



Research Article

Traditional Institution for Enhancing the Sustainability of Irrigation Management in West Sumatera Indonesia

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A B S T R A C T

Traditional indigenous institutions have played a significant role in natural resources management, particularly in facilitating farmer participation in irrigation activities over centuries. However, the introduction of new government institutions, such as Water Users' Associations (known as 'P3A' in Bahasa), has led to institutional challenges, including reduced farmer engagement in irrigation activities, in regions where traditional systems have disappeared. Nevertheless, some communities successfully integrate traditional institutions into the current irrigation framework. This study aims to reassess the pivotal role of traditional institutions in irrigation management in West Sumatra. Employing qualitative methods, data was collected in Agam district from January to August 2022, with a focus on two P3As (P3A Karya Mandiri and P3A Jorong Biaro) to evaluate traditional institution involvement. Findings indicate that matrilineal land ownership (known as 'ulayat kaum' in the Minangkabau language) ensures a stable water supply for irrigation and sustains rice farming. Additionally, 'mufakat' (a consensus-building process) in decision-making encourages farmer participation and mitigates water conflicts, especially during dry periods. To reintegrate indigenous institutions into irrigation management, concerted efforts are needed to foster mutual understanding between farmers and policymakers. This research underscores the importance of preserving and integrating traditional systems for sustainable natural resource management.

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1. INTRODUCTION

The traditional institution has been blended with local ecology and sociocultural contexts and that have adapted and evolved on natural resources management in most rural areas. Some studies argue that traditional institutions have positive capabilities in natural resources management, which has to be considered in the

development of natural resources management (Ntiamoa-Baidu, 1995; Appiah-Opoku, 1999; Atkinson, 2011; Aggarwal, 2022). For sustainable development, local institutions are important for mobilizing resources and regulating their use with a view to maintaining a long-term base for productive activity (Uphoff, 1992). In addition, indigenous institutions, and local-level organizations based on societal values, are receiving a positive appreciation from many researchers for their acceptability and

sustainability in managing natural resources (Genet, 2021).

In recent years, natural resources have been facing pressure from the increasing pace of development, especially water resources such as irrigation water. Nevertheless, policymakers, administrators, and technicians are heavily focused on the physical aspects of irrigation in designs. In addition, they commonly make decisions about the institution that has little empirical basis and that lead to failure in the sustainability of their development program. Uphoff (1992) argues that the social dimensions of irrigation management have been too often neglected, handled badly, or assumed not to require any special knowledge.

In point of fact, the institution is an essential factor in creating effective irrigation management that allows water users to work together efficiently. Uphoff (1992) argues that strong local institutions encourage resource users to participate in group activities as they create common expectations and a basis for cooperation that goes beyond individual interests, and to the extent institutions are regarded as legitimate; the resource users comply with the rules. In this regard, a traditional institution shows some promise through their successful natural resource management. In addition, the traditional institution can create sustainable use of irrigation water by involving the user of that resource in its rational management (William, 1995). Nevertheless, due to the global economy, industrialization and modernization, traditional knowledge has been disappeared, mostly. In addition, the top-down policy in natural resource management had not been recognized by the local institution in managing the resources. It is resulting in the disappearance of traditional practices and the roles of indigenous leaders who had an important function in sustaining the practice.

Minangkabau people in West Sumatra has been managed their irrigation water based on traditional institutions existing for hundred years ago. The traditional leader is an important actor with the responsibility to mobilize labour for irrigation maintenance and conflict resolution, the latter being important where norms have been violated (Utami & Hiroki, 2022). In addition, productive land such as rice fields has been managed under a matrilineal system (*ulayat kaum*) to ensure the sustainability of the field for the next generation, for instance. However, in the 1980s Indonesian government introduced a new institution called Water Users' Association ("P3A" in Bahasa) to take control over irrigation systems, both large- and small-scale systems. As a result, many P3As were developed at tertiary units in West Sumatra. Yet, institutional problems such as water use conflicts and low participation from farmers in irrigation management have occurred in some regions where the traditional institution has been displaced.

Nevertheless, some communities successfully managed the irrigation system by implementing traditional institutions in the current irrigation management. It is critical, then, to assess considerations of traditional institutions that successfully managed to integrate traditional knowledge in the newly formed of irrigation institution and evaluate the potential of traditional knowledge to accomplish the sustainability of irrigation management in West Sumatra.

2. RESEARCH METHOD

This study was conducted in Agam district West Sumatra Indonesia. Two P3As were selected namely, P3A Jorong Biaro and P3A Karya Mandiri (Fig.1).

P3A Karya Mandiri was established and initiated by farmers and indigenous leaders in 1994. Regarding social background, rice farming activities are still managed under Minangkabau customary law in which rice fields belong to communal land. The distribution of rice fields is obtained through clan leaders. Thus, the social capital of farmers is still substantial, and they respect the indigenous leader very much.

The second P3A is P3A Jorong Biaro established and initiated by the local government in 1992. Regarding social background, rice farming activities have been transformed from collective management into individual management as the role of the indigenous leader has been excluded from agricultural activities. The imposition of Dutch colonialism in the early 18th century resulted in changes in the traditional social system, particularly the relationship between Indigenous leaders and clan members. The most crucial change in the Minangkabau social system was the changes of Nagari in 1980, a cultural territory which is traditionally composed of land claimed by the community, into a government administration area called Desa. During this period, the roles of Indigenous leaders were replaced by Wali Nagari as government staff. The impact of those transformations on water resource management, particularly irrigation systems, has occurred with changes in the institutional framework of management, changes in systems of knowledge, and technologies and practices (Utami and Oue, 2022).

Furthermore, the rice field in P3A Jorong Biaro has been transforming from communal land into private land. Based on field observation, the role of indigenous leaders in this area has been excluded from agricultural activities, including managing rice field land. The indigenous leader's roles were to manage and distribute rice field to clan members as well as to organise rice farming activities such as *gotong royong* (communal work) to maintain irrigation facilities. After the role of the indigenous leader was decreasing, many landowners initiated selling their share of land due to economic reasons. In addition, it is resulting

a decrease in communal activities in the area. Thus, the social capital in this area is not substantial anymore as the farmers intended to determine the irrigation management individually.

Qualitative research methods were used to collect data on the traditional institution in managing the irrigation water from January 2021 to April 2022. The data was gathered through key informant interviews, Focus Group Discussions (FGD), and a literature review. Key informants for interview were selected for knowledge of the study area, *Adat* Minangkabau and irrigation management of two P3As. Thus, the key informants were selected from local government staff, farmers, and indigenous leaders such as *Penghulu* and *Niniak Mamak* (Adat elders).

Focus Group Discussions (FGD) were conducted to analyze irrigation management in the two P3As and reexamine the traditional knowledge in managing irrigation systems. The detail about FGD is shown in Table 1. The data was also collected by reviewing the important articles published in the scientific literature and governmental reports. The study used narrative analysis to describe the current irrigation management and narrate the traditional knowledge in managing irrigation systems. In addition, the study used narrative analysis to explore in-depth the traditional institution of irrigation management and farmers' experiences of the management.

Table 1. Focus Group Discussion Activities

Description	P3A Karya Mandiri	P3A Jorong Biaro
Date	21-22 August 2021	23-24 August 2021
Place	P3A meeting room	P3A meeting room
Participants	Farmers, respected persons in the community, indigenous leaders, and agricultural department officers	

3. REVIEW OF MINANGKABAU CUSTOM IN WEST SUMATRA

In West Sumatra, the traditional institution has been a part of the Minangkabau community's life even today. The Minangkabau of West Sumatra is widely known as the world's largest matrilineal society (Josselin de Jong 1980; Naim 1979). Despite many changes in the social system of the community, Minangkabau traditional institutions are still going strong and appear to be far from a breakdown. As a part of a matrilineal community, the Minangkabau people manage their natural resources as communal

property under *Penghulu* (clan leader) consent. In the traditional period, the penghulus functioned as protectors of their clan members on the one hand and administered the members in all respects: social cultural, political and economic (Akira, 1978), including managing agricultural land. The Minangkabau social system consists of different levels and units of matrilineal groups, as shown in Figure 1. The largest unit is called *Suku* (clan), and the smallest unit is called *Paruik*. *Suku* is a federation of *Kampung* that is a federation of *Paruik* (Utami and Oue, 2023).

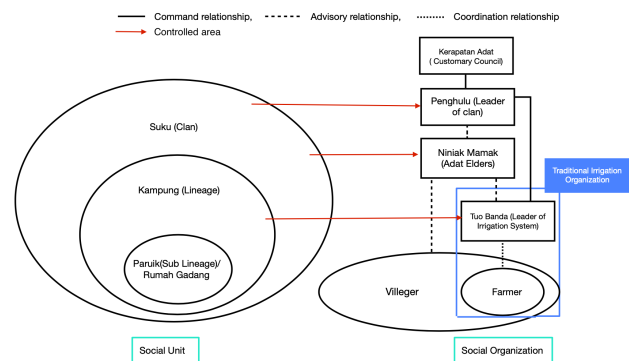


Figure 1. Schematic of Minangkabau social and organization unit

Minangkabau society manages the productive land, such as rice fields communally, known as matrilineal land ownership or *lahan ulayat*. The matrilineal land ownership system is an important traditional institution to ensure the availability of productive land for the community as well as to protect the sustainability of land for the next generation. Nevertheless, the landownership of individual rights is also recognized in the community. There are three basic types of land tenure: (1) land held by individuals under individual ownership rights, (2) land held by descent groups of varying size and generational depth (Josselin de Jong 1960) under communal ownership rights, and (3) land held by local groups, namely village communities (Evers, 1975).

For Minangkabau people, forests, streams, and rice fields belong to communal property (*ulayat kaum*) organized by *Penghulu* (clan leader). The *ulayat kaum* (it is called "*ulayat*" in this paper) is distributed among the clan member of the village and then administrated by *Penghulu* (Holleman, 1981). Additionally, the *ulayat* is inherited from the ancestors and utilized by the present generation but should be conserved for future generations. The rights to use the *ulayat* (*hak ulayat*) can be vested in a matrilineage (*kaum*) or minor lineage (*perut*) (Oki, 1984). Communal land rights give the highest possible claim to landownership (Saleh 1972), and communal land cannot be sold except for explicitly stated specific reasons. According to *Adat* (customary law), communal land

should not be divided until when after five generations, a fission of the original lineage into new autonomous units takes place.

In addition, the rice field (*sawah*) is a part of the Minangkabau spatial arrangement as rice farming is an important agricultural activity for Minangkabau society. Despite economic reasons, rice farming is conserved to sustain the *adat*. In addition, the community inherited an indigenous knowledge in determining the agricultural schedule, which is stated in below proverb: *Ka ladang di hulu tahun, ka sawah di pangka musim, hasia banyak karano jariah, hasia buliah karano pandai, dibuek banda baliku, tibo di bukk digali, tibo di batu dipahek, tibo di batang di kabuang* (Dryland farming is in the beginning of the year, rice farming is at the end of the year, abundant yield because of hard work, optimal yield because of being smart. A winding water canal was made, the hill was dug, the stone was chiseled, and the trunk was split).

The proverb above implies that rice planting season starts at the end of the year, and dryland farming starts at the beginning of the year. Additionally, irrigation construction starts by building a canal (*banda*) and a weir (*kapalo banda*) before constructing a rice field. Based on *adat*, the community develops a rice field based on the actual water supply provided by a *kapalo banda*. As a result, many irrigation systems developed incrementally, starting from a small rice field area and then expanding the area if the water supply was sufficient. When the community expanded the systems, they must first get permission from *Penghulu* under *mufakat* from all clan members. This system is one of the *adat* to protect productive land (Utami and Hiroki, 2021).

The Minangkabau community recognized the spatial pattern of agricultural land as a part of their village (*nagari*). According to *Tambo* (historical topography), the pre-Islamic *nagari* needed at a minimum the following: *basawah baladang, bataratak bapanyabuangan, badusun bagalangang, baitiak baayam, baanak bakamanaka, n bakabau bakambiang, batabek taman-taman, bakorong bakampuang, bacupak bagantang, baradat balimbago, bataratak bakapalo koto* (wet fields and dry fields, settlements and cockpits, neighbourhoods and open fields, ducks and chickens, children and nieces, water buffalo and goats, fishponds and gardens, neighbourhoods and villages customs, rules and institutions, clearings and water sources). This proverb explains that the importance of agriculture for the Minangkabau people is clear, as is the distinction between wet agriculture and dry agriculture (Ambler, 1988).

Water and culture are strongly interlinked in indigenous water management, especially in traditional irrigation

systems in West Sumatra. Traditional irrigation systems in West Sumatra are based on local ecological knowledge and depend on the traditional institution in which value, belief, and experience accumulated over time have been passed from generation to generation. In addition, the traditional institution plays a crucial role in conserving water resources, especially in ensuring irrigation water distribution for each system. This paper focuses on the traditional institution in irrigation management, which are matrilineal land ownership systems and decision-making and conflict resolution institutions. The Minangkabau custom classifies land as private land and common land (Beckmann, 1979). Private land is the new land that a man or a woman acquires through purchase or reclamation (Oki, 1977). On the other hand, common land (*ulayat kaum*) is always owned under communal property rights. In addition, communal land rights (*hak ulayat*) can be vested in a matrilineage (*kaum*) or minor lineage (*perut*), in a clan (*suku*), or in a village (*nagari*). For instance, rice field or *sawah* has been a part of communal land and spatial arrangement in each *nagari* of the Minangkabau people, as mentioned above. *Sawah* is an older inheritance bequeathed jointly from female predecessors (mothers and aunts) to female successors (daughters and nieces) within a lineage. Thus, every farmer must ask for *Penghulu* approval to cultivate the *sawah*. Then, the *sawah* has to be returned to the owner (community) when cultivation is finished.

Sawah is allocated to their daughters by the principle of representation. Although the *sawah* is owned by the women, the supervision of the land is exercised by the *mamak*. Ideally, decisions regarding land are taken in joint consultation among the members of the family until a consensus is reached, and the *mamak* can do nothing with it formally without the consent of all the female owners. The matrilineal land ownership system of Minangkabau is an important Minangkabau customary law. Despite securing agricultural land, the matrilineal land ownership system created strong kinship relationships among the community that can produce strong social capital. For instance, members of the clan share the same clan's name, a sense of belonging to a single family, and they are known each other well and regularly interact. The people within one *suku* possessed the most relevance in everyday life, as the members of a *suku* usually formed an economic unit such as rice production, and they lived close together. *Penghulu suku* acts as a manager to mobilize the labor as well as a mediator to solve conflicts. Thus, the community can do collective work efficiently and ensure the benefit are shared equally among community members.

4. RESULTS AND DISCUSSIONS

4.1. Traditional institution in irrigation management: lesson learn from two P3A in West Sumatra

In the verdant landscapes of rural Indonesia, two contrasting models of irrigation management have emerged, each intricately interlinked with the historical and cultural fabric of their respective communities. In this discussion, we explore the narratives of P3A Karya Mandiri and P3A Jorong Biaro, two irrigation management systems that stand as living testaments to the power of tradition, consensus, and governance in shaping the sustenance of agriculture.

P3A Karya Mandiri

P3A Karya mandiri was established and initiated by farmers and indigenous leaders under *mufakat* or consensus in 1994. The system has been managed by *Panitia Urang Bawasah*, or an irrigation committee that consists of indigenous leaders and farmers in the area. Before the P3A was established in this area, the irrigation management was managed by some people (consisting of 10-15 people) under one traditional group. This group's responsibility was to drain water into the rice field from the river. They used bamboo to construct the weir in the river to flow the water into each rice field. In 1988, there were two consecutive crop failures due to a lack of water drains to rice fields as the weir construction was damaged due to flood. The weir was not strong enough to divert the water to the rice field. Then *Penghulu*, *Niniak Mamak* and farmers held a meeting to rebuild the weir.

One person (Datuak Katiak Nan Basa) initiated to build permanent weir. He is a *Penghulu* as well as a religious scholar in the community. He invited some people to join his group. Finally, eight persons joined the group. They called this group "Panitia urang basawah". This group independently built the weir without government help. They borrow money from the community to build the weir. At that time, 60 gold coins (around IDR. 1.000.000.000) were borrowed to build the weir. The design of the weir was created by Datuak Katiak Nan Basa himself without any help from the local government. Then, the group construct the weir by themselves (*gotong royong*) in 6 months. After the weir was built, *Panitia Urang Bawasah* made a contract with farmers. The farmers have to give 20% of the harvested rice to *Panitia Urang Basawah* (the harvested rice was to pay debts to the community and for irrigation maintenance fees). After the contracts finish, the farmers ask the group to continue to manage the irrigation system. Now, the farmers have to pay 1/7 of their harvested rice to the group for irrigation maintenance fees.

In terms of social background, rice farming activities are still managed under Minangkabau customary law in which rice fields belong to communal land. The distribution of rice fields is obtained through a clan leader. Thus, the social capital of farmers is still strong, and they respect the indigenous leader very much.

Communal land also can ensure the availability of irrigation water. In the traditional period, the *nagari* could claim a certain area, including the natural resources, and govern the area according to *adat*, so the acquiring natural resources, such as water in the river for irrigation located in different *nagari* must be acknowledged by the *Penghulu* and there was compensation given to the *nagari* in order to ensure the availability of water for rice field. As in P3A Karya Mandiri, the irrigation water resource is from another upstream village that manages by another clan, so P3A Karya Mandiri has to compensate the other clan to get irrigation water by giving some amount of rice to the clan for each planting season.

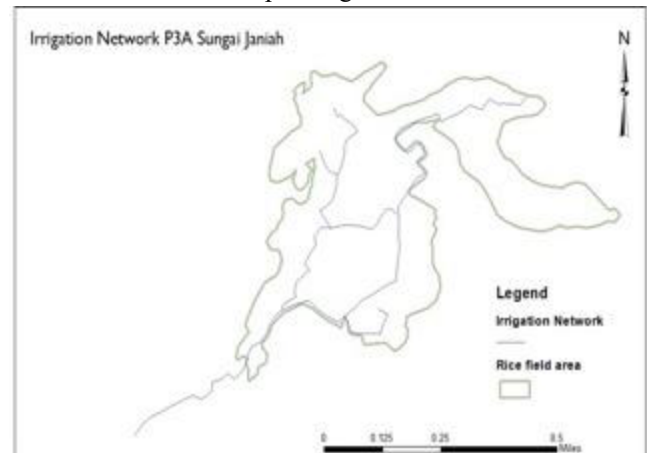


Figure 2. Map of P3A Karya Mandiri area

During field observation in August, it was found that the water supply in the river had been decreasing due to the long dry season. As the irrigation management institution in the area was highly linked to the local land tenure system, the P3A Karya Mandiri leader did a *mufakat* with a leader in the upstream system before starting planting. As the two systems have been accommodating water sharing since a long time ago and P3A Karya Mandiri has "rights" over water in the river, the two systems agreed to arrange a planting schedule. According to *adat* rules, the top system has priority to get water and planting the rice first. Thus, in August, the top system started to plan rice. After the top system did not need much water, the P3A Karya Mandiri started planting rice (about one month apart). P3A Karya Mandiri does not attempt to plant rice first; they acknowledge that de facto water rights lie with systems located higher in the stream.

Mufakat is a fundamental principle for Minangkabau people in the decision-making process in all daily aspects.

This principle is contained in this proverb; "*Bulek aie dek pambuluh - bulek kato dek mupakat Aie batitisan batuang - bana batatasan urang*". It refers to the requirement that decisions should be made in the process of deliberations leading to consensus; only when 'one word', *sakato*, or consensus, *mufakat* is reached by all those involved in the problems to be solved is there a true decision (Benda-Backman, 1984). Thus, in determining farming activities, including irrigation management, farmers have been using *mufakat* for a long time ago.

In P3A Karya Mandiri, irrigation management the agronomical and irrigation management have been managed and determined under *mufakat* by all farmers in the area. Based on the field observation, this decision-making system can encourage farmers' participation in irrigation management as the decision-making involves all farmers in the area. As a part of Minangkabau society, farmers have the right to voice their opinion because farmers respect *mufakat* values highly and consider them as the implementation of democracy.

P3A Jorong Biaro

P3A Jorong Biaro (Figure 3) was established and initiated by the local government in 1992 without any *Mufakat* or consensus by all farmers in the area. In terms of social background, rice farming activities have been transformed from collective management into individual management as the role of the indigenous leader has been excluded from agricultural activities. Thus, the system is experiencing dysfunction in managing the irrigation system. The rice field has been transformed from communal land into private land. Thus, the social capital in this area is not strong anymore as the farmers intended to determine the irrigation management individually.

Before P3A Jorong Biaro was established, the irrigation management was managed by *Urang Subuah Bawasah*, a group of people responsible for managing day-to-day technical irrigation systems such as water distribution and irrigation maintenance. In 1992, the local government invited three leaders of farmers' groups and a few farmers, who were served by a common weir, to a meeting to initiate the P3A. In this meeting, the local government selected one person to be a leader of P3A Jorong Biaro without *mufakat* or consensus by all farmers in the area. According to personal communications with key informants, P3A Jorong Biaro has been experiencing dysfunction in managing the irrigation system since its formation.

Contrary to P3A Karya Mandiri, neither the traditional institution nor modern institution has been dysfunctional in managing the irrigation system. As a result, it was observed that there was low participation from farmers regarding

irrigation activities, especially irrigation facilities maintenance. Farmers who are served by the same secondary canal managed the canal together to maintain the canal. However, there are no common rules in use in the whole system.

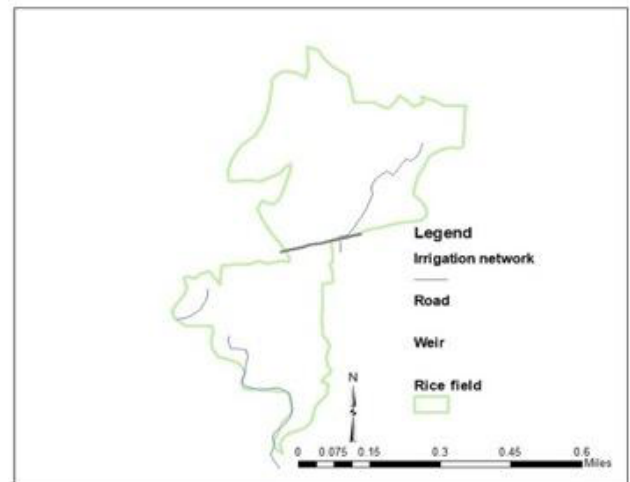


Fig. 3. Map of P3A Jorong Biaro area

In addition, *gotong royong*, or communal work activities, has been decreasing. Based on traditional rules, the *gotong royong* activity has an important function in determining ownership of irrigation facilities. In P3A Jorong Biaro cases, farmers whose rice field is close to the weir or farmers of the upper area joined *gotong royong* together to maintain the weir. As a result, during the very dry condition, the farmers in the upper area took irrigation water without considering farmers in the downstream system, as the upper farmers felt that the weir belonged to them. Thus, during field observation in August 2022, it was found that many rice fields experienced crop failure due to a lack of irrigation water supply to their rice field. Based on a personal interview with farmers, there has been decreasing in water supply in the river due to the long dry season (starting from June 2022). However, the farmers in the system, both the upper area and the down area, started to plant rice without considering the water supply. In addition, no institution nor P3A managed the planting schedule for farmers to distribute irrigation water under low water availability.

Different from P3A Karya Mandiri, *mufakat* in decision-making has almost disappeared in P3A Jorong Biaro. During the study, it was found that the practices of *Adat* have been decreasing in these recent years. In addition, the community's minds and beliefs are changing in response to various pressures, such as economic growth, population growth, the introduction of market values, and change in occupation. These pressures are resulting on declining in *mufakat* practices in farmers' communities. As a result, farmers intended to do individual management rather than collective management. This condition is

resulting conflicts over water, especially during the very dry condition. During the field research, it was found that farmers in the down area intended to start planting rice at the beginning dry season. In addition, the farmers in the upper area were also starting the planting activities. Considering this situation, most of the rice fields were experiencing water stress as the water supply in the river was not enough to serve all rice fields. This condition could be avoided if farmers do *mufakat* to re-arrange the planting schedule, as implemented in P3A Karya Mandiri.

4.2. Re-implementing traditional knowledge to improve irrigation management in West Sumatera

One big challenge for farmers in irrigation management is distributing water fairly to each rice field, especially during very dry conditions. Fairness in water distribution must be organized by an effective institution. Some studies argue that an effective institution can be achieved through local and traditional knowledge (Uphoff, 1992; Aggarwal, 2008; Mowo et al., 2013) as the knowledge is bounded among the users. In terms of irrigation systems, institutional arrangements are more successful where the users are a socially cohesive group (Uphoff, 1992).

P3A Karya Mandiri has proven to have an effective institution in which the institution is based on traditional knowledge, namely matrilineal land ownership and *mufakat* principle. The matrilineal landownership allows the fairness of water distribution among the systems and could guarantee irrigation water even in the dry season. In addition, the *mufakat* principle in determining irrigation management created high participation from farmers in irrigation activities as the *mufakat* must involve those concerned. As an egalitarian community, the farmers respect *mufakat* highly in decision-making. Thus, in managing the natural resources, in general, both land distribution and utilization of the resource are determined under *mufakat*. Based on some studies, *mufakat* system is a good warranty against the excessive fragmentation of productive land; it also reduces the chances of any sudden transformation of the agricultural system (Michon, 1986; Benda Backman, 1984; Utami and Hiroki, 2022). Moreover, the deliberation process in *mufakat* gives a fair solution to managing natural resources and conflict resolution. Once *mufakat* is concluded, all farmers must agree with the results (Utami and Hiroki, 2021).

The matrilineal landownership system (*ulayat*) is one of the fundamental solutions for fairness in water distribution. Based on the research results, in P3A Karya Mandiri area, the rice field has been managed by a matrilineal land ownership system. Despite securing agricultural land, the matrilineal land ownership system created strong kinship relationships among the community that can produce

strong social capital. Thus, the community can do collective work efficiently and ensure the benefit are shared equally by community members. In addition, communal land also can ensure the availability of irrigation water. In P3A Karya Mandiri, the irrigation water resources (irrigation weir) are located in another upstream system that manages by another clan. Thus P3A Karya Mandiri has to compensate the other clan to get irrigation water by giving some amount of rice to the upper system. Due to this system, the P3A Karya Mandiri could secure an irrigation water supply even in dry conditions. According to customary law, the upper system has first rights to water, while down system has only subordinate rights to irrigation water. Thus, in very dry conditions, the top system has priority to get water and plant the rice first. After the top area does not need water, the immediate lower system can start planting rice. Until at some point in the down system area, no water is left for systems further down the system. Farmers below that point do not attempt to plant rice; they acknowledge that de facto water rights lie with systems higher in the stream. Thus, often the down system farmers plant another crop such as corn, tomato other vegetable plants.

5. CONCLUSION

Traditional institution represents successful adaptations to local environments as it has adapted and evolved based on local specificities. Notably, in irrigation management, the traditional institution has proven itself over the course of centuries to be environmentally sustainable, productively viable, and manageable. The Minangkabau community in West Sumatra managed the natural resources collectively under customary law, such as in irrigation water management. The community has practiced collective environmental wisdom and ethics based on cultural practices, known as *adat* (custom). This study examined the role of the traditional institution in irrigation management as well as their potential to accomplish the sustainability of irrigation management in West Sumatra. By comparing two P3As, this research found a fundamental traditional institution that can be integrated into the current irrigation system: the matrilineal land ownership system and decision-making institution called *mufakat* (deliberation to reach consensus). This two traditional knowledge ensure the sustainability of irrigation institutions in West Sumatra.

Statements and Declarations

- The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.
- The authors declare that no funds, grants, or other support were received during the preparation of this

manuscript and there has been no significant financial support for this work that could have influenced its outcome.

- The authors did not receive supports for any organization for the submitted work.
- The authors declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere.
- The authors know of no conflicts of interest associated with this publication.
- The authors confirm that the manuscript has been read and approved for submission by all the named authors.

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