MANAGEMENT OF THE TRADITIONAL IRRIGATION SYSTEM TOWARD THE CLIMATE CHANGE: Case of Rice farming development in Bali Province-Indonesia

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Indonesia is one of the vulnerable countries to climate change in the relation to rice farming. This might influence to rice production and food security in the country. The availability of irrigation water is significantly very important for rice productivity as a main staple food for the people in Asia. Irrigation management should be technically and socially needed to control rice field cultivation along the year. In case of Bali province in Indonesia, the irrigation management along the river and at the farming level is run by government and local farmers groups called *subak* as a traditional irrigation system. The objectives of this study are to describe traditional irrigation system in the irrigation and rice farming development, and to explain the mitigation efforts conducted by *subak* to solve the irrigation water problem.

The study pointed out that *subak* manages irrigation under the local wisdom called *tri hita karana* (three harmonious relationships among the farmers with the God, with the environment, and with the other farmers and outsider persons). It has internal rules to manage the water distribution and allocation, operation and maintenance of irrigation facilities, fund raising and ritual activities. Mitigation efforts done by *subak*s are changing of planting schedule, rotation of cropping pattern, selecting of crops, improving of agricultural technologies, and performing of ritual activities. These were conducted simultaneously by farmers as *subak* members based on the climate information provided by government. It is needed to make a digitalized map for the forest area which is being a water catchment area as a source of water for *subak*. Besides, government should provide periodical information about the water balance and the plan of water allocation for irrigation and non-irrigation and improve the environmental upstream area. Besides, it must be also provided digitalized information about the climate forecast, water availability along the river and each weir/dam.

Keywords: *Subak, climate change, irrigation, digitalized map, and ritual activities*

INTRODUCTION

Commonly, economic development is addressed to promote productivity of natural and human resources and to provide more opportunities for the economic actors at the every levels of producer and consumers. Agricultural development constitutes a main sector in economic development for the developing countries which generates food, employment and income especially for rural development (Acharya, 2006; Anríquez, and Kostas, 2007; Holcer, et al., 2013). Most of population's food is still dependent on the production from the small holder farmers in the developing countries (Stanton, 2000). Several researches have pointed out that the rural people in the developing countries are still poor due to low productivity (Ravallion et al., 2007; Eteng, 2005). They also have unskilled labor to work on agricultural works and unlimited access to information, technology, capital, and market (Anriquez and Lopez, 2007). In the rural areas, there are several categories of rural people income gained from crop production, livestock

production, and other non-agricultural wage employment. it is very important for the government to make the improved approaches and rural and agricultural development to reduce rural poverty and unequal disparities of income. One of the disparities which should be overcome is a gap (inequality) of income among the rural people including urban people (Rao, 2009; Bezu, & Barrett, 2012). Inequality of income of rural people contributes to rural poor and might hinder the rural economic development. The improvement of agricultural development might not be separated to industries developed in rural area and urban area, as well.

In the relation to agricultural development, Indonesia is one of the vulnerable countries to climate change in the relation to rice farming. This might influence to rice production and food security in the country. The availability of irrigation water is significantly very important for rice productivity as a main staple food for the people in Asia. Irrigation management should be technically and socially needed to control rice field cultivation along the year. In case of Bali province in Indonesia, the irrigation management along the river and at the farming level is run by government and local farmers groups called *subak* as a traditional irrigation system. The objectives of this study are to describe traditional irrigation system in the irrigation and rice farming development, and to explain the mitigation efforts conducted by *subak* to solve the irrigation water problem.

Implementation of agricultural development, particularly on rice farming has become increased in order to increase productivity of land and crop. Intensification on the rice field has been conducted through the application of new technologies or good agricultural practices. Selection of new high yield varieties has given significant impact on land and crop productivity. This has also been enriched by the uses of recommended fertilizers and irrigation water and the application of integrated pest and diseases management. In Bali province-Indonesia, management of rice field farming has been done under the farmers' organization called *subak*. It is a widely known that 'traditional' irrigation management institution for rice cultivation in Bali has been established since thousands ago (Roth, 2011; Sedana, 2012; and Roth and Sedana, 2015). The existence of *subak*(s), therefore, has still significantly played a great role in supporting agricultural development on rice field (Sedana, et al, 2013). Aside from this, cultural aspect on *subak* has become a buffer for Balinese culture as an interesting factor for supporting tourism development.

As an international tourism destination, the growth of economic development in Bali province has brought about some problems on the *subak*, such as competition of water uses, and land (rice field) conversion. Competition in using water has been felt by *subak* since the irrigation water source was also extracted by the other sectors for domestic water and industry uses. Water availability has become scarce for irrigation, thus cropping intensity is decreased. The consequence is production of rice becomes lower and being the threat on food security program of government. Land conversion is also difficult to control as the high need of land for housing, physical infrastructure and industry in line with economic development.

Aside from this, the youth in Bali seemingly might not have good interest any more to work on rice farming with some reasons, such as a relative low income, high risk, income gained after harvest (take relative long time) with the high risk of harvest failure. Cumulative reasons found in rice farming have pushed farmers and the youth strive to work on non-agriculture job in urban area as a daily worker and others. Even, some of farmers as members of *subak* should sell their own rice field since the income gained is relatively low, thus also make land conversion. Higher rate of land conversion will threat the existence of *subak* as shown in Denpasar city, in which three *subak*s was disappeared during a decade of 1993-2003 (Sedana, et al. 2003). Within

five years (2011-2016), land (rice field) conversion happened in Bali province is about 370 ha/year (see Table 1). This condition should be controlled by government and farmers and other stakeholders including tourism actors. The most area of land conversion was happened in the regency of Tabanan. The construction of houses, offices, road and other facilities have contributed to this land conversion aside from socio-economic condition of farmers and their family. This paper is addressed to describe farming system under *subak* management, and to formulate agribusiness works conducted by *subak* to sustain traditional irrigation system.

Table 1
Areas of rice fields in Bali province based on the regencies

No	Regency	Year						Average of decrease	
		2011	2012	2013	2014	2015	2016	ha	%
1	Buleleng	10,992	11,039	10,904	10,798	10,798	10,791	40.2	0.37
2	Jembrana	6,836	6,836	6,811	6,789	6,775	6,757	15.8	0.23
3	Tabanan	22,435	22,388	22,184	21,962	21,714	21,642	158.6	0.71
4	Badung	10,243	10,195	10,144	9,984	10,006	9,975.7	53.46	0.52
5	Denpasar	2,597	2,519	2,509	2,506	2,479	2,444	30.6	1.18
6	Gianyar	14,732	14,729	14,706	14,575	4,420	14,420	62.4	0.42
7	Bangli	2,910	2,910	2,910	2,910	2,886	2,876	6.8	0.23
8	Klungkung	3,845	3,843	3,843	3,843	3,843	3,843	0.3	0.01
9	Karangasem	7,154	7,166	7,157	7,156	7.151	7,142	2.4	0.03
10	Total	81,744	81,625	81,165	80,542	80,063	79.891.20	370.56	0.45

Source: Office of Agriculture, Bali Province (2017)

II. SUBAS AS THE TRADITIONAL IRRIGATION SYSTEM

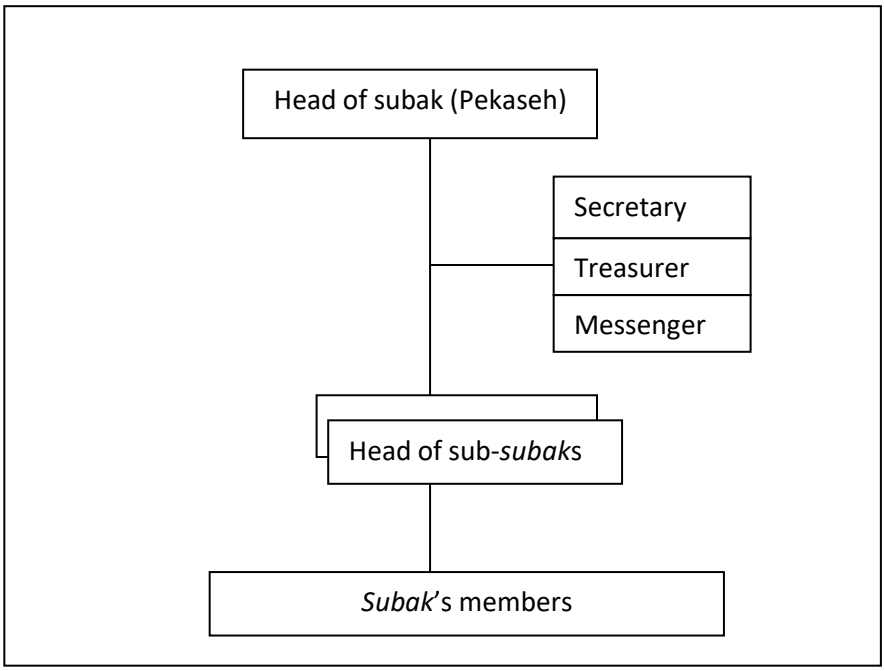
2.1. Subak system

Sedana (2017) cited that *subak* is the traditional irrigation system which has been managed by the water user association (farmers) in Bali since more than a thousand year ago. This has some specific characteristics in the relation to irrigation, agricultural and cultural aspects. *Subak* is not controlled and managed by the village administration due to it has independent management because of its autonomy. It has the internal rules and regulations that the members are subject to comply. In term of cultural aspect, *subak* is strongly related to the socio-cultural activities under the Balinese Hindu society life. The main affiliating factors of *subak*s' members are irrigation water and temple within *subak* area and its surrounding. In general, *subak* has five functions, namely: (i) to equitably distribute and allocate irrigation water to the members, (ii) to conduct operation and maintenance of irrigation system, (iii) to create fund raising; (iv) to manage conflicts among members, and (v) to perform ritual activities. The latest function--ritual activity is done based on the phases of rice growth starting from getting water, land preparation, seedlings, transplanting till harvesting. For the *subak*, ritual ceremony is a power for farming and irrigation activities on rice field.

Management of *subak* is very simple which is chaired by a head of *subak*, called pekaseh elected democratically by all members. *Pekaseh* is assisted by secretary and treasurer in

implementing administration aspects. In the larger size of *subak*, there might be elected a head of sub-*subak* coordinating the activities in each sub-*subak*. The organizational structure of *subak* is show in Figure 1.

Figure 1
Organizational structure of *subak*



In the implementation of agricultural development program, government agents always coordinate with *pekaseh* in order to make easier and faster for disseminating innovation. The application of new practices on rice farming will be effective through *subak* system. *Subak* will make a decision under the *subak* meeting in the relation to selection of variety, cropping pattern, planting schedule and others. Introduction of commercial farm has been developed by the extension agents in order that farmers might have higher income gained from rice farming. The higher income could be an incentive for farmers to intensively work on their rice filed. Thus, land conversion might be control or minimized.

PROBLEMS AND THREATS OF *SUBAK* AND THE ALTERNATIVE SOLUTIONS

The main physical problems and threats encountered by *subak* as a result of climate change are (i) scarcity of irrigation water, (ii) water use competition, (iii) pest and diseases attack and (iv) land conversion. Scarcity of water is contributed by the poor management in the upstream area or hilly area. Deforestation and changes of land use in the hilly area by the people have made the degraded functions of forest and soil. The forest might not function to storage of water that could be a source of water, especially during the dry season. Even, this could make a flood and landslide during rainy season. Most of water coming from the rain would flow directly to the river and sea without any infiltration to the soil. Change of land use from the trees cultivation into horticultural cultivation has affected to the soil physical and chemical structure.

The farmers prefer to cultivate the land for planting cash crops (including horticulture) in order that to gain more money rather than perennial crops. The effect of this situation is water availability at the source level (river) becomes decreased in the dry season. Meanwhile, farmers have a plan to plant rice that needs much more water.

Concerning these problems, *subak* takes an internally solution by conducting the proper cropping patterns, such as rice-rice-secondary crops or rice-secondary crops-rice, or rice-secondary crops-secondary crops. The secondary crops commonly planted by *subak* are maize, mungbean, soybean and the likes. Water irrigation management under the *subak* system would be in the forms of staggering and rotation. In the staggering way, *subak* will arrange the members to have land cultivation alternately. Some of farmers would firstly use the irrigation water for the land cultivation (by using tractor or cattle) until the process of rice transplanting. The other members then have turn to use water for the land cultivation. In this way, the planting schedule for rice within *subak* might take a longer period due to the water scarcity. In the rotation way, *subak* might make a decision to define the cropping patterns among the members of *subak* as mentioned above. Cropping patterns would be based on the sub-*subak*s area. For instance, one sub-*subak* would be plant rice again after the harvesting rice (at the second planting) in this year, while the other sub-*subak*s would be plant secondary crops. In the following year, however, the first sub-*subak* would have turn to plant secondary crops. In some cases, *subak* allow farmers to have water borrowing whenever they need water. It must be agreed between the farmers.

Another solution that would be done is to make a digitalized map for the forest area which is being a water catchment area as a source of water for *subak*. This might have a function to identify the condition of forest area regarding the tress population, deforestation, changes of tress or crops, etc. The government could use this map to take alternative and anticipative efforts for controlling the use of forest and water supply and availability for *subak*. Information about the digitalized water balance along a year is also important to provide by government to *subak*s. Calculation of water balance should consider some aspects such as water volume, infiltration, evaporation, water requirement of rice and other crops on the rice field, and other components. Government must also provide digitalized information about the climate forecast, water availability along the river and each weir/dam for the *subak*s.

Water use competition among the *subak*s and non-*subak*s, such as industries, water domestic users has been more complex. The demand of water for domestic use and industries has become higher every year. Usually, *subak* will have big problem if the industries need water which is coming from the same source. The solution for this problem should be clearly understood by the competitors. Government should have an updated data or information about water allocation for the irrigation, water domestic, industries and other sectors.

Pest and disease attacks on the crops planted by farmers are usually caused by the uncertain climate (rain and drought). Open circumstance of rice planting is prune for the risk and failure of harvesting. Pest and disease always threaten farmers in their farming activities. It is needed to conduct intensive extension and training for farmers in order to control the pest and disease. Sustainable integrated pest and disease management should be introduced to farmers (*subak*'s members). *Subak* should be recommended to have good agricultural practices for rice farming and secondary crops farming, such as by using proper seeds, fertilizer and pesticide. In specific case, *subak* conducts ritual activities for controlling the pest and disease attacks.

Land (rice field) conversion has increased due to the construction of infrastructures such as building, main road and others. Relating to water irrigation needed, this conversion is actually making the water excess for farmers due the rice field already converted. The problem, however,

is in the ecological aspect. The flood in the city would be threatened after the conversion of rice field in the city area. The air environment is also affected since there is no crop after the rice field changed to building. The solution for this, government should have the spatial regulations and the law enforcement to this regulation. The spatial map should be disseminated by government to the community in order that they know and understand what they must do and must not do for the rice filed regarding the land conversion.

CONCLUSION

Subak as a traditional irrigation system manages water under the local wisdom called *tri hita karana*. Subak has internal rules to manage the water distribution and allocation, operation and maintenance of irrigation facilities, fund raising and ritual activities. Subak has mitigation efforts to solve the problems by implementing a flexible planting schedule, rotation of cropping pattern, selecting of crops, improving of agricultural technologies, and performing of ritual activities. These were conducted simultaneously by farmers as *subak* members based on the climate information provided by government. Besides, government should make a digitalized map for the forest area which is being a water catchment area as a source of water for *subak*. Also, government should provide periodical information about the water balance and the plan of water allocation for irrigation and non-irrigation and improve the environmental upstream area. Land conversion should be control by making the spatial map and regulations and its law enforcement.

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