equipment that moves on it

(Black 2018). In this research, the distance of the land to the provincial strategic highway is an aspect of assessment because the closer the land is to the access road, the easier it is for transportation to enter the location to transport agricultural materials and products. Transportation costs increase proportionally with distance. The greater the distance between a business and the economic center, the greater the transportation costs incurred (Tarigan 2005). Apart from the distance to the provincial strategic highway, the distance to the Urban Local Activity Center in Lambu Kibang District is also an assessment criterion. This distance describes the costs that will be incurred by farming at each research location.

Based on the criteria that have been explained, potential locations for developing irrigation areas certainly have their own value against these criteria. These different values can give rise to the ranking/priority of locations with the most potential to be developed as irrigation areas. There are several methods for determining priorities for developing irrigation areas. One of them is the Analytical Hierarchy Process (AHP) method. AHP is a method that considers many objective and subjective factors in ranking alternatives. Apart from that, AHP can help the decision making process through a hierarchical decision model (Muhammad and Darmawan 2019). The AHP method uses a pairwise comparison matrix which forms a reciprocal matrix in changing qualitative ratio data. Eigenvalue is used to access the final weight of the criteria and measure the level of consistency obtained through the consistency index (Saaty 2008)

Method and study area

This research uses several methods (mixed method). The first objective uses farming income analysis and to answer the second objective, Analytical Hierarchy Process (AHP) analysis is used to determine the direction of irrigation area development.

Farming Income

Net income or business profit is obtained from the difference between total revenue and total expenditure. Total costs are the

sum of fixed costs and variable costs. Revenue is the result of multiplying the number of products by the selling price of the product (Soekartawi, 2016). Income is mathematically formulated as follows:

I = TR – TC ..... (1)

Information:

I : Income (IDR)

TR : Total receipts (IDR)

TC : Total cost (IDR)

Analytical Hierarchy Process (AHP) Method

Analytical Hierarchy Process is a decision support method developed by Thomas L. Saaty. This decision support model will decompose complex multi-factor or multi-criteria problems into a hierarchy (Munthafa and Mubarok 2017). Hierarchy is defined as a representation of a complex problem in a multi-level structure where the first level is the goal, followed by the level of factors, criteria, sub-criteria, and so on until the last level of alternatives (Saaty 1993).

In this research, the aim of AHP is determining development priorities. The criteria used are potential area, slope of land, number of rivers and distance to provincial strategic highway and local urban activity centers (PKLP). There are four alternatives chosen in this research. These alternatives are potential locations for developing irrigation areas around the Way Tulung Buho Irrigation Area, West Tulang Bawang Regency. Because there are four alternative locations, the weighting is divided into four ranks with the weighting for each rank presented in Table 1.

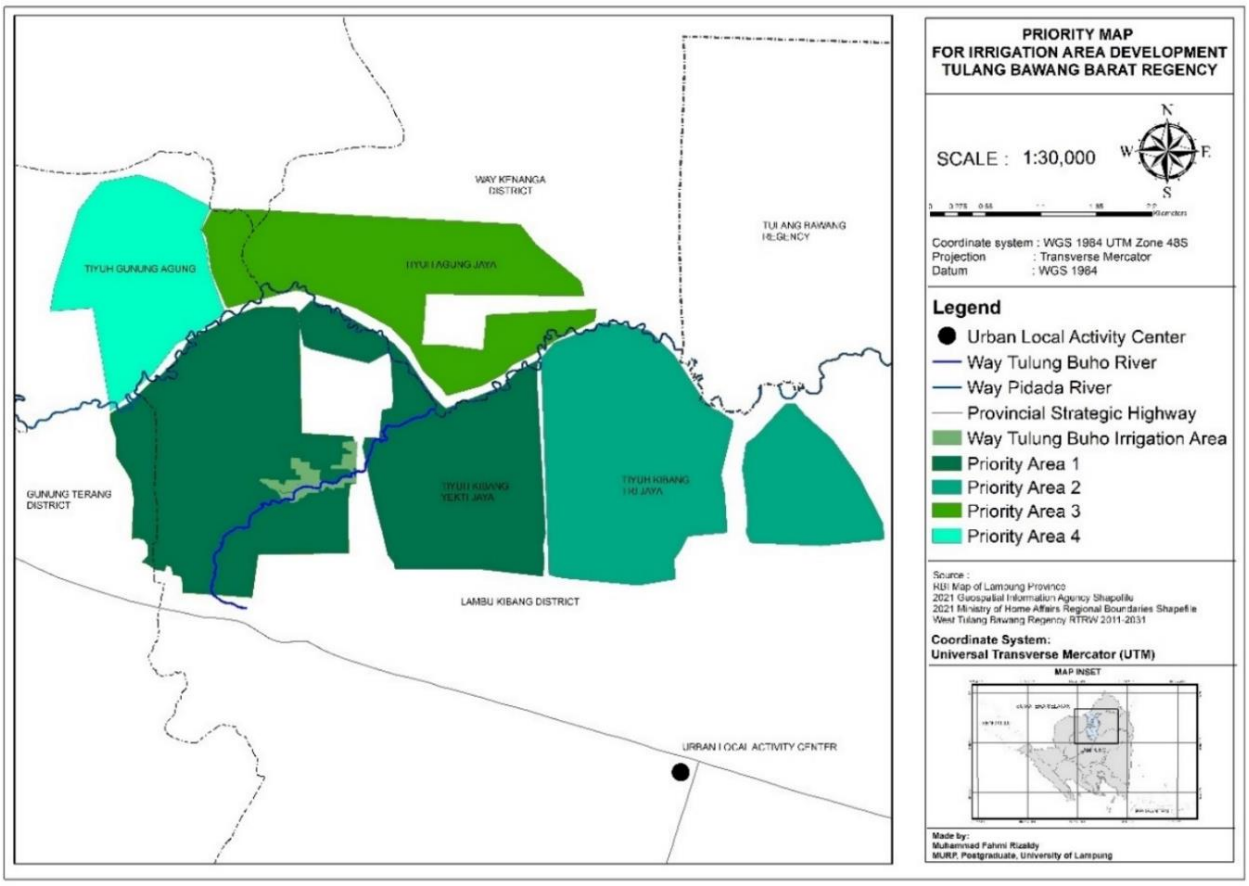
Table 1. : Weighting of each parameter of the AHP method

Rank	Weight	Mark
1	4	Very important
2	3	More important
3	2	Important
4	1	A Little Bit Important

Source: Hasil analisis, (2023)

Study Area

The Way Tulung Buho Irrigation Area is located in Tiyuh Kibang Yekti Jaya, Lambu Kibang District, West Tulang Bawang Regency. The Way Tulung Buho Irrigation Area is an irrigation area that was built from April to October 2021 with a planning area of 40 Ha. The irrigation network consists of a weir building and a 1,240 m long Uditch concrete irrigation canal. The Way Tulung Buho irrigation area takes irrigation water from Way Tulung Buho which divides Tiyuh Kibang Yekti Jaya..



Source: Data processing results, (2023)

Figure 1. : Study location map

Based on spatial analysis, there are several potential locations to be developed into irrigation areas, namely Tiyuh Kibang Yekti Jaya (790.07 Ha) and Tiyuh Kibang Tri Jaya, Lambu Kibang District (523.46 Ha); Tiyuh Gunung Agung, Gunung Terang District (364.31 Ha), and Tiyuh Agung Jaya, Way Kenanga District (240.50 Ha). The

location determination was based on the potential area, slope of the land, number of rivers and distance to provincial strategic highway and local urban activity centers in Lambu Kibang District, West Tulang Bawang Regency.

Results and discussion

Impact of Irrigation Development on Farming Income

Irrigation development has an impact on increasing the use of production factors, productivity and rice production in the Tiyuh Kibang Yekti Jaya irrigation area. There are 9.50 ha of wetland rice land where the planting index has increased to 300% as well as clearing of 8.75 ha of land with two planting seasons a year. This increase has an impact on the amount of income farmers get from sales minus agricultural production costs. To determine the impact of development on farmers' income, it is necessary to calculate an analysis of farming income in the Way Tulung Buho Irrigation Area.

Analysis of farming income is calculated based on sales obtained from production multiplied by the prevailing selling price minus the production costs incurred which are the result of multiplying the number of production factors used and the prevailing prices before and after the construction of the Way Tulung Buho Irrigation Area.

a. Increasing the Farming Income of Rice Farmers

Analysis of lowland rice farming income was carried out on eight respondent farmers who cultivated lowland rice before and after irrigation construction (Table 2).

Table 2. : Rice farmers' farming income

No	Description	Per 0,69 Ha (IDR)		Per Ha (IDR)	
		Before	After	Before	After
	Per year	2 Seasons	3 Seasons	2 Seasons	3 Seasons
1	Production cost	14,969,004.48	15,299,087.39	22,101,428.68	22,619,197.86
2	Rice Sales				
	a. Production (Kg)	7.51	13.15	10.97	19.20
	b. Price (IDR/Kg)	5,400.00	5,400.00	5,400.00	5,400.00

	c. Sales Value	40,533,750.00	71,010,000.00	59,220,000.00	103,680,000.00
3	R/C (2/1)	2.71	4.64	2.68	4.58
4	Income	25,564,745.52	48,061,368.91	37,118,571.32	69,751,203.21
	Income difference	**22,496,623.39**		**32,632,631.89**	

Source: Analysis results, (2023)

Table 1 explains that there is an increase in rice production of 57.12% per hectare per year. This significant increase occurred because there was an increase in the planting index from 200% to 300%. Apart from that, according to farmers, the presence of irrigation water also increases rice productivity in rice fields. This increase in production is in line with the increase in production costs and sales, which means increasing farmers' income. Farmers' income after irrigation construction increased by 87.91% per hectare per year.

This is in line with research conducted by Brown (2017) where the construction and development of irrigation areas can increase household income. Other research shows that irrigated agricultural land has a significant effect on increasing the income of farmers in the northeastern region of Ghana (Awunyo-Vitor and Ziba 2017). In rice commodity farming, research by Jordiansyah et al. (2019) the presence of irrigation networks has an impact on increasing production, productivity and farmer income which is directly proportional to increasing production costs.

b. Increasing the income of rubber farmers into paddy fields

Analysis of farming income for farmers whose land was originally converted into paddy fields was carried out to determine the difference in income before and after irrigation development with different commodities. The analysis was carried out on four hectares of land owned by four farmers. Before the construction of irrigation, rubber harvesting was carried out five to six days a week for the entire year. After the construction of irrigation, the land turned into rice fields with three growing seasons.

Table 3. : Rubber farmers' farming income becomes rice

No	**Uraian**	**Per Ha (IDR)**	
		Before	**After**

	Per Year		**(3 Seasons)**
1	Production cost	14,719,657.66	32,925,695.12
2	Farming sales	36,339,933.82	99,450,000.00
3	R/C (2/1)	2.47	3.02
4	Income	21,620,276.16	66,524,304.88
	Income difference	**44,904,028.73**	

Source: Analysis results, (2023)

The area of rubber land that was converted into paddy fields after irrigation construction was 4.00 Ha owned by four farmers. The land function will be carried out in early to mid-2022 after the completion of the Way Tulung Buho irrigation construction. Apart from the availability of irrigation water for agriculture, the declining price of rubber has also caused some farmers to convert their land into irrigated rice fields. World rubber prices continue to decline starting from 2020 to mid-2022 as a result of the continued decline in demand for world rubber commodities (Syarifa et al. 2023).

Based on Table 3, rubber farmers' income increased rapidly to IDR 44,904,028.73 per year after changing their crops to irrigated rice fields. This fairly high rice production and income is obtained from rice fields which produce three times a year. Based on the planning document for the Way Tulung Buho Irrigation Area, there are still 21.50 Ha of rice land that has the potential to be converted into irrigated rice fields with land conditions suitable for rice fields..

c. Increasing the income of cassava farmers into paddy fields

This analysis was carried out on 14 farmers who, before the irrigation development, had cassava farming with a planting period of once a year for approximately 10 months. The land was turned into a lowland rice farming business with two planting seasons a year. This analysis was carried out on an area of 8.75 hectares.

The cassava plantation land that was converted into wetland rice after irrigation development was 8.75 Ha. One of the factors causing the conversion of agricultural land is the availability of water (Setiawan and Purwadio 2013). The availability of irrigation

water on this land allows farmers to plant lowland rice twice a year. Table 4 shows that irrigation development increases the income of cassava farmers who convert to lowland rice by IDR 23,969,113.03 per hectare per year with an R/C ratio of 2.51.

Table 4. : Cassava farmers' farming income becomes rice

No	Uraian	Per 0,63 Ha (IDR)		Per Ha (IDR)	
		Sebelum	Sesudah	Sebelum	Sesudah
	Per Tahun		**(2 Musim)**		**(2 Musim)**
1	Production cost	7,587,323.27	14,243,379.52	11,708,605.03	24,809,491.99
2	Farming sales	20,428,571.43	38,473,557.08	32,371,428.57	62,232,908.59
3	R/C (2/1)	2.69	2.70	2.76	2.51
4	Income	12,841,248.15	28,686,620.48	20,662,823.54	44,631,936.58
	Income Difference	**15,845,372.32**		**23,969,113.03**	

Source: Analysis results, (2023)

Based on the analysis of farming income in Tables 2, 3, and 4, irrigation development can increase production and productivity of rice farming, increasing farmers' income from farming between before and after irrigation development. This means that irrigation development increases the income of farming households, thus economic activities in the area will continue to grow and develop. The positive impact of this irrigation development can be extended to the surrounding area which has characteristics and conditions of internal and external factors similar to the Way Tulung Buho Irrigation Area. For this reason, it is necessary to analyze the location of land around the Way Tulng Buho Irrigation Area which has the most potential to be developed as an irrigation area so that increasing community income can be expanded so as to encourage regional development in West Tulang Bawang Regency. These factors are the slope of the land, water availability, distance to the location of the regional economic center or to a causeway, and potential area (land conversion).

Determining Irrigation Area Development Priorities

a. Land Slope

Slopes are surface conditions that connect low ground surfaces with higher surfaces (Setiawan et al. 2022). The slope of the land at the research location was obtained from secondary data from the Regional Government of West Tulang Bawang Regency which is presented in Table 5.

Table 5. : Land slope classification and ranking

No	Village	Planned Area (Ha)	Presentase Luas Kemiringan (%)			Rank
			Flat (0-2%)	Wavy (3-7%)	Sloping (8-13%)	
1	Kibang Yekti Jaya	790.07	79.43	20.57	0.00	2
2	Kibang Tri Jaya	532.46	81.99	18.01	0.00	1
3	Agung Jaya	364.31	52.39	45.35	2.26	3
4	Gunung Agung	240.50	33.54	66.46	0.00	4

Source: Hasil olah data, (2023)

Table 5 shows that most of the land has a relatively flat slope (0-2%). However, in Tiyuh Gunung Agung, Gunung Terang District, most of the land has a slope of 3 – 7% which falls into the wavy category. Rice plots are more suitable for flat land. The steeper the slope class on a land, the narrower the plot width and the greater the frequency of landslides (Mardinata and Zulkifli 2014). Steep land requires special treatment before being converted into rice fields, such as engineering for excavation and embankment, which requires greater costs than flat land. Therefore, for development priorities, flatter land is chosen over steeper land.

The ranking selection in Table 5 is obtained from the multiplication ratio of the planned land area by the percentage of slope of the land area. Then, flatter land will get a higher ranking. In the study location, the most suitable land based on the slope of the land is located at Tiyuh Kibang Tri Jaya, while the most sloping land is at Tiyuh Gunung Agung.

b. Number of Rivers

In the construction of irrigation networks, rivers play a role as a source of irrigation water. The more rivers there are, the more choices there are for locations to build irrigation networks. At the research location there are two rivers, namely the Tulung Buho River and the Way Pidada River. Table 5 presents data on

the number of rivers in each irrigation development plan location.

Table 6. : Number of rivers at the location of the irrigation development plan

No.	Village	District	Number of Rivers	Rank
1	Kibang Yekti Jaya	Lambu Kibang	2	1
2	Kibang Tri Jaya	Lambu Kibang	1	2
3	Agung Jaya	Way Kenanga	1	2
4	Gunung Agung	Gunung Terang	1	2

Source: Data processing results, (2023)

Table 6 shows that in Tiyuh Kibang Yekti Jaya there are two rivers that cross it. The number of rivers is greater than the other three locations. This makes Tiyuh Kibang Yekti Jaya occupy first position. The other three locations are only crossed by one river, namely the Way Pidada River, which makes these three locations occupy second place.

c. Land Distance to Local Urban Activity Centers and Cross Roads

In agricultural business buying and selling activities, distance and accessibility influence the transportation costs of agricultural products. The farther and more difficult it is to access the agricultural location to the center of economic activity, the greater the transportation costs that will be borne in farming costs. The greater the farming costs, the smaller the farming profit. Proper access to irrigation infrastructure will increase crop yields and agricultural production and agricultural income in a region (Bhattarai et al. 2002). Table 7 presents data on the distance from the location of the irrigation area development plan to the center of local economic activity in Lambu Kibang District and the provincial strategic highway in Lampung Province.

Table 7 shows that Tiyuh Kibang Tri Jaya is the location closest to the center of local urban activities, while Tiyuh Gunung Agung is the land with the furthest location. Tiyuh Kibang Yekti is closer to the provincial strategic highway, namely 2.1 km, which is ranked first, while with the lowest ranking is Tiyuh Gunung Agung which is in fourth position.

Table 7. : Distance of the irrigation development plan location to cross-provincial roads and PKLP

No	Village	Distance to PKLP		Provincial strategic highway	
		Distance (Km)	Rating	Distance (Km)	Rating
1	Kibang Yekti Jaya	4.8	2	2.1	1
2	Kibang Tri Jaya	3.4	1	3.4	2
3	Agung Jaya	9.2	3	5.3	3
4	Gunung Agung	9.6	4	4.9	4

Source: Data processing results, (2023)

d. Conversion Land Area

According to the West Tulang Bawang Regency Spatial and Regional Plan (2011 to 2031), most of the research locations are rubber plantations and mixed cultivation. Based on Tables 3 and 4, conversion of rubber and cassava plantation land is proven to increase farming income within a year. Thus, the wider the area of irrigated rice fields, the greater the profits obtained by farmers. Table 8 shows data on the potential area of irrigated rice fields in each location and their ranking.

Table 8. : Luas rencana pengembangan Kawasan Irigasi Way Tulung Buho

No	Tiyuh	Kecamatan	Luas Rencana (Ha)	Peringkat
1	Kibang Yekti Jaya	Lambu Kibang	790.07	1
2	Kibang Tri Jaya	Lambu Kibang	532.46	2
3	Agung Jaya	Way Kenanga	364.31	3
4	Gunung Agung	Gunung Terang	240.50	4
	Total		**1,927.34**	

Source: Data processing results, (2023)

Table 8 shows that the largest potential land is in Tiyuh Kibang Yekti Jaya, District, Lambu Kibang. This means that the biggest profits will be obtained at Tiyuh Kibang Yekti Jaya. The location with the smallest area is Tiyuh Gunung Agung, Gunung Terang District, which is ranked fourth with the smallest potential increase in income compared to other locations.

e. Analysis of Determining Priority for Development of Irrigation Areas with the AHP Method

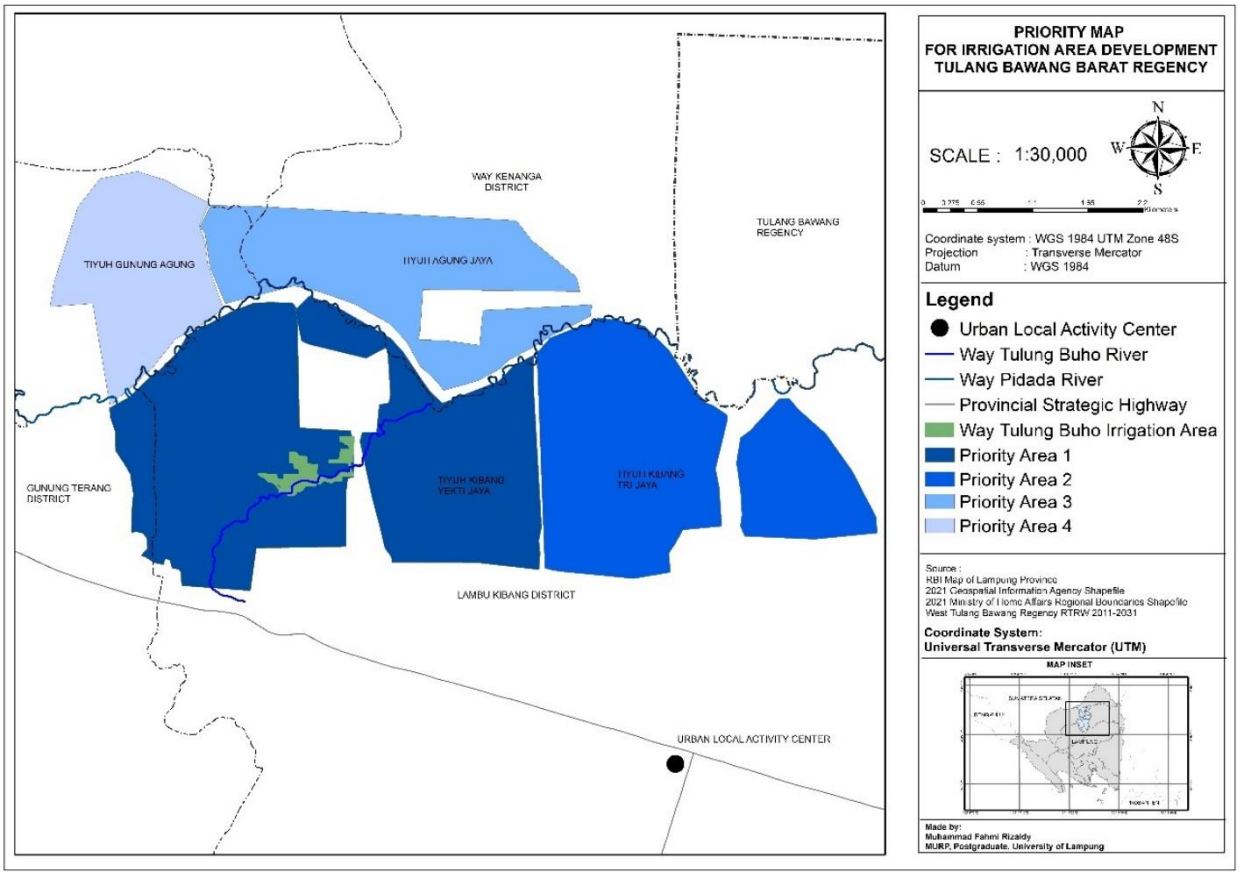
Based on Table 5 to Table 8, there are five criteria in determining priorities for developing irrigation areas, namely land slope, number of rivers, location distance to local urban activity centers, location distance to strategic provincial roads and potential land area. After obtaining the ranking of each location, it can be determined which locations have priority for developing irrigation areas using the AHP method as in Table 9.

Based on the results of the AHP method analysis (Table 8), Tiyuh Kibang Yekti Jaya has the highest score (1.00), which means it is the first priority location for developing the Way Tulung Buho Irrigation Area, followed by Tiyuh Kibang Tri Jaya (0.92) in the ranking. second, Tiyuh Agung Jaya (0.36) was ranked third and in last position was Tiyuh Gunung Agung (0.30). Thus Tiyuh Kibang Yekti Jaya is the most potential location based on land slope, number of rivers, location distance to local urban activity centers, location distance to provincial collector roads and land area to be developed as an irrigation area (Figure 2).

Table 9. : Priority development of irrigation areas

No	Village	District	AHP Value	Rank
1	Kibang Yekti Jaya	Lambu Kibang	1.00	1
2	Kibang Tri Jaya	Lambu Kibang	0.92	2
3	Agung Jaya	Way Kenanga	0.36	3
4	Gunung Agung	Gunung Terang	0.30	4

Source: Analysis results, (2023)



Source: Data processing results, (2023)

Figure 2. : Priority map for development of irrigation areas

Conclusion

Irrigation development in the Way Tulung Buho Irrigation Area increases production and productivity of lowland rice farming and increases farming income between before and after irrigation construction.

Increasing farmers' income can be expanded by expanding the Way Tulung Buho Irrigation Area to surrounding areas that have similar internal and external factor conditions. There are four potential locations to be developed as irrigation areas, namely Tiyuh Kibang Yekti Jaya, Tiyuh Kibang Tri Jaya, Tiyuh Agung Jaya and Tiyuh Gunung Agung.

References

Alkadri. 2001. Tiga Pilar dalam Pengembangan Wilayah: Sumber Daya

Alam, Sumber Daya Manusia, Teknologi. BPPT, Jakarta.

Awunyo-Vitor, D., and Ziba, D. S. 2017. The Impact of Irrigation Schemes on Farm Income: Implications for Sustainable Agriculture in the Upper East Region, Ghana. Journal of Global Business and Technology 13(2): 24–35.

Bhattarai, M., Sakthivadivel, R., and Hussain, I. 2002. Irrigation Impacts on Income Inequality and Poverty Alleviation: Policy Issues and Options for Improved Management of Irrigation Systems. International Water Management Institute.

Black, J. 2018. Urban Transport Planning: Theory and Practice. Cromm Helm, London.

Brown, J. R. 2017. Irrigation Development as an Instrument for Economic Growth in Saskatchewan: An Economic Impact Analysis. University of Saskatchewan.

Direktorat Perluasan dan Perlindungan Lahan Kementerian Pertanian. 2018. Pedoman Teknis survei, investigasi calon petani-calon lokasi dan desain perluasan sawah. Direktorat Jenderal Prasarana dan Sarana Pertanian, Kementerian Pertanian, Jakarta.

Food and Agricultural Organization (FAO). 1996. Food Production: The Critical Role of Water. in: World Food Summit FAO, Rome.

Friedmann, J., and Alonso, W. 2008. Regional Development Planning : A READER. New Zealand Geografer 23: 179.

Jordiansyah, Fajri, and Hamid, A. H. 2019. Impact Of Irrigation Network In Indrapuri District Aceh Besar Regency, On Production And Income Of Padi Farmers. Jurnal Ilmiah Mahasiswa Pertanian Unsyiah 4(3): 21–29.

Mardinata, Z., and Zulkifli, Z. 2014. Analisis Kapasitas Kerja Dan Kebutuhan Bahan Bakar Traktor Tangan Berdasarkan Variasi Pola Pengolahan Tanah, Kedalaman Pembajakan Dan Kecepatan Kerja. Jurnal Agritech 34(03): 354. DOI: 10.22146/agritech.9465

Marshella Febriani, O., and Setya Putra, A. 2022. Jaringan Irigasi Desa (JIDES) Berbasis IoT di Provinsi Lampung. Ijccs x, No.x(x): 1–5.

Muhammad, A., and Darmawan, M. 2019. Pengembangan Potensi Agroekowisata Di Kawasan Bulu Dua Kabupaten Soppeng. Gorontalo Journal of Forestry Research 2(2): 105. DOI: 10.32662/gjfr.v2i2.718

Munthafa, A. E., and Mubarok, H. 2017. Penerapan Metode Analytical Hierarchy Process Dalam Sistem Pendukung Keputusan Penentuan Mahasiswa Berprestasi. Jurnal Siliwangi 3(2): 192–201.

Saaty, T. L. 1993. Decision Making for Leader : The Analytical Hierarchy Process for Decisions in Complex World. University

of Pittsburgh, Pittsburgh.

Saaty, T. L. 2008. Decision making with the analytic hierarchy process. Services Sciences 1(1): 83–97. DOI: https://doi.org/10.1504/IJSSCI.2008.017590

Setiawan, A., and Purwadio, H. 2013. Arahan Pengendalian Alih Fungsi Lahan Pertanian Pangan Menjadi Perkebunan Kelapa sawit di kabupaten katingan. Jurnal Teknik Pomits 2(3): 250–252.

Setiawan, F. A., Ridwan, Suharyatun, S., and Asmara, S. 2022. Requirement Analysis of Hand Tractor, Using Geographic Information Systems in Pringsewu District and Gading Rejo District, Pringsewu Regency. Jurnal Agricultural Biosystem Engineering 1(2): 1–10.

Subroto, G., and Susetyo, C. 2016. Identifikasi Variabel-Variabel yang Mempengaruhi Penentuan Lahan Pertanian Pangan Berkelanjutan di Kabupaten Jombang, Jawa Timur. Jurnal Teknik ITS 5(2). DOI: 10.12962/j23373539.v5i2.18297

Syarifa, L. F., Agustina, D. S., Alamsyah, A., Nugraha, I. S., Asywadi, H., and Selatan, S. 2023. Commodity Outlook of Indonesian Natural Rubber 2023. Indonesian Journal of Natural Rubber Research 41(September): 47–58. DOI: 10.22302/ppk.jpk.v41i1.841

Tarigan, R. 2005. Perencanaan Pembangunan Wilayah. Bumi Aksara, Jakarta.

.