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The Sustainability Prospective of Irrigation System Management in Bali and Outside of Bali

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Abstract

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unquestionably required to meet the high demand of water to support rapid population growth and socio-economic expansion. The water supply availability is slowly decreased due to plantation land clearing, construction projects, and land-change activities in the watershed area. This study aimed to analyze the sustainability of irrigation management in Bali and outside of Bali (Bolaang Mongondow Regency, North Sulawesi). Primary and secondary data were employed in this study. In-depth interview and focus group discussion sessions conducted to collect the primary data. The literature review technique applied to gather secondary data to support the study result and discussion. We recruited the committee of subak, farmers, and stakeholders or policymakers from the Local Board of Agriculture and Public Works and Public Housing (sub-irrigation division) to participate in this study. Multi-Dimensional Scaling method employed to analyze the study data. Results revealed that the sustainability prospective of the irrigation system management in Mongondow was relatively weak, especially on the physical-ecological, infrastructure-technology, and policy-institutional dimensions. However, we noticed that the economy and social dimension of the watershed area was relatively sustainable. Contrary situations were found on Saba Watershed in Buleleng Regency, Bali Province. We found that the sustainability prospective on the physical-ecological and infrastructure-technology dimension was

relatively weak. But the dimension of the economy, socio-cultural, and policy-institutional was adequately sustainable.

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INTRODUCTION

The rapid growth of population and socio-economic expansion contributes to the high utilization of water resources. This situation also would increase the demand of water for the need for industrial works. On the other hand, adequate water supply is constantly decreasing. Global warming and climate changes that induce anthropogenic carbon dioxide emission and intensification of hydrology cycles would worsen the water supply. The increase of water flux alters the frequency and magnitude of extreme climate (floods, droughts, heatwaves, extreme cold snaps, etc.). These events commence to a serious impact on the future irrigation system management (Prodanovic & Simonovic, 2010).

Despite those dangerous future of water supply, no policies issued to inclusively acknowledging the significance of environmental sustainability management in regional economic growth and sectoral policies in Indonesia. Negative impacts had occurred due to the lack of recognition of the importance of environmental management in supporting economic growth, such as environmental degradation and limitations in utilizing natural resources due to illegal logging. Degradation of water catchment areas, soil erosion, and limited water supply are also noticed as the impact of deforestation due to over-exploited forest for industrial need. The water supply is insufficient to meet plenty of water demands from the industrial, domestic, irrigation, and other need. In the agricultural field, the lack of water supply produces lower agriculture productivity, especially on rice paddy production that had been decreasing each year.

A study conducted by Rachman and Kariyasa (2003) yielded that adjustment of the governmental organization, private organization, and farmers required to create equally distributed and efficient water resources. Water user association capacity needed to be improved to manage the irrigation systems in the economic enterprises. Hariawan *et al.* (2020) explained that equally distributed and efficient water resources are highly influenced by the performance of the water management institutions on the distribution and allocation levels. The role and participation of water

management organizations such as the Committee of Irrigation, Water Resource Management Committee, and Water Users Association were required to be widely identified and noticed. In line with this statement, Jansing *et al.* (2020) also highlighted the importance of opportunity provided for the association of local resource organizations in managing water resources on the agribusiness, distribution, and allocation levels. A professional and competitive irrigation system management was essential in dealing with policies of regional autonomy in Indonesia.

Irrigation system management was ruled by three aspects: (1) representation policies, (2) jurisdictional boundaries, and (3) property rights. It was also composed of technical components of working procedure/maintenance and water allocation. Integrated technical and institutional components of irrigation systems significantly affected the outcome, optimization, and efficiency of water resources allocation. Weak irrigation management potentially triggered conflicts in managing the water resources (Meinzen-Dick, 2014).

Dumoga Mongondow Watershed in North Sulawesi had encountered several management-related issues. The function of facilities employed in the irrigation system did not meet the standard set for irrigation tools. All tools applied for the irrigation system in all layers, from the primary to the tertiary level had performed the poor function. This situation led to a lack of water supply during the dry seasons. All farmland in the downstream area was experiencing water scarcity issues during those times. The damage of the sluice gate was recognized as the major cause of this issue. Several sluice gates had leaks. Defective debit meters, dripped water canals, and illegal water tapping also contributed to this issue (Hariawan *et al.*, 2020; Kalesaran *et al.*, 2016; Lepa & Rachman, 2019). The irrigation area in Kosinggolan and Toraut, Bolaang Mongondow were significantly decreased, from 5,381 Ha (DI Kosinggolan) and 7,800 Ha (DI Toraut) in 2017 to 3,865 Ha (DI Kosinggolan) and 4,850.25 Ha (DI Toraut) (Ineke *et al.*, 2017; Soetopo *et al.*, 2017).

A similar situation occurred at Saba Watershed, Buleleng Regency, Bali Province. Fifty-five *subak* organizations (Balinese traditional water management system) were involved in the irrigation system management in Saba Watershed. Unfortunately, some areas under the reservoir could not access the water for their agriculture activities. This situation was led by the barricades on the major water canal constructed by the local community. The damage of the demarcation line in the watershed area also contributed to this situation. The demarcation line was destroyed by the land-use change activities that occurred in the Saba Watershed area. Due to these activities, the rice paddy field almost transformed completely. It was significantly decreased from 1,223.42 ha to 771.13 ha from 1991 to 2014 (Setiawan *et al.*, 2015).

The novelty of the recent study is a discussion of irrigation management issues encountered on each level of stakeholder, from the farmer to the governmental level, on a multi-dimensional scale application in recognizing attributes or variables that need to be improved in the system. This study aimed to describe the sustainability of irrigation system management. The sustainability was obtained from issues literate by stakeholders in Bali and outside of Bali (North Sulawesi) through the Multi-Dimensional Scaling (MDS) method.

RESEARCH METHOD

Study Location and Duration

The study location conducted in two regencies and purposively selected prior to the study: (1) Saba Watershed, Buleleng Regency, Bali Province, and (2) Dumoga-Sangkub Watershed, Bolaang Mongondow Regency, North Sulawesi Province. These watersheds were picked as study locations due to their role as one irrigation water source and had a similar organization (*subak*). Both watersheds also could not provide their best functions in all dimensions: ecological, economic, social, technology, and institutional of system sustainability. This one-year study was conducted from 2019 to 2020.

Data Collection Techniques

We conducted virtual FGD sessions due to the Covid-19 pandemic to collect the study data. Primary and secondary data enrolled in this study. Primary data were collected through the focus group discussion (FGD) and in-depth interview sessions from the *subak* organization committee, stakeholders or policymakers of the board of agriculture, stakeholders or policymakers of the board of public works and public housing, and other associated stakeholders. The primary data was composed of: environmental, economic, institutional, social, and technology variables that related to the sustainability of the irrigation system done outside of the Bali area. Secondary data collected through the literature review technique. We gathered information about irrigation system management (area of *subak*, the number of *subak* members, the average of rice volume production, etc.) from several local or national boards associated with the local irrigation system management.

Data Analysis Method

The multi dimensional scaling (MDS) with the rap-irrigation software applied to analyze the study data. This was a multivariate method employed to examine a set of metric data and transformed a multidimensional form of data into a lower level of data dimension (Fauzi & Anna, 2005). These dimensions were institutional, physical-ecological, technology, social, and

economy that would be presented by each attribute. The attribute in each dimension was selected according to the indicators of *subak* system sustainability (Dale & Beyeler, 2001).

RESULT AND DISCUSSION

Sustainability Status of Physical-Ecology Dimension

Ten attributes applied to assess the sustainability status of the physical-ecological dimension. They were: (1) water availability, (2) land utilization for agribusiness purposes, (3) water catchment area (upstream area/forest), (4) soil fertility, (5) irrigation water utilization, (6) crop failure (flood, drought, pest attack), (7) land conversion (agricultural to non-agricultural land), (8) role of water user organization/*subak* in water maintenance, (9) role of water user organization/*subak* in land maintenance, and (10) water pollution (trash and waste in irrigation system). The sustainability index of this dimension in Dumoga Timur Watershed, Bolaang Mongondow Regency, North Sulawesi, and Saba Watershed, Buleleng Regency, Bali Province was 48.82% and 49.08%, respectively. Both values indicated a “less sustainable” dimension.

Sensitive attributes improved the sustainability index of the physical-ecology dimension. Leverage analysis on the physical-ecology dimension found three sensitive attributes of the physical-ecology dimension of the Dumoga Timur Watershed, North Sulawesi: soil fertility, land conversion (agricultural to non-agricultural land), and crop failure.

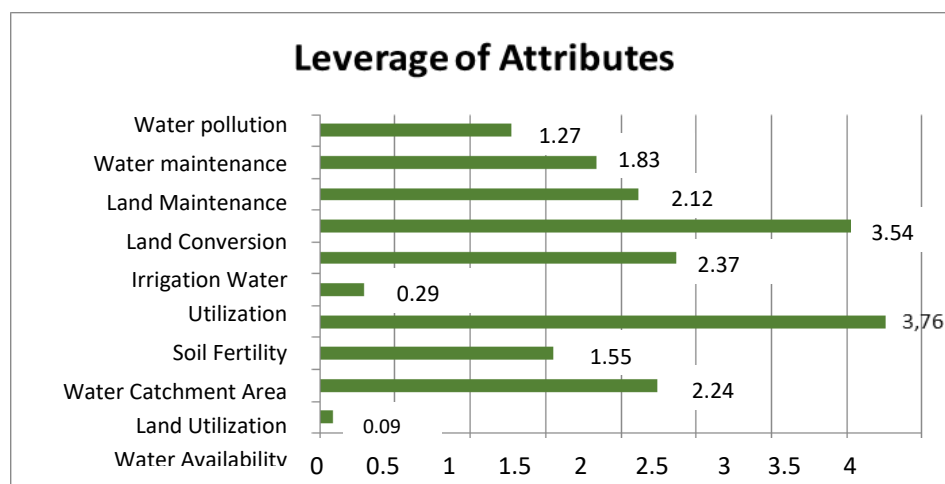


Figure 1. Sensitive Attribute of Physical-Ecological Dimension in Dumoga Timur Watershed, North Sulawesi

Soil quality is the capacity of the soil to conserve water availability, plant productivity, and environmental quality. High-quality soil presents no land subsidence and less pollution. It helps plants grow in a healthy and fertile environment, also safe for consumption (Yusuf *et al.*, 2018). The realization

of high-quality soil would improve the sustainability index of the physical-ecology dimension.

Tunggali, *et al.* (2016) explained land-use change conducted due to rapid population and economic growth. Land-use activity in the watershed area contributed to the decline of the forest functions that finally affected the quantity of river debit. Migratory inflammation and illegal logging are the dominant factors influencing the reservoir debit, in addition to the efficiency factor in the irrigation canal. The availability of water was directly proportional to agricultural production. This condition affects the occurrence of crop failure in the dry season. The sustainability status of the dimension could be improved if these circumstances can be overcome and well regulated in spatial regulations.

There were three sensitive variables that influenced the sustainability index of this dimension in Saba Watershed in Bali Province: land conversion, water pollution, and irrigation water utilization.

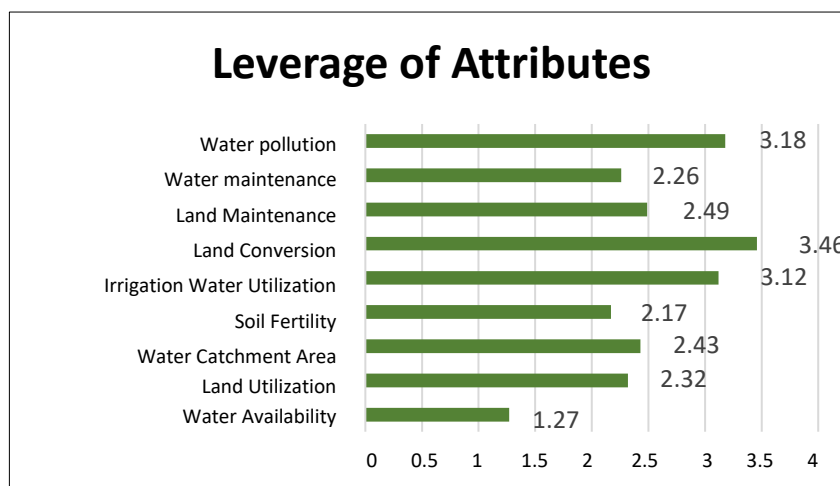


Figure 2. Sensitive Attribute of Physical-Ecological Dimension in Saba Watershed, Bali

Irrigated cropping land experienced a land-use change in the past 20 years. Survey revealed that 20 *subak* in Saba Watershed experienced a land-use change in 2014. After the land-use change activities that conducted from 1991 to 2014, the initial area of *subak* of 1,223.42 ha had turned into 771.13 ha (37%). The land-use change intended to provide fields for clove cultivation (165.91 ha), grape plantation area (129.72 ha), dragon fruit farming (1.5 ha), fishpond (20 ha), building (104.16 ha), and Titab Reservoir (31 ha) (Budiasa *et al.*, 2015).

The shrinking cropping land in the Saba Watershed area mainly caused by the rapid and uncontrolled growth of the population. This situation stimulated the growth of the need for residences or settlements. The need for

water would also distribute not only for agricultural requirements, but also for domestic demands.

The irrigation system of Saba Watershed managed by 55 *subak* organizations. The lower cropping area did not receive enough water due to the following situations (Setiawan *et al.*, 2015): 1) limited irrigation water flowed in *subak* Tukad Sumaga, Gerokgak District in KM10; 2) the irrigation water only flowed until the *Subak Berombong*, it could not reach the lower area due to the dysfunction of the secondary canal in KM17; 3) the low position of small bridges created to link each side of irrigation area from the main canal had blocked the water flow into the main canal, and 4) barricades built by the local community to meet their domestic water need had blocked the water flow.

We identified a moderate to high risk of pollution in the area of Saba Watershed. The moderate risk area was distributed from the upstream to the downstream, covered 68% or 9,263 ha from the total sub-watershed area. High-risk areas covered 32% or 4,413 ha from the total sub-watershed area. The pollution level in the watershed area was relatively low, approximately 0.04% or 58 ha from the total sub-watershed area (kaitannya-dengan-pertanian-pada-sub-das-saba-kabupaten-buleleng/).

Sustainability Status on Economy Dimension

Attributes applied to assess the sustainability status of the economic dimension were: (1) planting season, (2) the role of farmer organization (water user organization/*subak*) in managing business unit (cooperative) on farmer level, (3) partnership between the farmer and business unit, (4) operational and maintenance cost of the irrigation system (*subak*), (5) agribusiness profit, (6) profit distribution between the business unit and the farmer, (7) price fluctuation/stability of the agricultural commodity, (8) access in distributing the agricultural commodity, (9) agricultural sector contribution to the Original Local Government Revenue, and (10) the mean income of the farmer relative to the Regional Minimum Wage. Analysis revealed that the sustainability analysis on the economic dimension of the Dumoga Timur Watershed was 51.84%. The comparison between the index and multidimensional value of the socio-cultural dimension revealed the “adequately sustainable” status of this dimension. The sustainability analysis on the economic dimension of the Saba Watershed in Bali Province was 52.26%. This finding also indicated the status of the dimension as “adequately sustainable”.

Leverage analysis identified three sensitive attributes: profit distribution between the business unit and the farmer, partnership between the farmer and business unit (rice paddy milling business), and the role of farmer organization (water user organization/*subak*) in managing business unit (cooperative) on farmer level. The majority of farmers prefer to process the

harvested rice paddy to the milling business. Hence, they could not obtain maximal profit from the harvest period. The absence of an agricultural cooperative unit produced different ways of rice paddy processing method.

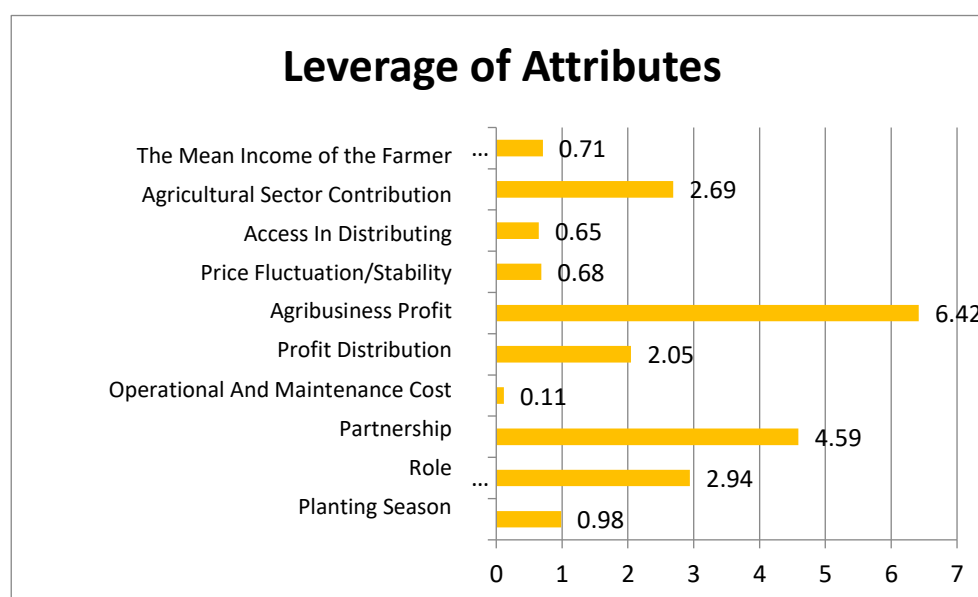


Figure 3. Sensitive Attribute of Economy Dimension in Dumoga Timur Watershed, North Sulawesi

This finding was parallel with a study by Soegoto and Sumarauw (2014). Bolaang Mongondow Regency covers 4,083.94 km² area with 213,484 populations. Micro-economic enterprises produced the majority of agricultural and fisheries commodities of this regency. They produced copra, rice, corn, fish, and livestock. These commodities potentially promoted as high-quality commodities at the national or international level. Unfortunately, the commerce system did not appropriately manage. This situation led to the slow development of the microeconomic enterprises in this regency. Some situation associated with commerce system in the Bolaang Mongondow Regency were elaborated as follow: 1) the scale of the commerce system was locally-based, 2) pander involvement dan imbalanced demand and supply situation that put the producer in price-taker position, 3) the transaction filled by the asymmetry of information because the lack of regional market price knowledge, 4) high shipping cost, 5) wholesaler from outside of the local area controlled the local price, and 6) random pattern of the market distribution lines.

Sensitive attributes in Saba Watershed were the operational and maintenance cost, business partner, and the role of *subak* in managing the agribusiness. The majority of irrigation system in Bali was broken. This situation indicated that the funding required to be designated for the need of system operation and maintenance. Rumambi and Ludong (2017) added that

the broken irrigation system is usually naturally built (by soil) or old river stones. No system restoration was conducted due to the limitation of funding in maintaining and restoring the system.

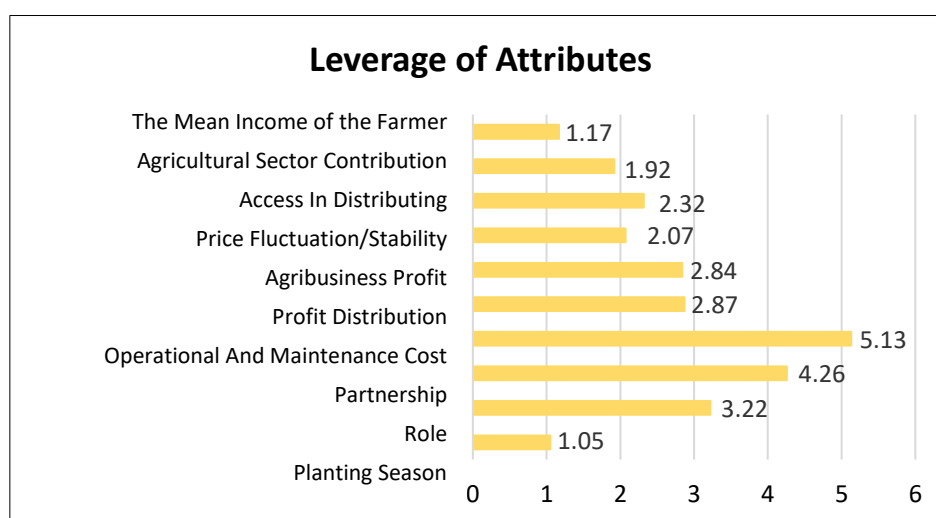


Figure 4. Sensitive Attribute of Economy Dimension in Saba Watershed, Bali

The inadequate work performance of the irrigation system induced by the elevation of the base of the canals. A higher canal base could not provide an adequate amount of water for the tertiary water canals. Hence, in the dry season, the lower area of crops did not receive enough water. The lack of farmer participation in rehabilitating the irrigation system self susbsitently and slow restoration administered by the governmental parties caused dysfunctional and poor irrigation systems. The lack of farmer participation was rooted in the incompatibility of the irrigation system design with the farmer's perception and ideas. We have also identified three major causes of the incompatibility of the irrigation system design: (1) incompatibility between the assumption and design criteria with the irrigation system management, (2) incompatibility between the irrigation system design with the implementation of the irrigation, due to lack of data input, quality of contractors, and the lack of supervisions, and (3) incompatibility between the assumption of appropriate design of system between the farmer and designer. The elevation that was higher than the water level in the secondary canal with the river water level that is the source of its taps in the dry season is low. Sand-mining activities highly contributed to lower stability of water base that finally caused lower water levels.

Local farmer institutions remained incapable of improving farmer's income, wellness, and farmer's bargaining power. Issues related to weak bargaining positions were frequently encountered by the farmer in building business partnerships. Legal regulations are required to be issued to make a

solid foundation for business partnerships between the farmers and their business partners. This situation would help the farmer earning a proper position in the market and improve the sustainability status of the irrigation system management on the *subak* level.

Sustainability Status of Socio-Cultural Dimension

There were ten attributes applied to assess the sustainability of the socio-cultural dimension: (1) population growth around the local water user organization area, (2) farmer's educational background, (3) farmer knowledge about agriculture works, (4) farmer knowledge about water user management organization (*subak*), (5) farmer participation in communal works (*gotong royong*), (6) water conflict, (7) land ownership status, (8) labor absorption rate, (9) agricultural-local ceremony practices, and (10) participation of non-Hindu farmers in implementing the concept of *Tri Hita Karana* (THK). The socio-cultural dimension index in Dumoga Timur Watershed was 56.12%. The comparison between the index and multidimensional value of the socio-cultural dimension revealed the "adequately sustainable" status of this dimension. Leverage analysis yielded three sensitive attributes of the sustainability index in this dimension: farmer participation in communal works (*gotong royong*), the labor absorption rate in the agricultural field, and farmer knowledge about water user management organization (*subak*).

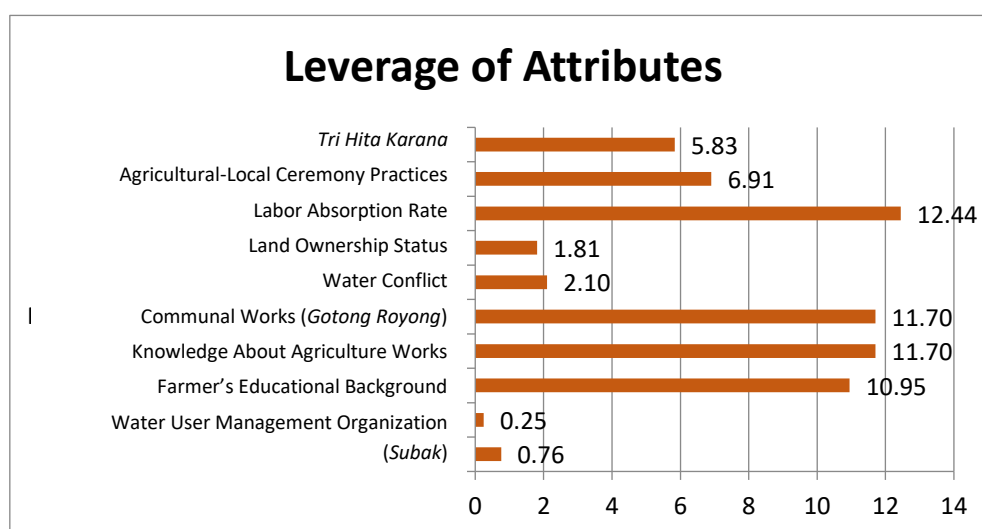


Figure 5. Sensitive Attribute of Socio-Cultural Dimension in Dumoga Timur Watershed, North Sulawesi

North Sulawesi Bureau of Statistic (2019) had mentioned the growth of the service and industrial sectors contributed to a higher labor absorption rate. However, we identified a declining trend in the agricultural labor absorption rate. In February 2018, the total labor absorption rate was

27.59%, but in February 2019, it had decreased to 24.27%. It might happen due to the higher enthusiasm to work in the service and industrial sectors rather than in the agricultural field. Farmer's participation in *subak*-related ceremonies in North Sulawesi was relatively low due to non-Hindu members of the water user organization. Hence, the number of the *subak*-related ceremony was relatively limited. Irrigation system-related issues would be solved by asking for support or funding from the government.

The sustainability index of the socio-cultural dimension in Saba Watershed Bali was 74.56%. Hence, the status of this dimension was "adequately sustainable". Three sensitive attributes identified in this area: water conflict, population growth, and farmer knowledge about environmental conservation. Watershed management aimed to create healthy soil, water, and vegetation resources to deliver maximum and sustainable benefits for wellness. A formulation and implementation of natural resources and human management manipulative actions in the watershed area intended gaining advantage from the production activities and services without harming soil and water, land use, and the association between the area of downstream and upstream (Asdak, 2002). The upstream of the watershed area was the provider of water that would transport the water to the downstream area. The upstream area is highly vulnerable to water conflicts due to various needs of water transported: tourism, agriculture, mining, or habitation. Poor control of the upstream area would convey negative impacts on the downstream area. Mutual understanding and consensus (*musyawarah mufakat*) between *subak* members played an essential role in solving water-conflict issues. The nature of the downstream area is to conserve the water supply. An adequate level of knowledge of environmental conservation is required to be applied to improve the sustainability index.

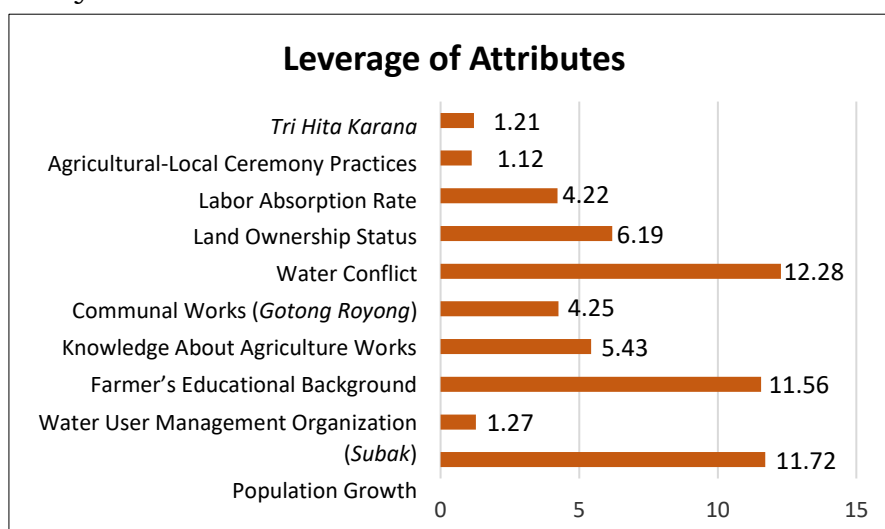


Figure 6. Sensitive Attribute of Socio-Cultural Dimension in Saba Watershed, Bali

Sustainability Status of Infrastructure-Technology Dimension

Attributes applied to assess the sustainability status of the infrastructure-technology dimension were: (1) agricultural technology adoption, (2) availability of adequate cropping tools, (3) road condition, (4) type of agricultural product processed-business, (5) access to agriculture-related information and communication technology, (6) technological aids compatibility, (7) irrigation gate function, (8) embankment function, (9) water board function, and (10) secondary irrigation canal function. The sustainability of the technology-infrastructure dimension of the Dumoga Timur Watershed was 42.77%. This result yielded the watershed status as “less sustainable”. We identified three sensitive attributes in Dumoga Timur Watershed: gate valve of water line function, embankment function, and the type of agricultural product processed-business.

Irrigation water system applied to transport water to the crops. Watergate manages the total debit of water transported from the reservoir to the crops. The majority of the irrigation gates and embankments in Werdhi Agung Selatan Village was broken. Funding from the Water Users Association would be applied to repair damage on the tertiary waterlines.

The most common type of agricultural business was the rice milling business. Lack of individual capital in running the business stimulated the establishment of the group-based rice milling businesses among the farmers (Soegoto & Sumarauw, 2014).

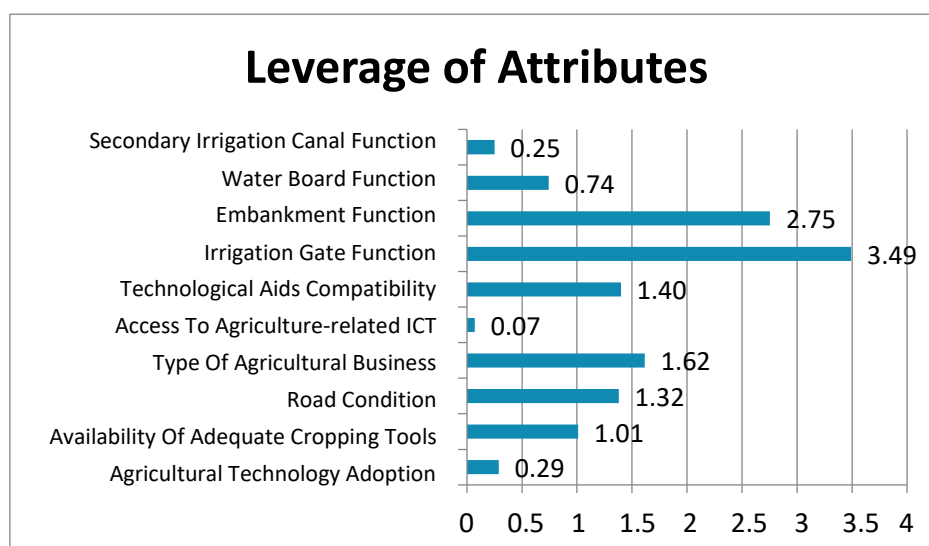


Figure 7. Sensitive Attributes of Infrastructure-Technology Dimension in Dumoga Timur, North Sulawesi

The sustainability index of the infrastructure-technology dimension in Saba, Bali was 40.21%. This finding indicated that this dimension was “less sustainable”. Leverage analysis found four sensitive attributes in this

dimension: (1) water board function, (2) secondary irrigation canal function, (3) embankment function, and (4) gate valve of water line function. Setiawan *et al.* (2015) found that the water from the Saba Watershed should have flowed to the area under the *Subak Berombong*. However, due to the damage on secondary water lines, there was no adequate amount of water flowing to this area. Hence, this situation is influenced by the performance of the irrigation network.

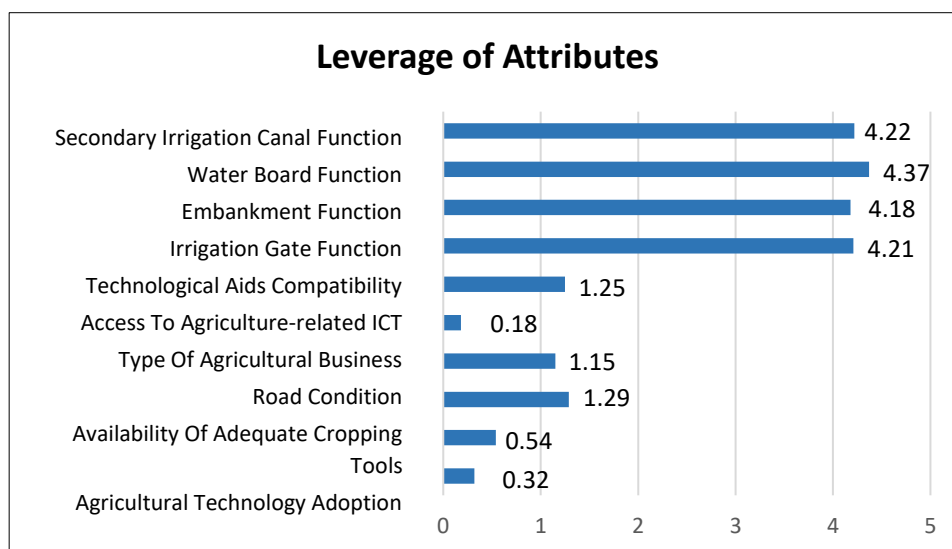


Figure 8. Sensitive Attributes of Infrastructure-Technology Dimension in Saba, Bali

Sustainability on the Policy-Institutional Dimension

Attributes enrolled to assess the sustainability status of the policy-institutional dimension were: (1) policies/agreements related to the irrigation system, (2) government commitment in providing adequate water for irrigation system, (3) approval of the water utilization right according to the planting season and schedule set by the irrigation officer, (4) availability of conflict management mechanism and procedure, (5) agricultural field extension involvement on agricultural activities, (6) policies related to cropping area development programs as tourism sites, (7) availability of agribusiness capital fund institution for farmer organizations, (8) refinement of the organization structure of the water user association (*subak*), (9) the establishment of farmer organizations union in managing water irrigation, and (10) farmer organization acknowledgment. The sustainability index of the policy-institutional dimension in North Sulawesi, Dumoga Timur was 47.42%. This finding indicated that the policy-institutional dimension was classified into “less sustainable”.

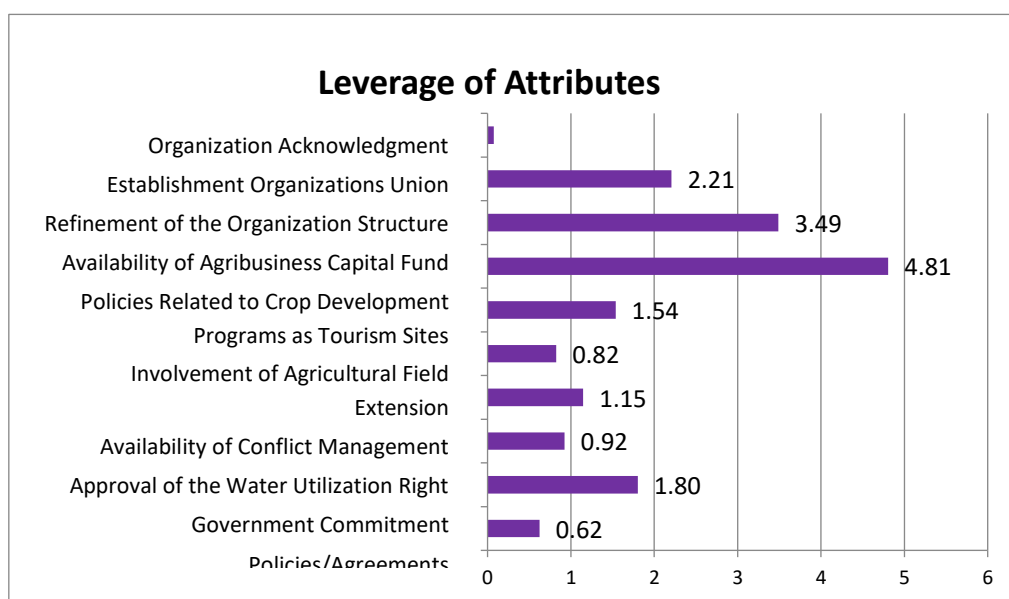


Figure 9. Sensitive Attribute of Policy-Institutional in Dumoga Timur Watershed, North Sulawesi

Three sensitive attributes identified in this dimension were availability of agribusiness capital fund institution for farmer organizations, refinement of the organization structure of the water user association (*subak*), and the establishment of farmer organizations union in managing water irrigation. In February 2020, the Ministry of Cooperatives and Small and Medium Enterprises had liquidated 116 cooperatives in Bolaang Mongondow Regency. Seventy percent of them were agricultural cooperatives. The main reason behind the liquidation was the inactive status of the cooperative. The annual general meeting has also never been directed (<https://totabuan.co/bolmong>). Well-managed cooperatives would highly contribute to the sustainability of the policy-institutional dimension. Another sensitive attribute yielded from the finding was the water users association. The incomplete structure of the organization and inadequate management of the farmer organizations union contributed to a poor sustainability index in this dimension. A study by Kalesaran *et al.* (2016) showed that passive participation from the committee of the water user association associated to the substitution of the local board in charge of water user organization perceptorials. The Local Board of Public Works and Public Housing was initially appointed to accompany the local water user organization in managing the organization and water irrigation system. However, suddenly the Local Board of Agriculture selected to substitute the role of the Local Board of Public Works and Public Housing. According to the legal documents issued for water user organization perceptorial (ministerial regulation, government regulation), the Board of Public Works and Public Housing mandated to supervise the local water user organization in managing the water resources based on the Government

Regulation Number 22 of 1982 on Water Management declared that water management consisted of the work associated with water management for various purposes: drinking water, agriculture, urban businesses, human resources, industrial, recreation, water traffic, health, mining, floatation, etc. Therefore, all guidances associated with irrigation system management issued by the Ministry of Public Works and Public Housing mentioned irrigation water management as the essential role of the water user organization.

Water user organization management and preceptorial through the Local Board of Agriculture conducted according to the Government Regulation Number 26 of 1982 on Irrigation that emphasized agricultural irrigation as the main agriculture activity. The legal cause of action in the national water resources field and irrigation altered the implementation of water management. Several regulations introduced to manage and precepted the farmer in using the water from Ministry of Agriculture were: (1) Presidential Regulation Number 24 of 2010 on Position, Duties, and Function of State Ministries and Structure Organization, Duties, and Task of First Echelon of State Ministries to Ministry of Agriculture to arrange the Guideline of Preceptorial and Empowerment of Water User Organization that legally performed according to Regulation of Ministry of Agriculture Number 79 of 2012 on Water User Organization's Guideline of Preceptorial and Empowerment and (2) Government Regulation Number 38 of 2007 on Sharing of Government Affairs between the Government, Provincial Governments and Regency/Municipal Governments. During the regulation transition, the water irrigation system was managed by some members of the water user organization who were not worked as a farmer and lived in the concerned local community. This situation triggered a gap between the member of the water organization and the local farmer groups. Hence, to prevent conflicts and gaps between the organizations, the member of the water user organization is required to be pick from the local farmer group's members. Regulation of Ministry of Public Works and Public Housing Number 30 of 2015 on Development and Management of Irrigation System explained that water user organization would be organized the irrigation system management. The preceptorial and training would be administered by the Ministry of Public Works and Public Housing or related local boards. The organization should be developed in the irrigation area and consisted of farmers from the concerned area.

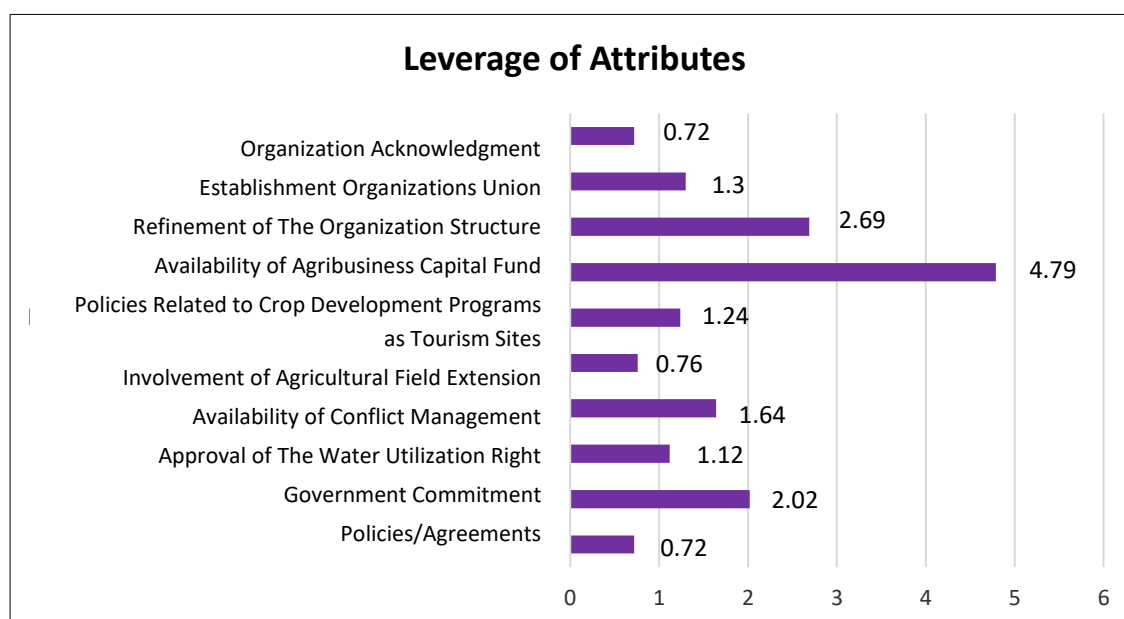


Figure 10. Sensitive Attribute of Policy-Institutional in Saba Watershed, Bali

A contrary result was found in Saba Watershed, Bali. The index of sustainability of the policy-institutional dimension was 52.32%. This finding indicated the “adequately sustainable” policy-institutional dimension. Sensitive attributes identified were the availability of agribusiness capital fund institutions for farmer organizations, refinement of the organization structure of the water user association (*subak*), and government commitment in providing adequate water for the irrigation system.

Capital funding remained a major hindrance in running the agricultural activities. Limited capital funding produced low quality and quantity of agricultural commodity volume production. This issue was recognized as the main factor of poverty among the farmers.

Based on data from the National Socio-Economic Survey in 2016, only 15% of farmers had access to get bank credit. High-risk of credit, bureaucratic issues, and interest rates were situations that hindered the farmer lending money to the bank. The non-bank financial institution provided a higher interest rate that burdened the farmer. This situation could lead to new issues in obtaining capital funds for their agricultural businesses.

Farmer income mainly originated after the harvest period. Crop failure might happen due to extreme climate changes or pest attacks. During these difficult times, fast and easy access to the capital fund would provide significant aid for the farmer to restore and re-planting their agricultural land. The amount of capital fund required was not necessarily high, but fast and easy access were essential for the farmer.

Organizations in Saba Watershed need to be more active in communicating, implementing the action plan, coordinating, participating in

public relations, and training activities to create integrated water resources and sustainable agriculture activity in the watershed area. The organization in Saba Watershed had conducted annual meetings together with the executive board and five working groups. Non-binding funding support provided by various parties highly supports the organization. The legal foundation also required in running the organization. A Bali Governor Decree would present substantial legal support for the organization (Setiawan *et al.*, 2015).

A planning team had been formed in Saba Watershed by Bali Governor to control the water system management. It consisted of governmental and non-governmental organizations: association, organization, institution, coordination group to manage the watershed area and individual parties to manage the natural resources and environmental preservation. The local government of Bali Province had issued Local Government Regulation Number 11 of 2008 on Integrated Management of Watershed Area in Bali Province. Adequate implementation of the watershed integrated management would improve the sustainability of the policy-institutional dimension in Saba Watershed.

CONCLUSION

The result and discussion of the recent study considered the irrigation system management in the Buleleng Watershed as a sustainable watershed. However, more focus is required to be placed on the dimension of environmental/ecological and infrastructure-technology to improve this system. The sustainability of the irrigation system in the watershed located in Mongondow Regency, North Sulawesi Province, was relatively weak. They demanded prioritizing the dimension of physical-ecological, infrastructure-technology, and policy-institutional to develop their irrigation system management.

RECOMMENDATION

Future studies suggested examining strategies to improve the irrigation system management on both watersheds studied. These strategies are expected to align with the requirements at all levels of stakeholders, from the farmer to the governmental level.

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