

Simulation Subak Management Function Optimally in Subak Lodtunduh, Bali, Indonesia

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Abstract
Subak system has a very important role in agriculture development in Bali, especially on irrigation lands. *Subak* system with *Tri Hita Karana (THK)* philosophy has an opportunity to be transformed into other areas, as long as technology equity could be fulfilled. Optimal management of *subak* function is needed for such transformation, therefore this study aims to develop optimal management of *subak* function using analyses of linear program. The object of this study was *Subak* Lodtunduh, located in the upstream region of Kedewatan Irrigation Area, Gianyar, Bali. This *subak* was purposely choiced as its fuction works normally. Parameters of *subak* function management were determined by collecting primary data such as allocation, distribution, and water irrigation loan; *subak* facilities' maintenance; conflicts resolution; ritual activities; output and input of production, cost of production, applied areas, and household labor supply; while the secondary data collected include irrigation volume and climate conditions. Results showed that *Subak* Lodtunduh optimally managed *the subak* function as its accomplished the five *subak* functions optimally during each planting season. These include (1) conducted allocation, distribution, and irrigation water loan; (2) maintened of *subak* facilities; (3) conflict resolution by conducting meetings on the early planting season; (4) conducting ritual activities; and (5) managed of *subak* resources. Analyses of optimal *subak* functions resulted that water distribution proportionally (*tektek*) by using one inlet and one outlet methods could be transformed into other areas as long as the technology equity could be fulfilled.
Keywords: *subak* function, optimal management, Bali

1. Introduction

Subak is an organization of irrigation management of a single water source. The organization has a full autorhization and apply a universal philosophy *Tri Hita Karana* (THK) or Three Resources of Goodness (Sutawan, 2008). *Subak* outlining a harmony among nature, human, and God. *Subak* system in Bali had been recognized as a world heritage site by UNESCO on 2012. This recognition gets more interests from more people to know better the *subak* system, and this recognition also support conservation (Nagaoka, 2012).

Subak system has an important role in agriculture development in Bali, especially on irrigation fields (paddy fields). Mean while, during 2001-2022, the paddy fields decreases by 323 ha (0.39%) per year because of land conversion into non-agricultural uses (BPS Provinsi Bali, 2011). The land conversion has to be limited as the rice field has multi-roles such as function for production dan economic to guarantee food safety, ecological and cultural functions, village development, as well as eco- and agro tourism (Sutawan, 2005).

Subak system needs a proper management to meet its aims. In order to meet the optimal organization aims, management of the *subak* system should emphasize on process aspects or its activities (Downey & Steven 1992). These activites are called as *subak* functions (Sutawan 2008). *Subak* system with THK philosophy has a possibility to be transformed into other areas, as long as the technology equity could be fulfilled. *Subak* system which has been proven to have an important role for development of irrigation fields, could be transformed to other areas (Windia, 2005). However, previous studies on *subak* system have not been analyzed the effectivity of the system for maximal land production. Where as Budiasa (2005) explained that one dimension of the sustainability of *subak* irrigation system as supplier and maintaner of water resource is productivity of agricultural system. Therefore, it needs to evaluate an optimal pattern of *subak* system management that gives a maximal productivity. This optimal pattern could be used as a basic for conserving and transforming *subak* system. This research was aimed to analyze optimal management of *subak* function and develop a transformation through simulation for optimal *subak* function management into other areas.

2. Methodology

The object for analyses of optimal *subak* function is *Subak* Lodtunduh, located at upstream of Kedewatan Irrigation Area, Gianyar, Bali. Activities of *Subak* Lodtunduh are relatively similar to other *subak* system in Bali which include five functions, i.e., (1) function on allocation, distribution, and loan of irrigation water. (2) function on maintaining of *subak* facilities; (3) function on resources management; (4) implementation of conflict resolution function; and (5) the function of the organization of ritual. *Subak* Lodtunduh was chosen purposively as a study object as this *subak* works normally.

Data collected comprised of primary and secondary data. The primary data collected include activities on allocation, distribution, and loan of water irrigation; maintenance of *subak* facilities; implementation of conflict resolution; organization of ritual**;** production; sale of production; consumption of production; price of product, number and cost of inputs, involved areas of paddy fields, costs of production, labor supply. The secondary data were collected from relevant data sources, include volume of water irrigation and climate condition. The primary data were obtained by random sampling from 30 respondents (44% of total members of the *subak* system) and by purposive sampling from 5 informen (2 *subak* managers and 3 *subak* experts).

Analyses of *subak* management pattern was done using linear program supporting by POM for Windows3. The unit analyses of this study was *subak* system, while for some variables used average of observed parameters.

Specifications of linear programming

Limited resources of *subak* are constrains to optimally function the *subak* system. *Subak* resources include (1) the volume of irrigation water, (2) funding, (3) labor, and (4) paddy fields. The objective of linear programming is to maximize the productivity of *subak*, *subak* gross income in the form of two seasons in 2012.The specific model in the optimization of management pattern *subak* function in this study is as follows.

Maximize: $z = c_1x_1 + c_2x_2 + ... + c_nx_n$

The limiting factor: $a_{va1}x_1 + a_{va2}x_2 + ... + a_{van}x_n \leq$ the volume of irrigation water

$a_{tk1}x_1 + a_{tk2}x_2 + ... + a_{tkn}x_n \leq$ labor

$a_{dn1}x_1 + a_{dn2}x_2 + ... + a_{dnn}x_n =$ fund

$a_{la1}x_1 + a_{la2}x_2 + ... + a_{lan}x_n \leq$ paddy fields

$a_{m1}x_1 + a_{m2}x_2 + ... + a_{mn}x_n \leq b_m$

where:

z: the objective function is to maximize the productivity of *subak* activities with various constrain encountered (c_nx_n)

x_n: alternative activity in managing *subak*: a_{mn} is the addition (<0) or reduction (>0) b_m by each unit of activity x_n. a_{va} is the volume of irrigation water supply and a_{la} is the supply of paddy fields. a_{va} and a_{la} decline (>0) or increased (<0) due to the production. a_{tk} is the supply of labor in the family and is a_{dn} supply funds. a_{tk} and a_{dn} decreased (>0) or increased (<0) due to production; sale of production; consumption of production; activity allocation, distribution, and borrow irrigation water; *subak* facility maintenance activities; implementation of conflict resolution activities; activities of the organization of the ritual; and implementation of farmer cooperative activities.

b_m: all the obstacles encountered in carrying out the functions of *subak*: constraint (<), equal (>)

c_j: the addition (>0) or reduction (<0) z by each activity x_n.

3. Results and Discussion

3.1 Description of Research Area and Farmers' Characteristics

Subak Lodtunduh located in the upstream region of Kedewatan Irrigation Area. Geographically, *Subak* Lodtunduh, Singakerta village located in the region of Ubud District, Gianyar, with total land area of 25 ha.

Characteristics of the farmers in this study focused on age, livelihood, potential family labor, and farmers' level of education. A total of 86.67% of the farmers are in the productive age with an average age of 51.70 years. Almost all members of the *subak* have principal livelihood as farmers (96.67%) with the status as the owner and tiller as much as 90% and 10% landtuner. The average of potential family labor in *subak* activities in one planting season was 157.98 man-days. The education level of farmers were from elementary to post graduate; the highest percentage was completed primary school (50.00%) and the lowest completed post-graduate (6.67%).

3.2 Patterns of Actual Management of Function *Subak* Lodtunduh

Pattern of management of 5 funtions *Subak* Lodtunduh comprises of:

3.2.1Function of allocation, distribution, and loan of irrigation water.

Water allocation is determined proportionally to the use *tektek* size. Water allocation of one *tektek* is the water flowing through the pipe (width of approximately 5 cm and a height of 1-2 cm). One *tektek* is used to irrigate one part of field 25 - 40 acres. *Subak* members who obtain water supply for one *tektek*, he has a accountability to contribute one labor. For *subak* members who obtain more than one *tektek,* he has to contribute the excess labor *(pengoot)* converted proportionally.

Distribution of *subak* irrigation water Lodtunduh using open systems (continuous flow) through a system of one inlet and one outlet. *Subak* members receive irrigation water in accordance to their rights, and irrigation water was flowed into the sewer after used. A proper distribution of irrigation water is the responsibility of the board and active *subak* members. Control over distribution of irrigation water is generally done twice, i.e., during land preparation and at the paddy age of 70 days after planting. If one doing land preparation, he has a priority to obtain water irrigation to ensure that the preparation will work well. If there is a shortage of water, the famer will allow to loan water to other farmers. In order to avoid conflicts among farmers, the schedule of land preparation is prepared by *pekaseh*.

Water loan is done by partially closing the threshold with coconut leaves. If the existing drain plug is opened, it means the water is needed by the rightly-owners of irrigation water. This suggests that there has been a mutual understanding between the borrower and the lender of irrigation water. Loan of irrigation water is possible, because the irrigation water distribution system using the one inlet and one outlet methode.

3.2.2Function of maintenance of subak facilities

Subak Lodtunduh is responsible for the maintenance of *subak* facilities which are consisting of (i) the irrigation facilities in tertiary channels, up to quarter channels and to the paddy fields of *subak* members, (ii) facilities of ritual activities, namely *Pura Subak*, *Pura* Bedugul, *Sanggah* Catu, (iii) *subak* hall, and (iv) weighing hall.

In keeping the condition of the facilities well, especially the *subak* irrigation infrastructure, *Subak* Lodtunduh does preventive and repressive actions. Preventive actions are those that regarding to the smooth distribution of irrigation water in *Subak* Lodtunduh. These include routine cleaning of irrigation infra structure and facilities by *subak* members all together in the beginning of each planting season for three days; inspecting of irrigation infra structure and water by patrol officers (*petelik*); and improving the quality of other *subak* facilities. Repressive actions are those that regarding to repair the damage that occurs in *Subak* Lodtunduh. These include draining the tap buildings; cleaning up trash from the river, and put up bamboo barriers for the trash on inlet and tap buildings; covering the leaking on tertiary walls.

Subak Lodtunduh differentiates its members into active and passive members. Active members are responsible for the maintenance of irrigation cannals which are simple and not costly, i.e., cleaning irrigation canals. For maintenance *subak* facilities, *Subak* Lodtunduh has routine sources of funding collected from *pengoot* and *amputan*. *Pengoot* is compulsory fee of passive *subak* members as conversion of labor in mutual cooperation *subak* facility maintenance. This fee is paid routinely after harvest. *Pengoot* is worth as the price of 17 kg grain at harvest for one *tektek*. *Amputan* is compulsory fee by passive *subak* members as conversion of labor in the implementation of ritual activities. This fee is paid periodically after harvest. *Amputan* in *Subak* Lodtunduh is worth the price of 10 kg of rice at harvest for one *tektek*.

The frequency of each active members to work together is as regards to *ayahan* of each load, the nature of work (regular or very important), and the scale of work (large or small). Mutual cooperation like this is governed by *pekaseh* wit emphasis on the "principle of fairness". Mean while, the passive members would participate in such mutual works when the work is important and require alot of labors.

3.2.3The function of subak resource management

Subak resource management include resource management of resources and resource use. There is an agreement in land management, namely the area for planting other than paddy should not occupies 10% of the total area owned by a *subak* member. For farming activities, *Subak* Lodtunduh obtains irrigation water from the Dam Kedewatan through the River Yeh Lauh. Irrigation water is used to meet the needs of the plant during the two growing seasons, i.e.,on February to June and on July to November.

Water supply in *Subak* Lodtunduh on February 2012 was 45.42% and in July was 59.13% of the requirement. Despite the lack of water supply, all farmers could grow rice as a staple crop in each growing season. For more details, requirements and irrigation water supply in *Subak* Lodtunduh in 2012 is shown in Figure1.

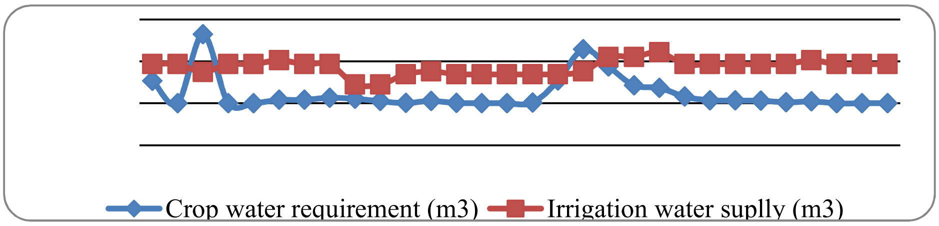

Figure 1. Water requirement and supply on *Subak* Lodtunduh System

Shortage of irrigation water in *Subak* Lodtunduh was overcomed by borrowing water in turns. This suggests that the irrigation water management led by *pekaseh* is capable to distribute irrigation water equitably and evenly in every planting season, which is reflected in the rice-rice cropping pattern. Planting schedule of rice in *Subak* Lodtunduh on 2012 are listed in Figure2.

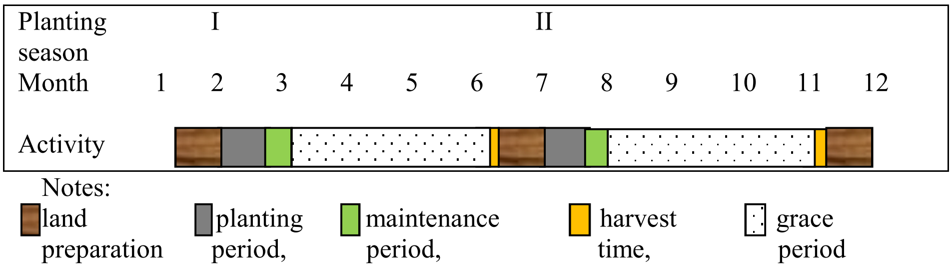

Figure 2. Schedule for planting in *Subak* Lodtunduh in 2012

In Figure 2 can be observed that the cultivation of land in *Subak* Lodtunduh range three weeks. Age of rice on the second growing season is relatively the same, 95 days. The timing of the planting has been agreed at a meeting of *subak* members. Farmers of *subak* members do not plant outside the agreed time for reasons to avoid pests and trouble in finding labor at harvest time. The grace period between harvest and land preparation in the next growing season ranges from 30 days. This means that the rice planting season in *Subak* Lodtunduh takes approximately five months.

Funds in *Subak* Lodtunduh consist of fees of active members and all of the *subak* members. The grouping of these funds are based on sources and uses of funds. Both groups of these funds are from internal and external sources of *subak*. Funds derived from internal *Subak*, include: (i) fees collected incidentally; (ii) fees levied on a regular basis; and (iii) the activities of a business.The fund is used for financing the rituals associated with rice cultivation stage at the subak and maintaining irrigation channels. External fund obtains incidentally from Gianyar government.

The fund of all *subak* members include (i) the aid from the provincial government, (ii) provision of production supply, and (iii) interest of delayed payments of production cost. These fund are used for financing the operations of the *subak* board; bailouts for the procurement of fertilizers; *subak* ritual activities that are not directly related to the phase of rice cultivation, such as *Pura Subak* ceremonies.

3.2.4Implementation of conflict resolution function

In 2012, there were no conflicts in *Subak* Lodtunduh. The conflicts are related to the problems of irrigation water. Management of irrigation water, *Subak* Lodtunduh has determined *awig-awig* in the *subak* meeting. The meeting of *subak* members aimed to prevent and resolve conflicts in *subak*. The decision was made based on the agreements, compulsory, and be held by the board to manage the organization.

Member meetings of *Subak* Lodtunduh are usually for two hours at 19:00 - 21:00 pm, three times before planting season. Discussions in the meeting include decision of initial land preparation, variety to be planted, planting time, fertilizer application and frequency of payments, ratification and the Definitive Plan of fertilizer requirements for the farmer's group.

3.2.5The function of the organization of ritual

Rituals by *Subak* Lodtunduh in two cropping seasons of year 2012 were performed at the same time of *Magpag Toya* ritual, which was performed by *pekaseh* at *Pura* Bedugul in conjunction with activities of mutual cooperation *subak* members at the beginning of each planting season.

Ritual activities related to the stages of rice cultivation activities include: (i) *Ngendagin*, for land preparation; (ii) *Ngurit*, for sowing seeds; (iii) *Nuasen nandur*, for planting; (iv) *Ngeroras*, for 12-day-old rice; (v) *Neduh*, for 27-35-day-old rice; (vi) *Nyungsung*, for after 42 days old rice; (vii) *Biukukung,* during the rice ages between 65-70 days; (viii) *Ngusaba,* before harvest; (ix) *Mebanten Manyi*, for harvesting; (x) *Mantenin*, for storing rice in storage. *Nyungsung* and *Ngusaba* performed at the level of the *subak*, while other ritual activities carried out by the individual members of the *subak*. Implementation of ritual activities *Nyungsung*, *Ngusaba*, and ceremony at *Pura Subak* held once every 210 days. It has different scales in the two season turns, small and large scales.

Management functions of *Subak* Lodtunduh have been implemented based on the principle of *THK*, which is reflected by:

a. Natural aspects, including water distribution system proportionally through one inlet and one outlet in each paddy fields with continuous flow method, so that the water can be distributed in a fair and equitable;
b. Human aspects include (i) farmers who work in the land more than one *tektek* has to pay fines; (ii) there is a policy of mutual borrowing between members of irrigation water. Loan irrigation water on a rotation, so that all members can arrange their land in every growing season. These policies create an atmosphere of harmony and togetherness; (iii) activities of mutual cooperation *subak* members; (iv) there are *pekaseh* roles in regulating the distribution of water in a fair and equitable to avoid conflicts.

c. Godne**ss** aspects, *subak* members have a feeling of fear of breaking *awig-awig subak*. In addition to the penalties imposed on the financial and social sanction, also believes that his actions will have an impact to himself.

3.3Optimal Management Pattern of Function *Subak* Lodtunduh

Based on the analysis of linear programming, the values of *Subak* Lodtunduh optimal function is with in confidence intervals. This suggest that the pattern of optimal management functions of *Subak* Lodtunduh has represented the management scheme *Subak* Lodtunduh actual function (survey results). This result supports the assessment of Budiasa (2011); Antara (2001), a small farmer was efficient in resources allocation as indicated by optimal solution which conforms to observed behavior. On the other hand, Schultz (1964) cited Hayami & Ruttan (1985) stated that small and poor farmers in developing countries, economically rational in the allocation of resources in the state of availability of resources and existing technology. Pattern management functions of *Subak* Lodtunduh, both survey results and the optimal results are reprensented on Table 1.

Table 1. Pattern management functions of *Subak* Lodtunduh, survey results and the optimal results (i)

Activities	Results of the survey	Optimal results (i)	Confidence interval
The objective function (Rp 000)	562,002.20	565,713.60	-
a. *Subak* activities on season 1:			
Allocation, distribution, and loan irrigation water (times)	1.00	1.00	1.00 – 1.00
Maintenance facilities *subak* (times)	3.00	3.00	3.00 – 3.00
Organizing conflict resolution (times)	3.00	3.00	3.00 – 3.00
Implementation of ritual activities (units)	1.00	1.00	1.00 – 1.00
Subak resource management:			
Rice farm size (ha)	21.76	22.50	20.26 – 23.26
Impatients walleriana farm size (ha)	2.12	2.50	1.71 – 2.53
Ipomoea aquatica farm size (ha)	1.12	0.00	-
Rice sold (tons)	114.12	117.90	110.05 – 118.19
Impatients walleriana sold (tons)	12.03	14.20	9.73 – 14.33
Ipomoea aquatica sold (tons)	2.06	0.00	-
Rice consumption (tons)	4.13	4.28	3.77 – 4.49
Ipomoea aquatica consumption (tons)	3.98	0.00	-
Implementation of farmer cooperatives (units)	1.00	1.00	1.00 – 1.00
b. Activities *subak* season 2:			
Allocation, distribution, and borrow irrigation water (times)	1.00	1.00	1.00 – 1.00
Maintenance facilities *Subak* (times)	3.00	3.00	3.00 – 3.00
Organizing conflict resolution (times)	3.00	3.00	3.00 – 3.00
Implementation ofritual activities (units)	1.00	1.00	1.00 – 1.00
Subak resource management:			
Rice farm size (ha)	21.76	22.50	20.26 – 23.26
Impatients walleriana farm size (ha)	2.12	2.50	1.71 – 2.53
Ipomoea aquatica farm size (ha)	1.12	0.00	-
Rice sold (tons)	113.89	117.68	109.89 – 117.89
Impatients walleriana sold (tons)	12.03	14.20	9.73 – 14.33
Ipomoea aquatica sold (tons)	2.06	0.00	-
Rice consumption (tons)	3.92	4.05	3.56 – 4.28
Ipomoea aquatica consumption (tons)	3.94	0.00	-
Implementation of farmer cooperatives (units)	1.00	1.00	1.00 – 1.00

Optimizing the management pattern of *subak* function is attempts in the water control system to obtain maximum productivity. The management pattern of *Subak* Lodtunduh optimal function is as follows: (i) Implement a time series of allocation, distribution, and borrow irrigation water; (ii) Implement three times *subak* facility maintenance; (iii) Conduct three times meetings to resolve conflicts among *subak* members before the planting season begins; (iv) Initiate ritual activity as a series of rituals; (v) Implement a time series of farmer cooperatives; and (vi) Manage *subak* resources for all functions including farming activities. Optimal farming activities in *Subak* Lodtunduh in 2012 consisted of: (a) an area of 22.50 ha of rice farming and *impatients walleriana* farming area of 2.50 ha, in season1 and season 2. That is, in the optimal state of all existing wetland can be cultivated as an actual state, but not recommended *Ipomoea aquatica* farming to achieve maximum productivity.

Optimal management functions of *subak* generates revenue Rp 565,713.60 thousand. This revenue increased 0.66% from the *subak* actual revenue (USD 562,002.20 thousand). These revenues will be achieved if the type of farming changed from rice + *Impatients walleriana* + *Ipomoea aquatica* into the rice + *I.walleriana*, because *I.aquatica* farming efficiency is lower than that of *I.walleriana* farming. This suggests that *subak* needs to pay attention on farming efficiency in order to achieve maximum revenue.

3.4Simulation of Optimal Management Function *Subak* Lodtunduh

Simulation of optimally *subak* management function determines the effect of changes in input-output coefficients and the resources available on the optimal solution (Agrawal and Heady, 1972). *Subak,* as farmer organizations on irrigation water, would work well when water supply meets the farming needs.

Water supply on *Subak* Lodtunduh fluctuated in accordance with the water discharge at the Dam Kedewatan. This happens because the distribution of irrigation water using a proportional system. This condition can affect the optimal solution for management of *Subak* Lodtunduh functions. Therefore, this study performed two simulations of the solution patterns of *subak* optimal management functions, namely (i) if there is a reduction in *Subak* Lodtunduh water supply corresponds to the fluctuations in the water level in the Dam Kedewatan in last 12 years (2001 to 2012) and (ii) if *subak* do not perform its role in the water management, such as irrigation water loan to fit the needs. Results of two simulations of optimally management of *Subak* Lodtunduh function are presented in Table 2.

Table 2. Patterns of optimal management function *Subak* Lodtunduh, results of simulation (i), and simulation (ii)

Activity	Results of simulation (i)	Results of simulation (ii)	Confidence interval
The objective function (Rp 000)	565,713.60	307,475.60	-
a. Activities *subak* season 1:			
Allocation, distribution, and borrow irrigation water (times)	1.00	1.00	1.00 – 1.00
Maintenance facilities *subak* (times)	3.00	3.00	3.00 – 3.00
Organizing conflict resolution (times)	3.00	3.00	3.00 – 3.00
Implementation of ritual activities (units)	1.00	1.00	1.00 – 1.00
Subak resource management:			
Rice farm size (ha)	22.50	9.88	20.26 – 23.26
Impatients walleriana farm size (ha)	2.50	2.50	1.71 – 2.53
Ipomoea aquatica farm size (ha)	0.00	0.00	-
Rice sold (tons)	117.90	51.80	110.05 – 118.19
Impatients walleriana sold (tons)	14.20	14.20	9.73 – 14.33
Ipomoea aquatic sold (tons)	0.00	0.00	-
Rice consumption (tons)	4.28	1.88	3.77 – 4.49
Ipomoea aquatic consumption (tons)	0.00	0.00	-
Implementation of farmer cooperatives (units)	1.00	1.00	1.00 – 1.00
b. Activities *subak* season 2:			
Allocation, distribution, and borrow irrigation water (times)	1.00	1.00	1.00 – 1.00
Maintenance facilities *Subak* (times)	3.00	3.00	3.00 – 3.00
Organizing conflict resolution (times)	3.00	3.00	3.00 – 3.00
Implementation of ritual activities (units)	1.00	1.00	1.00 – 1.00
Subak resource management:			
Rice farm size (ha)	22.50	12.87	20.26 – 23.26
Impatients walleriana farm size (ha)	2.50	2.50	1.71 – 2.53
Ipomoea aquatica farm size (ha)	0.00	0.00	-
Rice sold (tons)	117.68	69.62	109.89 – 117.89
Impatients walleriana sold (tons)	14.20	14.20	9.73 – 14.33
Ipomoea aquatica sold (tons)	0.00	0.00	-
Rice consumption (tons)	4.05	2.32	3.56 – 4.28
Ipomoea aquatica consumption (tons)	0.00	0.00	-
Implementation of farmer cooperatives (units)	1.00	1.00	1.00 – 1.00

Optimal management pattern of *subak* function resulted in maximum productivity. The management pattern of *Subak* Lodtunduh function in 2012 was as follows: (i) Implemented a time series of allocation, distribution, and loan of irrigation water; (ii) Implemented maintenance of *subak* facility three times; (iii)

Conducted meetings to resolve conflict of *subak* members three times before planting time; (iv) Conducted ritual activity as a series of rituals; and (v) Managed *subak* resources for all functions including farming activities. Optimal farming activities in *Subak* Lodtunduh in 2012 consisted of: (a) an area of 22.50 ha of rice farming and *I. walleriana* farming area of 2.50 ha, the season1 and season2. That is, in the optimal state of all existing wetland can be cultivated as an actual state, but not recommended *Ipomoea aquatica* farming to achieve maximum productivity.

Results of simulations showed that (1) although there was a decrease in water supply by 45.42% of the requirement, if the *subak* function of water distribution worked well, then all paddy fields can be cultivated in two seasons in 2012 and gave maximum productivity of Rp 565,713.60 thousand; and (ii) if the supply of irrigation water under normal circumstances but no role in the distribution and loan of *subak* irrigation water, the land that can be cultivated in two seasons only 27.75 ha (55.50%) of the total area in *subak* revenue of Rp 307,475.60 thousand (54.35% of the maximum income).

These results indicate that (i) the *subak* has been trying to manage irrigation water in order to meet the water needs of all paddy fields to obtain circum stances of harmony and togetherness. This result supports the assessment of Windia et al. (2005) that subak system could anticipate the water shortage in during dry season by arranging planting pattern based on its success opportunities through concerning the basics of harmony and togetherness in water management. On the other hand, Ulumuddin (2013) stated that “management system of the resources that based on the community would give social energy for the local people in managing development process to streng then the effective mechanism of resources management”. Therefore, Supadi (2009) argued that the irrigation management for each region can not be uniform, but need to be adapted to the local culture.

Mean while, results of simulation (ii) indicate that management of *Subak* Lodtunduh functions reached optimal managemnet. One of the reason was the water distribution system applied proportionally using one inlet and one outlet system. This system made possible water loan without any conflicts. Priyono (2008), when the crop water requirements exceed the availability of water in the soil and no irrigation applications, the loss of the results will be very real. Therefore, such water distribution system of *subak* with one inlet and one outlet methods could be transformed into other areas, as long as the values of equivalence technology could be fulfilled. The other *subak* functions are related to social factors that associate with local culture and have otonomic characters. The weakness of *subak* system transformation process are culture factors that is bound in subak system, showed in religius values used as *subak* fondation system (Windia et al. 2005).

4 Conclusion

Optimal management pattern of *subak* functions could distribute water fairly and evenly on every planting seasons although water supply only 45.42% of the farming requirement. *Subak* system that could be transformed into other areas is technical function on proportional water distribution by applying one inlet and one outlet methods. In order to get maximal productivity of the land, *subak* has to apply aan optimal *subak* management function and takes into account the farming efficiency of the cultivated commodities.

The optimal management pattern of *Subak* Lodtunduh function in 2012 was as follows: (i) Implemented a time series of allocation, distribution, and loan of irrigation water; (ii) Implemented maintenance of *subak* facility three times; (iii) Conducted meetings to resolve conflict of *subak* members three times before planting time; (iv) Conducted ritual activity as a series of rituals; and (v) Managed *subak* resources for all functions including farming activities. Optimal farming activities in *Subak* Lodtunduh in 2012 consisted of: (a) an area of 22.50 ha of rice farming and *I. walleriana* farming area of 2.50 ha, the season1 and season2.

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