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The Role of Terraced Paddy Fields and Its Critical Issues in Sustaining a Mountainous Tropical Monsoon Rural Community: Case Study of Malasari Village, Bogor Regency, Indonesia

Kenta Tsuchiya[1*], Ernan Rustiadi[2,3], Darmawan[3] & Shinya Funakawa[1]

[1]Graduate School of Global Environmental Studies, Kyoto University, Yoshida-honmachi, Sakyo-ku, Kyoto 606-8501 Japan; [2]Center for Regional systems Analysis, Planning and Development, IPB University, Jalan Meranti, IPB Dramaga Campus, Bogor 16680, Indonesia; [3]Department of Soil Science and Land Resources, Faculty of Agriculture, IPB University, Jalan Meranti, IPB Dramaga Campus, Bogor 16680, Indonesia;
[*]Corresponding author. *e-mail*: tsuchiya.1991.16@gmail.com
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ABSTRACT

Terraced paddy fields play an important role not only in the food production function, but also in flooding control, water source recharge, and soil erosion and landslide prevention in mountainous area. Abandonment has been occurring in many countries due to natural condition climate, low-productive, less economic condition, depopulation, aging, and poor work efficiency. However, the terraced fields in Malasari village, Bogor Regency are relatively sustained and constantly maintained by traditional local farmers. Therefore, this study aims to seek keys to how to maintain of the terraced paddy fields by local farmers in Malasari village. The survey was conducted from October 2019 to January 2020 on Malasari village (6°40'S and 106°31'E) by using primary and secondary data with a sample of 28 households. Questionnaire survey was conducted to elicit primary data on farmer's basic information. Verification of land cover in Malasari village was carried out by visual interpretation land cover in images obtained from drone image in 2019. The terraced paddy fields have been maintained by local farmers contentiously. Two factors are discovered maintained the terraced paddy fields, namely: (1) the local wisdom technique is an act that has direct influences on the physical structure of terraced paddy fields for maintaining, especially land management which is plowing and making levee are playing an important role, and (2) social capital is an act that has indirect influences on the terraced paddy fields. These factors interact with each other to maintain the terraced paddy fields.

Keywords: local wisdom and knowledge, social capital, soil and water management, sustainability, terraced paddy fields

INTRODUCTION

Most of East, Southeast, and South Asia regions are often collectively called Monsoon Asia. The Monsoon Asia has defined that annual precipitation more than 1000mm temperate and heavy rainfall region (Masumoto, 2004). The landmass of Monsoon Asia is about 14% of the world, but it is an overcrowding region where 54% of the world's population lives. Humid Monsoon Asia has abundant water resources. The rice cultivation is adapted to the natural conditions of Monsoon Asia. The island of Java in Indonesia, as a part of Monsoon Asia, is highly overcrowding. Java Island one of the hugest population density islands in the world. Java (128,300 km^2) is only about 7% of the total area of Indonesia (1.9 million km^2), but about 60% of the total population lives, and cultivation is progressing (Harashina *et al.*, 2002).

According to the World Bank (2019) data, the population in Indonesia is 270 million in 2019. The population growth are still increasing. As the population grows, demand for food accordingly, at least agricultural production must be increased following the rate of population growth. The main staple food is rice in Indonesia. About 60% of the rice produced in the country comes from the fertile, volcanic ash soils of Java Island (Amien *et al.*, 1996). Bogor Regency which is located in the western part of Java Island is one of the administrative regencies in Indonesia. Those who settle in the regency are called *Sunda*, who is one of the major ethnic groups of Indonesia and they have conversations in Sundanese. The most dominance ethnic groups are *Sunda* in Malasari village. The *Sunda* people mostly work in agriculture, which is a major industry in this area.

As the main island with the most populous population in Indonesia, traditional agricultural activities in Java Island are spread up to the peaks of the mountains and play an important role in the lives of mountainous rural areas. Terraced paddy fields are one of the most important land-use systems for agricultural products and greatly influence regional landscapes in mountainous areas (Maltby *et al.*, 1999).

In many parts of Indonesia, most cultivated land is used for growing low-land wet rice (cf. Pelzer, 1948; Gertz, 1963; Puspita *et al.*, 2005; Sastrapradja & Widjaja, 2010; Iskandar & Iskandar, 2011; Nugroho *et al.,* 2017). Wet rice farming is a common practice in Malasari village as not only does it provide food income but also social status (Iskandar *et al.*, 2018). Adaptation to climate change in rice production systems is complex and must involve a range of environmental, social and economic factors (Suzanne *et al.*, 2009).

However, urbanization is one of the most an issue that has been occurred in Java island Indonesia. In Java, Indonesia, farmers lose some 200 km^2 of cropland a year to industry and human settlements (Sundquist, 2007). With the continued increase in urbanization, the loss of agricultural lands, especially paddy lands, is predicted to increase rapidly in the next few years (Suzanne *et al.*, 2009).

Terraced paddy fields are one of the most important land-use systems for agricultural products and greatly influence regional landscapes in mountainous areas (Maltby *et al.*, 1999). The terraced paddy fields play an important role not only in the food production function, but also in flooding control, water source recharge, and soil erosion and landslide prevention. In general, the terraced fields are low productivity due to their small area approximately 0.4 ha and the difficulty of using machinery on the plots.

The hilly and mountainous area is natural, economically, and socially disadvantaged compared with the flatland. However, there strongly social capital in this area. Characteristics of social capital such as "trust", "norm", "network" that can enhance social efficiency by activating the cooperative behavior of people (Putnam *et al.*, 1993). Social capital plays an important role in natural resources sustainability. Social capital is an important resource for agricultural cooperatives (Sedana *et al.*, 2014). It seems that the utilization of rural social capital cannot be ignored in the hilly and mountainous areas (Tanoi, 2007).

In general, reported that is difficult to sustain terraced paddy fields. In mountain areas, soil erosion is one of the most pressing environmental problems affecting soil fertility, water availability, and farmland productivity (Posthumus & Stroosnijder, 2010; Montgomery, 2007). Abandonment has been occurring in many prolonged previously labor-intensive but low-productive cultivated rice fields (Arnáez *et al.*, 2015). Improper handling can cause various disasters. Uncontrolled land use/land cover changes can cause environmental problems and anthropogenic events disasters such as floods and landslides (Pravitasari *et al.*, 2018).

These disadvantages have undermined the career agriculture of the next generation of farmers, and agricultural land resources are deteriorating in hills and mountains. On the other hand, the terraced fields in Malasari village, Bogor regency are relatively sustained and

constantly maintained by traditional local farmers (Figure 1). Consequently, terracing serves as a key technology for soil and water conservation and suitable land management (Shrestra *et al.*, 2004; Cao *et al.*, 2007).

This study aims to: (1) analyze land cover of terraced paddy fields, (2) analyze technical local wisdom in maintaining terraced paddy fields, and (3) analyze the rule of social capital / local customary and terraced paddy production system on maintaining sustainability.

Sustainable land management is important in the rural mountainous area. Adaptation to climate change in rice production systems is complex and must involve a range of environmental, social, and economic factors (Suzanne *et al.*, 2009). It must also involve local knowledge and technological factors such as the application of coping sustainable strategies. Nevertheless, farmers have developed routines and strategies to cope with uncertainties and continuously create more resistant and resilient production systems (Suzanne *et al.*, 2009).

Figure 1. Terraced paddy fields in Malasari

METHODOLOGY

The survey was conducted from October to December, 2019, in Malasari village (6°40'S and 106°31'E). The Malasari village is located on the edge of Halimun Salak National Park, Bogor regency, West Java. The total area is about 82.62 km^2. The climate is a tropical rainforest climate. The temperature varies from 22 to 30 ºC. Verification of land cover in Malasari village was carried out by visual interpretation land cover in images obtained from drone image in 2019. Land cover classification in this village such as forest, paddy fields, abandonment field, and residential area is digitization scale. A Digital Elevation Model (DEM) is a digital file consisting of terrain elevations for ground positions at regularly spaced horizontal intervals (USGS, 2001). DEM (8 m × 8 m) was download from DEMNAS (DEMNAS online: http://tides.big.go.id/DEMNAS/) for the present study. The Digital Terrain Model (DTM) with a resolution (0.1 m × 0.1 m) was taken by drone. DTM and DEM were used to delineate land cover of the study area on Arc GIS software (ArcGIS Ver.10.5, ESRI Japan).

The topographic map is a type of map characterized by large-scale detail and quantitative representation of relief, usually using contour lines in the modern mapping (Center for Topographic Information, 2007). The paddy fields in the observation area were classified divide into 8 slope categories that flat (0~3%), undulating (3~8%), moderately sloping (8~15%), hilly (15~30%), moderately steep (30~45%), steep (45~65%), and very steep (>65%) in Arc GIS. Table 1 showed that slope gradient classes based on USDA classification. The terraced paddy fields can be defined as "rice fields arranged in a shelf-like irregular fashion on slopes steeper than 1/20" (Nakajima, 1996).

The terrace paddy field is located in a hilly and mountainous area. These terraced paddy fields that form a terraced system appear to be beautiful landscapes, the unique nature of the amazing achievement of the work of local wisdom technology. That is terracing which is managed neatly and with traditional systems. Terraces are mechanical soil and water conservation buildings. In Malasari village, terracing technology that forms the charm of the beauty of the landscape with cultivation and the behavior of agriculture governed by the local wisdom system has become an attraction for agro-tourism and cultural tourism.

The survey such as questionnaire for the interview the farmers and field observation and interviews with local farmers were conducted to

collect how to maintain terraced paddy fields and ownership from respondents. 28 respondents were chosen by purposive sampling methods. Farmer's basic information (name, age, education, land area, and ownership status).

Historical background of terrace paddy field and farmers' experience on cultivating and improve terrace paddy field (how long has he been cultivating the land, who made the terraced paddy fields, when started to cultivate, what activities are needed in maintaining paddy and from whom learn to maintain and improve terraced paddy fields). Those data will be analyzed by field observation and interview.

Identification of the existence of social capital in Malasari village was conducted by interviewing several farmers who have their paddy fields. Interviews were conducted to determine whether there were farmer institutions in the village as well as systems in farming in the Malasari village that were adopted by the farmers.

To study the changes of farmer's social dimension in maintaining the sustainability of terraced paddy fields. To be conducted a questionnaire survey to local farmers such as questionnaires on agribusiness aspects and questionnaires on the social aspect.

Agribusiness aspect: (production yield, productivity, input-output, benefit, and income). Social and social capital aspect: (basic norms/value system, related organization, common rules and related to managing rice farming). It's a comparison with several years ago.

Table 1. Slope gradient classes based on USDA classification

Description	Slope (%)
Flat	0~3
Undulanting	3~8
Modaerately sloping	8~15
Hilly	15~30
Moderately steep	30~45
Steep	45~65
Very steep	>65

RESULTS AND DISCUSSION

As geographically point, it is easy to frequently occurring landslides due to steep slope (15 to 30%) and heavy rainfall event varies from 2500 to 3000 mm in this village. Even under such circumstances, the terraced paddy fields have been maintained in this village. In addition, the terraced paddy fields in Malasari village cannot generate any income. Nevertheless, the terraced paddy fields are maintained by traditional local farmers.

Adachi (2007) reported two important points that the fact technologies that have sustained the terraced rice cultivation can be maintained only by the farmer's continuous action on the environment and how closely the technologies in terraced rice cultivation are related to the ecological environment of the area.

The reason why the terraced paddy fields in Malasari were maintained by local wisdom technique such as soil management and water management. The local wisdom technique is an act that has a direct influence on the terraced paddy fields of physical structures. Local farmers try to maintain the paddy by techniques such as traditional rice cultivation, traditional tools, and wisdom. Especially land management which are plowing and making levees are playing an important role. These techniques were effective and maintain terraced paddy fields.

On the other hand, the social capital is an act that has an indirect influence on the terraced paddy fields. The social capital such as numbers of customary rules are still thick and obeyed by all citizens such as prohibiting cutting rice on Friday and hoeing on Sundays in this village. This is conceivable to be farmers follow the rules to increase cohesion, cooperate in rice cultivation. In addition, they might be trying to solve agricultural issues.

Spatial Distribution of Terraced Paddy Fields

Kampung Sijagur is located in the northern part of Malasari village and is a huge paddy area within the village. Figure 2 is a

picture of study site taken by a drone. Figure 3 showed the land cover of the study site. Table. 2 showed that land cover in the site is mainly classified into five types: (1) forest (75.31ha, 66.5%) is the biggest area in the study area, (2) the terraced paddy (31.3ha, 27.7%) a second biggest area, (3) the third is a residential area (4.42ha, 3.9%), (4) the fourth is the abandonment field (1.29ha, 1.1%), (5) the last is road (0.87ha, 0.8%). Sijagur had a higher percentage of the residential area includes paddy fields. Farmers who live in Sijagur are in a state of dependence on the paddy fields.

Figure 4 showed that the area of the classified slope ratio. The slope classifications are divide 8 categories that flat (0~3%), undulating (3~8%), moderately sloping (8~15%), Hilly (15~30%), moderately steep (30~45%), steep (45~65%), and very steep (>65%). The definition of terraced paddy fields slope is 20%.

Table. 3 showed that most dominant slope category is hilly level (15-30%). The hilly slopes dominate with 26.1% of the total area in this village. In addition, the ratio of slope categories which moderately steep, steep, and very steep are also very high. Comparing the definition with the study site, it can be said that the paddy fields are located on a steep slope, which makes them prone to landslides. From a geographic dimension perspective, the paddy slope is steeper in this area. Therefore, soil erosion or landslide may occur with the same land management method as in the lowland paddy areas.

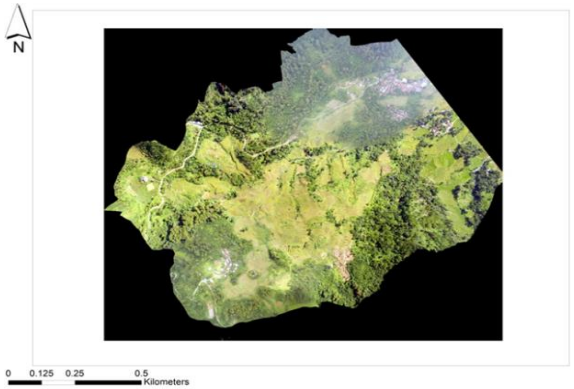

Figure 2. Image of study site taken by drone

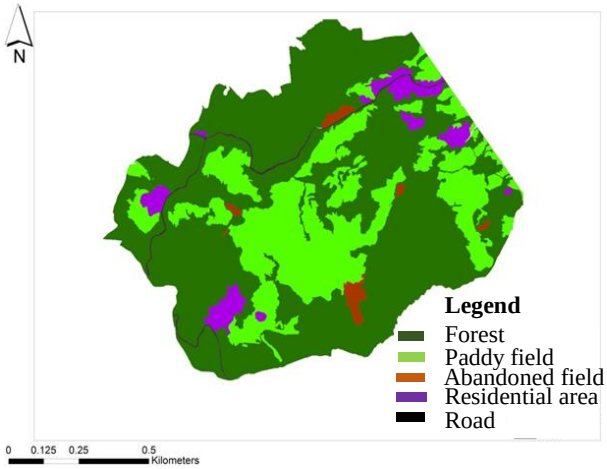

Figure 3. Land cover map in study area

Table 2. Study site of land cover percent

Land use type	Area (ha)	Ratio (%)
Forest	75.31	66.5
Paddy	31.30	27.7
Residential area	4.42	3.9
Abandoned field	1.29	1.1
Road	0.87	0.8
Total	113.19	100

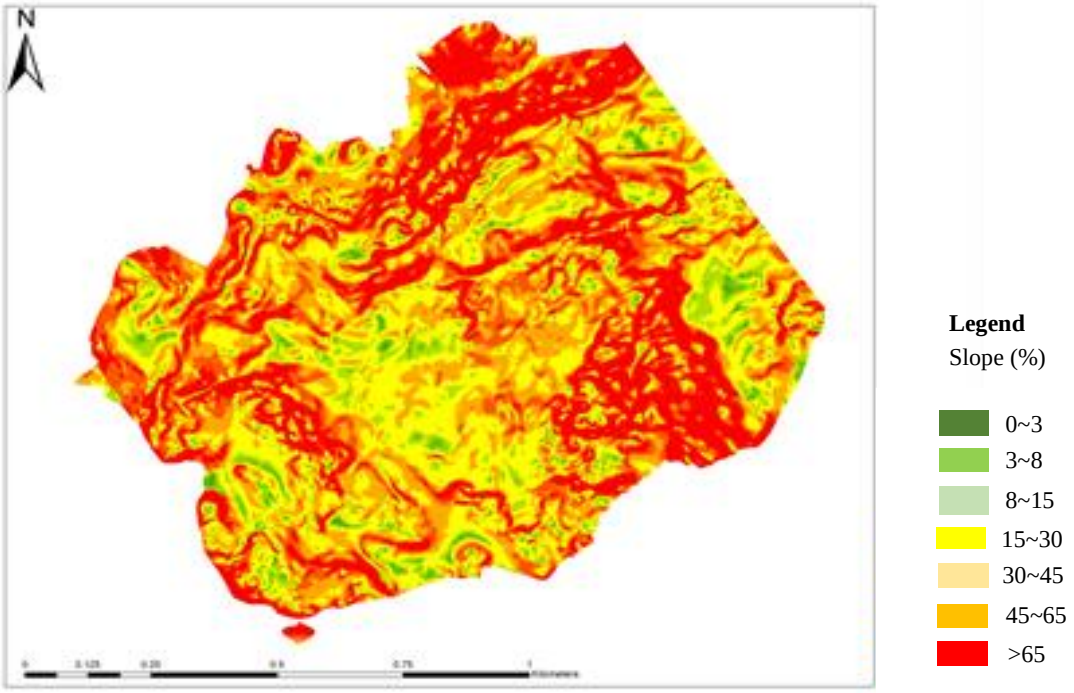

Figure 4. Slope map in study site

Table 3. Slope categories and ratio in the site

Description	Slope (%)	Area (ha)	Ratio (%)
Flat	0~3	0.3	0.3
Undulating	3~8	2.3	2.0
Moderately sloping	8~15	7.6	6.7
Hilly	15~30	29.5	26.1
Moderately steep	30~45	27.2	24.0
Steep	45~65	20.2	17.8
Very steep	>65	26.1	23.1
Total	-	113.2	100

Technical Local Wisdom Applied as The Keys for The Sustainability of The Terraced Paddy Fields

Land management is most important to maintain terraced paddy fields. Therefore, local farmers take actions that have a direct impact on maintaining the terraced paddy fields. For instance, farmers using traditional weeding tools and harvesting tools so that they can apply rice straw to the paddy as organic matter. And also, the levee of the terraced paddy fields in this village is set lower than in other areas. It can be drained easily under heavy rain conditions. In this way, it can be said that the direct application to the paddy fields leads to maintain of the terraced paddy fields. Thus, techniques and wisdom of local farmers are the hard aspects of maintaining the terraced paddy fields.

Rice straw is also used to fill deep soil surfaces levee. The levee of the terraced paddy fields in this Village is set lower than in other areas. The material of the levee is soil (Figure 5). Therefore, it needs low cost. In addition, it can be drained easily. It is said that making levee with soil materials is suitable for environmental conditions in this area.

On the other hand, the ratio of stonewall levees fortified with concrete and that of consolidated levees has been steadily increasing since the 1970 s in Japan (Fukamachi *et al.*, 2005). The concrete levee has advantages in that strong and sturdy resistant to landslides and no need for weeding and it saves labor. However, there are disadvantages that the cost of construction is high.

According to field observation, when farmers weeding near the levee, the grass were weed approximately 5 cm above the ground so

as not to cut the roots of the weeds. Farmers careful weeding was done so as not to cut the soil. Because plant roots tighten levees and prevent soil erosion. Those land management and weeding are agricultural methods suitable for this environment. There are 3 types of weeding equipment which (a) *Sabit*, (b) *Kored*, and (c) *Cengkuk* in this village (Figure 6). Farmers change the equipment where they would like to weed such as soil surface and levee. (A) *Sabit*, and, (b) *Kored* are used to weed on the levee. (C) *Cengkuk* is used to weed on the ground surface.

Farmers are cultivating rice two times in a year which are March and September. As a result of harvesting and observation, there are two types of harvesting methods. The first method uses a sickle at a height of about 10 cm from the above-ground part for a short height of rice varieties. The second method uses a traditional tool called *anai* (Figure 7) to harvest about 10 to 15 cm from the ear of rice. By cutting only the top ears, more can be left than rice straw, and the rice straw is returned to the paddy as organic matter.

Basically, harvesting is done by family and relatives. However, when the number of harvesters is small, there are complementary functions of assisting the harvest. After harvest, they could receive the harvested rice as compensation. Rice straw is also used to fill deep soil surfaces levee. The levee of the terraced paddy fields in this Village is set lower than in other areas. The material of the levee is the soil in Indonesia.

Figure 5. The levee of Malasari

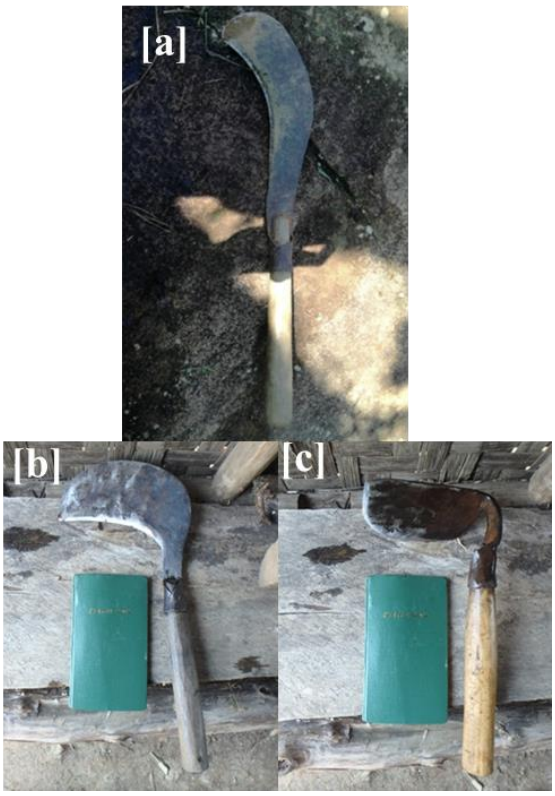

Figure 6. Weeding equipment (a: *Sabit*, b: *Kored*, and c: *Cengkuk*)

Figure 7. Harvesting equipment *aniani*

The Role of Social Capital / Local Customary Practices as The Keys on Sustainable Management

According to the literature review, Putnam (2001) simply defines it as a feature of social organization, consists of networks, norms, and trust, which allows a certain community to act collectively and mutually benefit by coordinating and cooperating. It is an important

tool to understand factors that contribute to successful collective actions (Woolcock & Narayan, 2000). It is a customary institution, which is a form of social capital for managing collective resources since it provides structure and develops trust and norms of reciprocity for cooperation and coordinated actions (Dahal & Krishna, 2008). The social capital of this village is an important factor in the soft aspect of maintaining the terraced paddy fields.

Malasari village also has social capital which are consists of networks, norms, and trust. The traditional rulers that farmers should not take care of rice on Monday and Friday, except cooking rice and farmers may not tillage and weed on Sunday in this village. The reasons why Monday rest for a superstitious, Friday for religion, and Sunday for socializing time. Those norms were determined by traditional leader. Farmers must not cut down trees around water sources. Because water sources are important for their life and agricultural activities. The time to start transplanting and harvesting is determined by the traditional leader (traditional calendar). There is a meeting every month that an outline is to discuss agricultural problems. Mutual cooperation leads to maintain of terraced paddy fields. In this way, it can be said that the indirect take action to the paddy fields leads to maintain.

Interview survey results found personal attributes. The rice harvested in this village is not sold at markets but is consumed by farmers themselves. Even in paddy rice cultivation areas, the employment opportunity distribution function in paddy cultivation is still high. In traditional agricultural rice cultivation, there are functions in the form of redistribution of rice between relatives in the case of self-sufficiency production and the form of distribution of employment opportunities.

There is a relative workforce in rice cultivation. Especially in the terraced paddy cultivation need much labor such as plowing and making embankment. Employed labor is used for tasks that require human power. In the pattern of the workforce, labor only helps landowners in the process of transplanting and harvesting. *Liliweran*: a labor system that only transplanting and harvesting is done by a group. Workers do *liliweran*, receive 1/6 compensation for harvested grain.

Social capital in this village gives benefits to local residences. For instance, the labor system that does not have enough rice yields can apply exchange workforce functions for exchanging rice which is harvested by employed labor. Besides, when a natural disaster happened, there is a rice stockpiling system in place where the whole village helps each other for risk hedge. And then, the social capital of Malasari related indirectly to maintain terraced paddy fields.

CONCLUSIONS AND RECOMENDATIONS

The conclusions from the results are as follows:

a) In Malasari village, the terraced paddy fields (31.30 ha, 27.7%) are the second-largest land cover map area and spatially distributed. In this village, the category of hilly slopes (15-30%) dominates with 26.1% of the total area.
b) The local wisdom technique is direct influences on the physical structure of terraced paddy fields for maintaining. Especially land management which is plowing and making levees are playing an important role to fix it up again every season. These techniques were effective and maintain terraced paddy fields. We can see that farmers try to change soil physically structure with the actions of direct impact against the terraced paddy fields. It is found that traditional cultivation methods and conservation soil and water management for the maintenance of terraced paddy.
c) The social capital is an act that has indirect influences on the terraced paddy fields. The social capital such as numbers of customary rules are still thick and obeyed by all citizens such as prohibiting cutting rice on Friday and hoeing on Sundays in this village.

These factors interact with each other to maintain the terraced paddy fields. Even, rice production and economic aspects affected both interactions. Sustainable development of rural communities supports elements which are the direct take action and the indirect take action of maintenance caused by this kind of reaction. It can be said that the interaction of both actions leads to the maintenance of terraced paddy fields.

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