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A case study of Balinese irrigation management: institutional dynamics and challenges.

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Explanation:

This paper aims at exploring different institutional levels of the Balinese *subak*, a long-standing socio-religious agricultural organisation which manages the irrigation of the rice fields with great success. Recent and current external impacts are discussed, and problem solving on the farming level is demonstrated. The analysis shows that although formal regulations on the *subak* level exist, farmers rely mainly on informal arrangements which help to fine-tune the system.

Abstract:

Rice cultivation in Bali cannot be separated from the intricate irrigation system that is part of the traditional water user associations called *subak*. *Subak* are socio-religious communities which organise activities related to rice cultivation. These include water allocation and distribution, the operation and maintenance of the physical infrastructure, as well as conflict resolution and religious ceremonies within a clearly defined geographical area. *Subak* have been widely recognised for their flexibility to operate efficiently, to incorporate new farming practices, and to adapt to external changes in the past.

Nevertheless, today the *subak* system is again challenged due to internal and external pressures. Rising land prices, better paid off-farm employment (mainly in tourist related industries) and increasing living costs are but some of the factors that influence the incentives of farmers to seek alternatives to rice cultivation.

This paper discusses several examples on how the *subak* was subject to change.

The first section concentrates on the development phase in the 1970's and 80's. During the Green Revolution the government implemented new agricultural technologies. Traditional rice varieties and rotational cropping patterns were replaced by high yielding varieties and mono-cropping. Religious practices closely related to irrigation and pest management were neglected. The result was fatal. Pest outbreaks and water management difficulties threatened the farming community. During the 80's and 90's the Bali Irrigation Project implemented better irrigation infrastructure and new irrigation management structures to improve irrigation water use. The project design failed to take long established traditional irrigation institutions into account. Again, the disturbance to the *subak* system was immense. *Subak* which had no institutional relationship were merged, leading into constant struggles for water rights. The two development projects could stop further damage by restoring former components of the traditional Balinese irrigation system.

The second section discusses present day changes to the *subak* system by presenting a case study. The authors analyse the impact of a recently established government-assisted federation (*subak-gede*) of five *subak* which share a common weir. In addition, the authors discuss what impact increased off-farm employment by farmers has on irrigation and agricultural management.

All examples are examined using the concept of social-ecological systems. The authors argue that all levels within the *subak* system are both autonomous and interdependent at the same time. The analysis shows that although formal regulations are existent on the *subak* level, farmers at the bottom end fine-tune the system by relying on informal arrangement.

Introduction

Bali has made the most rapid economic development of all the islands of Indonesia. One of the main reasons is the many income possibilities created directly by tourism or indirectly by industries which produce goods for the tourist industry. 51% of people's income in Bali is directly associated with tourists' expenditure and tourism investment (Pitana 2003). Nevertheless, in 2001 agricultural products still amount to 11% of the GRDP.[1] A quarter of the 342'513ha agricultural land, i.e. 85'128ha, are irrigated rice fields. With 5,5 t/ha Bali yields the highest harvests of rice in Indonesia, producing a predicted 792,463 tons of rice in 2005.[2] Besides the high fertility of the volcanic soils, Balinese rice farmers' success is also due to the long standing socio-religious agricultural organisations called *subak*.

The *subak* system has grown over a thousand years, constantly adjusting to changing situations. The result is an intricate system which is strongly interlinked with Bali's natural, social, cultural and religious environment.

In a first section of this paper the Balinese *subak* is explained using the theories of socio-ecological systems with a special focus on the social constituents - the individuals and institutions which set the "rules of the game". In the following section the working of the *subak* system, its sub-groups the munduk, and the inter-*subak* federation *subak-gede* are explained.

In the recent past, government irrigation and agricultural projects have tried to increase rice production. But since they neglected the complicated constellation of Balinese irrigation the result were substantial disturbances. This paper discusses the lessons learned from the past and analyses how the *subak* and its institutional framework coped with the changes made.

At the present time, the *subak* are still very much alive manifested by the picturesque sights of the island's abundance of rice terraces with their intricate patterns of canals, ditches, weirs and water division structures (Spiertz, 2000, Mitchell, 1994). However, increasing off-farm employment opportunities are challenging the relevance and vitality of the *subak* once more. The authors explore a present day case study of five *subak* which share a common weir. External factors that challenge the *subak* nowadays are discussed by means of two examples, the government initiated *subak-gede* and growing off-farm employment opportunities for farmers. Conflict solutions and responses to disturbances on the munduk level are demonstrated.

Balinese irrigation as a social-ecological system

The interesting thing about the Balinese *Subak* is that on the one hand it doesn't seem to fit into the models of a centralised irrigation management, but at the same time, it also doesn't really fit into a decentralised, headless management model. It is some sort of small-scale interconnection of sub-systems, which are part of a larger group with strict and formal rules informal regulations. It was originally built on a shared model with a long history, adapted over several centuries to meet the needs of the rice farmers. Then it was modified through the Dutch and the Indonesian governments. The different *subak* dimensions might be linked

[1] GRDP is the Gross Regional Domestic Product. Source: BPS Statistics of Bali Province, 2001.

[2] Source: BPS Statistics Indonesia, Land Utilisation by Province, 2000, yield rates of rice, 2002 and forecast production of paddy by Province, 2005.

together, but not necessarily as a centralised organism. How are we, then, to understand the *subak*, acknowledging the dynamic of the Balinese irrigation system?

To understand the different dimensions of an irrigation system with several actors involved the authors follow the concept of socio-ecological systems. This conceptual framework which is discussed by various authors (Holling, 1973, Redman et al., 2002, Walker et al., 2002), explicitly advocates that what is often divided into natural and human systems, be considered a single complex adaptive system. The concept also refers to systems in which the organisational dimensions and the interactions between these dimensions constantly try to adapt to internal and external changes (Holland, 1995).

In socio-ecological systems the social constituents are the individuals and the institutions. Individuals change their strategies, change their human relationships and change the rules they are using. However, individuals cannot choose freely. They make choices within an institutional framework. Institutions set the "rules of the game" of a given society. They reduce uncertainty in human relations through specifying the structure within which individuals are free to perform strategic moves. Institutions therefore include any socially constructed constraint to define what individuals are prohibited from doing and under what circumstances they are permitted to undertake activities (North, 1990, Ostrom, 1992). Institutions are the networks of interrelated rules and norms that support social relationships, comprising the formal and informal social constraints that shape the alternative choices of actors. Norms are the implicit or explicit rules of expected behaviour that embody the interests and preferences of the members of a group or a community. So, choice is situated within a social matrix. Thus, to understand a social-ecological system one has to focus on institutions and individual action.

Further, a social-ecological irrigation system must be seen as a nested structure of several sub-systems. The sub-systems are semi-autonomous, but strong interaction between them occur (Gunderson and Holling, 2002). This is important to emphasise in relation to development projects with the incentive to motivate changes to optimise or even sustain an irrigation system. Generally, one can distinguish between endogenous and exogenous irrigation design and development (Boelens, 1998). The former design originates from the system users themselves and evolves over time to adjust and adapt to changes. In the latter, the system users are not the inventors, but the irrigation design originates from external sources. Such interventions into an existing irrigation system have to be done very carefully. It is crucial that newly introduced technology or organisational structures show a flexibility to adjust to the already existing structures. Socially and culturally embedded irrigation management practices, as well as normative and organisational structures need time to adjust and adapt to newly implemented structures. Project initiators often have technically or policy driven incentives and lack time, financial means and willingness to adjust system improvements to local irrigation structures.

Local users may have invested in the development of rules over a long period of time. Moreover, many of the farmer-managed irrigation systems achieve high levels of effectiveness whose physical appearance seems to be outdated to many contemporary engineers. If improvements are intended to be made in the operation and maintenance of such existing irrigation system, two important factors have to be considered. Firstly, the crafting of irrigation institutions is an ongoing process and secondly, all the actors involved in the supply and use of irrigation water need to be included throughout the process (Ostrom, 1992).

Understanding the subak

Balinese rice cultivation is famous all over the world for its efficient use of irrigation water. At the heart of irrigation management are the water user associations called *subak*. They are the backbone of Balinese rice cultivation.

Subak has been described by several authors. It is commonly recognised as an autonomous socio-religious association which deals with matters related to the cultivation and irrigation of rice (Sutawan 2000). They have evolved over centuries, organised by the farmers themselves without (or little) guidance from central authorities. The *subak* are considered to be one of the most effective irrigator organisations in the world (Ostrom, 1992).

The *subak* is a mixture of different units:

- Technologically, it includes a dam and an intricate system of collectively owned irrigation canals.
- Physically, it comprises all rice terraces within clearly defined *subak* boundaries. These boundaries are defined by all rice fields which receive irrigation water from the *subak* irrigation infrastructure.
- Socially, it consists of all farmers who cultivate land within the *subak* boundaries and receive water from the *subak* irrigation infrastructure.
- Religiously, it includes ceremonies on the individual level, the *subak* level, and the inter-*subak* level. The ceremonies are linked to a hierarchical order of water temples which play an important role in the coordination of irrigation water and pest management (Geertz, 1972; Lansing, 1991; Pitana, 1993; Sutawan, 2000).

Every farmer owning or sharecropping land within the *subak* boundaries is automatically a member. The *subak* secures equal access to irrigated water which is diverted to the fields through an intricate system of canals. Responsibilities and duties for *subak* communal work such as the maintenance of the canals are equally distributed regardless of social status (Dinas PU, 1997). Next to the reduction of labour and time for the individual farmer the *subak* structure also allows a coordinated planting cycle with all its members planting rice at the same time. The synchronisation of rice planting over large areas minimises growth and dispersal of pests and makes pest control more effective (Lansing, and Kremer, 1993, Aryawan et al. 1993).

The general Balinese philosophy guiding the *subak* system adheres to the principle of *Tri Hita Karana* which emphasises that happiness can only be reached if the Creator (God), the people (the farmers) and nature (the rice fields) live in harmony with each other. Based on this philosophy are the ceremonies which are a substantial part of the rice cultivation cycle. The ceremonies are carried out at the various temples which are associated with the *subak*. They are organised hierarchically from the simple shrine at the individual water inlet to the Bali-wide inter-*subak* temple at the crater lake Batur, the most sacred lake in Bali (Pitana, 2005).

The *Tri Hita Karana* philosophy is also the basis for the clearly defined rules of a *subak*, called awig-awig. This set of laws regulates rights and duties among the members. It includes public obligations, regulations concerning land and water use, legal transactions of land transfers, and collective religious ceremonies. For instance, all members have the right to the same share of water at all times. This principle of equitable water sharing is put into action by fixed proportional flow division structures.

Subak internal matters are handled by the pekaseh, the *subak* head who is democratically elected by all members of the *subak*. He is responsible to overlook the irrigation management within the *subak* area, to schedule cultivation cycles and to organise *subak* ceremonies. He is supported by several assistants, such as the secretary, the treasurer, the messenger and the heads of the sub-*subak* groups. Bigger *subak* are divided into sub-groups, called munduk. Munduk may have a separate inlet from the *subak* main canal. A munduk usually comprises an average of 20 to 40 farmers.

Every munduk is headed by a pengliman who receives direct orders from the pekaseh and is responsible for all matters related to the munduk. As a sub-group of the *subak*, the munduk has to follow the *subak* rules and regulations. However, certain organisational and water management issues can be decided autonomously on the munduk level. The munduk is an important dimension within the *subak*. Day-to-day cultivation decisions are made on this level and provide the fine-tuning of the *subak* water and crop management – not always following the *subak* laws by doing this.

The relationship between *subak* and munduk is to facilitate top down and bottom up information flow.

The *subak-gede*

Water management in Bali is not only a matter of distributing water among farmers within a *subak*, but also among several *subak* in a river course (Pitana 2005). In a river stream there are usually dozens of *subak*. Often, several *subak* share a dam. The water is then divided through diversion weirs further down into the single *subak*. To improve irrigation water management and coordination the government implemented another irrigation management level in 1981, a federation of several *subak* which share irrigation infrastructure. They were called *subak* gede.[3] The term *subak-gede* has been known already during the period of the Dutch occupation and means literally large *subak* (Sutawan, 2000). The strengthening of the inter-*subak* institutions brought benefits to the irrigation system. However, as we will discuss later, the implementation of a new water management level is also influencing informal institutions between the various *subak*, and it affects working rules right down to the farmer's level.

Description of the study site

The five *subak* that we have chosen for this case study form together a government motivated federation called *subak-gede*. This *subak-gede* was founded 1996 as a pilot project in the Regency of Badung within the government project IPAIR ("Irrigation Premium Service"). The goal of the IPAIR project was to reduce costs in administration, and hand over operation and maintenance (O&M) responsibilities to the federation.

The main responsibility of the *subak-gede* is optimal water distribution amongst the five *subak*. The *subak* heads come together several times per year to discuss how the water is distributed for the next few months. As irrigation water is the crucial ecological variable, the cultivation cycles have to be staggered within the five *subak*. Also, the regular face-to-face

[3] Not all of the existing "*subak-gede*" are newly government created institutions. There are many *subak-gede* that were created by *subak* themselves, not only those sharing a single dam but along one or more river courses as well.

interaction among the five *subak* heads allows greater flexibility in water management during times of water shortage.

The establishment of the *subak-gede* has enabled the *subak* heads to coordinate and prepare certain larger rice cultivation ceremonies together and therefore reduce time and labour input as well as expenditures.

The irrigation infrastructure feeds 738ha rice fields. It is divided into primary, secondary, tertiary and quaternary canals. As *table 1* shows, the O&M is hierarchically ordered within the irrigation system. The responsibility of O&M of the primary canal lies with the *subak-gede*. This is because all five *subak* are fed by this canal. The secondary canals lie in *subak* territory and thus the O&M is the responsibility of every individual *subak*. The tertiary canals are operated and maintained by the munduk who receive the water from these canals. The quaternary canals lead into the single rice fields and are the responsibility of the individual farmers.

Table 1 - Irrigation Infrastructure subak-gede

Infrastructure	**Total Length**	**Percentage concreted**	**Percentage tunnelled**	**Responsibility for O&M**
Primary canal	2.3km	22%	17% (or 400m)	*subak-gede*
Secondary canals	15.2km	22%	0	*subak*
Tertiary and Quaternary canals	95km	0	0	munduk (tertiary) and farmer (quaternary)

Source: Regional Dept. of Public Works, Badung, Denpasar

Renovations on all canals are organised in communal work on each of the different levels. In case of larger renovations works on the primary and secondary canal, the *subak-gede* or the *subak* can apply for financial support from the government to cover costs for material.

Green Revolution and Bali Irrigation Project – changes to the traditional system and increased government interventions

New high yielding rice varieties (HYV) were introduced in Bali around 1968-69. In the late 1970s, HYVs were grown in most of the suitable rice growing areas. Farmers were encouraged to plant rice as quickly as possible, without considering traditional irrigation schedules (Lansing, 1991, Pringle, 2004) and cropping patterns (Sutawan, 2000). The commonly used crop rotation rice-rice-palawija (secondary crop) was abandoned. Farmers planted up to six times rice in two years. Fallow periods were neglected. Hence yields per hectare were substantially increased (Drysdale and Zimmerman, 1995, Pringle, 2004). Yet, the Green Revolution has been a mixed blessing. The immediate gains in rice yields were offset by water shortages and unprecedented outbreaks of rice pests and diseases (Lansing, 1991, Sutawan, 2000, Pringle, 2004).

It was Lansing (1991) who revealed the function and importance of the water temples and convinced the Indonesian Government to encourage farmers to return to the traditional *subak* rice farming system. The hierarchical order of the water temples and the complex Balinese calendar play a central role in regulating the timing of offerings and allow for different levels of coordination, from the farming level, to the regional level, right up to the temple at the crater lake, the most important temple in relation to rice cultivation. By 1983, farmers had returned to their coordinated cultivation cycles, irrigation schedules and traditional rotational cropping patterns (Sutawan 2000).

A second intensification program launched by the Indonesian Government was a large irrigation improvement project. The “Bali Irrigation Project” (BIP) was introduced 1979. The BIP, financed by the Asian Development Bank, focused on the rehabilitation and expansion of irrigation facilities. Independent smaller irrigation systems with their previously own intake were physically integrated into single irrigation systems sharing new common permanent weirs (Sutawan, 2000). Problems started when the merged *subak* quarrelled over water allocation, rights and duties. The new irrigation system did not suit former water distribution which has developed over centuries. Sometimes the quarrels went so far that some *subak* abandoned the new irrigation structure by recreating the old canals. Similar to the Green Revolution, the BIP was only a partial success. Although existing irrigation systems were improved, new irrigation areas developed and operation and maintenance costs for farmers reduced, it did not suit into the long established informal institutional frame. The BIP did not recognise the complexity of long-standing water rights negotiated among *subak* along a river or of how contentious it was to form new relationships (ABD, 1997).

In response to the communication and coordination difficulties among the newly created *subak* groups the Udayana University together with the Balinese government agencies developed a participatory approach. This approach was used to assist *subak* in forming federations, so-called *subak-gede*. The new federations provided the organisational structure necessary for the *subak* to maintain their independence within *subak* activities. At the same time it allowed them to act jointly on decisions and activities that affected the larger group. It also provided a mechanism for conflict resolution (Sutawan, 2000).

In the beginning, both the Green Revolution and BIP irrigation and agricultural engineers failed to understand Balinese irrigation as part of a complex ecological system intimately woven into Balinese social live. The top-down management models introduced by the intensification and irrigation programs conflicted with the traditional *subak* system which builds upon democratic values. Irrigation and crop management was seen as a purely technological matter. The role of the water temples and its relative invisibility for irrigation experts shows how the irrigation system has evolved over a long period of time constantly adapting at different levels of scale. The technological and managerial change accompanying the Green Revolution and the Bali Irrigation Project did not take the local water rights, ecology, formal and informal institution into account. The system could not adapt fast enough to the imposed changes and thus broke down.

A re-evaluation made by the Asian Development Bank on BIP summarises the consequences of the Green Revolution and the BIP nicely: “…The designers’ limited understanding of farmer-managed hill irrigation and key physical and socio-cultural traits resulted in shortcomings of the project. *Subak* capabilities for operation and maintenance were weakened due to the Project…”

These two examples show in different ways how the inter-relations of institutional levels play a major role in the traditional Balinese irrigation system. In one case the management level of the water temples has been neglected. With the return to the water temples the system could recover. In the other case the complexity of traditional water rights and with it the missing inter-*subak* institutional framework was not taken seriously. With the introduction of *subak* federations, involving the farmers into process, the inter-*subak* institutions were strengthened and the system also could recover.

Institutional dynamics

The two cases discussed above led to severe system disturbances at a watershed level and at the *subak* level. Pest outbreaks, coordination insufficiencies, inter-*subak* conflicts are some of them. We shall now discuss changes at the farming level by means of two different external influences.

First, we discuss how the newly created *subak-gede* impacts on irrigation and cultivation management at the farming level. As mentioned above, there are three formally recognised organisations: the *subak-gede*, the *subak*, and the munduk. The *subak* including the munduk grew out of tradition and culture, adapting and changing over a long period of time. The *subak-gede*, on the contrary, is a newly created government initiated organisation.

The question is, how well was this new organisation accepted by the single farmers and have there been any improvements in regard to the irrigation management on the whole? What are the consequences for the farmers in a munduk, if a decision is made on the *subak-gede* level? How well are such decisions accepted? The following section analyses the dynamics between the three different levels including single farmers' or farming groups' perception and actions on the munduk level.

In the second part, we look at how increasing off-farm employment influences the *subak* system. Thus, adjustments of the working rules on the farming level are not triggered by changes on higher levels of the irrigation system. The changes come from outside agriculture in form of increasing living costs and off-farm employment opportunities.

The effects of the *subak-gede*

Since the founding year in 1996 the *subak-gede* has developed into a government independent organisation, lead by a senior pekaseh who is chosen every five years by the five *subak* heads. The newly implemented structure of this federation facilitates a better coordination of the water distribution to the five *subak*. The *subak-gede* has also started to take on responsibilities for major religious ceremonies which helped to reduce labour, costs and time for the single *subak*. While the structure of the *subak-gede* is predestined to take over such tasks, it was not on the government's priority list when initiating the organisation. As mentioned above the Government incentives were to improve irrigation water management and administrative procedures.

Every three to four months the five pekaseh meet to negotiate water allocation for the next cultivation period. Although the meeting is held in a rather informal way, the decisions have a considerable impact on the farmers of the *subak*. During the dry season, for instance, there is not sufficient water available to be delivered to all the five *subak* at the same time. Hence, cultivation on the *subak-gede* level is staggered with 21 days as the decided staggering time.[4] This should give each *subak* a greater share of water during the ploughing period when large amount of irrigation water is necessary.

There are two major problems with this rotational schedule. Ideally, all farmers transplant the seedlings within one week. Or at least within the 21 days, since thereafter, water will be considerably reduced to allow the next *subak* to start the ploughing. Often these 21 days are not enough to prepare all the rice fields in one *subak* for transplanting. This is due to a shortage of hand-tractors and in one of the five *subak* also due to a shortage of irrigation water.[5] It can take up to five weeks until all rice fields of one *subak* are ploughed and prepared. The consequence is that the cultivation cycle is not synchronised anymore and the effectiveness of integrated pest control may be considerably reduced. If all farmers grow rice simultaneously, pesticides will be also applied at the same time. Consequently pests can't travel from field to field. Also, live cycles of pests can be interrupted.

Further, there are environmental variables which play an important role. The best time to start rice cultivation in this area during the dry season is June and July[6]. April and May are transitional months with still considerable amounts of rain and higher temperature. These are good conditions for pests and diseases. Also, farmers prefer to harvest the rice before the beginning of the rainy season which starts in October.

This year's dry season cultivation and the rotation schedule of the irrigation water were discussed at the last meeting of the *subak-gede* early this year. The subject on when and which *subak* will start first was a delicate matter. Decisions were made, and the first *subak* was to sow their seeds at the last day of April. Many farmers were concerned when they heard that they have to start cultivating that early. The pekaseh argued that most of the *subak* in the area will harvest in September or October. Since they will already harvest in mid-August, the market won't be flooded with rice, thus the farmers can negotiate higher prices.

Table 2 shows the five *subak* staggering the cultivation cycle over this year's dry season. Delays as described above have been included.

As a matter of fact, the *subak* which cultivated first, faced major pest problems with some farmers having to replant seedlings. The second still had pest problems but not as bad as the first *subak*. The other three *subak* did not complain about pest problems.

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[4] This means the second *subak* starts planting rice 21 days after the first, the third starts planting 21 days after the second and so on.

[5] Farmers from this one *subak* claim, that at the time of construction of the diversion weir, the inlet to their *subak* was made too small and hence, water shortages are a recurrent problem.

[6] The preferred high yielding variety during the dry season is IR 64 which has a cultivation period of 115 days. The variety is resistant to the brown and green planthopper and several diseases, has a high and stable yield and tastes better than other high yielding varieties. (Source: Centre for Rice seed propagation, Indonesia, 1998)

Table 2 – Staggering of the cultivation cycle in a subak-gede

			subak1	subak2	subak3	subak4	subak5
Rains		wk12					
	28.3.	wk13					
	April	wk14	**SOW**				
Dry Season		wk15	delayS				
		wk16	delayS				
	25.4.	wk17	**TRANS**	**SOW**			
	May	wk18	delayT	delayS			
		wk19	delayT	delayS			
		wk20	delayT	**TRANS**	**SOW**		
	23.5.	wk21		delayT	delayS		
	June	wk22		delayT	delayS		
		wk23		delayT	**TRANS**	**SOW**	
		wk24			delayT	delayS	
	20.6.	wk25			delayT	delayS	
		wk26			delayT	**TRANS**	**SOW**
	July	wk27				delayT	delayS
		wk28				delayT	delayS
	18.7.	wk29				delayT	**TRANS**
		wk30					delayT
	Aug	wk31					delayT
		wk32	**HARVEST**				delayT
	15.8.	wk33	delayH				
		wk34	delayH				
	Sept	wk35	delayH	**HARVEST**			
		wk36		delayH			
	12.9.	wk37		delayH			
		wk38		delayH	**HARVEST**		
		wk39			delayH		
	Oct	wk40			delayH		
Rain	10.10.	wk41			delayH	**HARVEST**	
		wk42				delayH	
		wk43				delayH	
	Nov	wk44				delayH	**HARVEST**
	7.11.	wk45					delayH
		wk46					delayH
		wk47					delayH

Legend:

SOW = sowing

TRANS = transplanting

HARVEST = time of harvest

delayS = farmers sowing with delay

delayT = farmers transplanting with delay

delayH = farmers harvesting with delay

(blue line) = irrigation water needs

The uncertainty and fear of loss of harvest triggered different reactions within the farming community. Farmers turned active and creative in trying to deal with the insecurity, often stretching the *subak* regulations as far as possible. Many decided to cultivate a variety which only has 90 days instead of 115 days until harvest. This meant that they could push back the cultivation for up to 25 days and bring them closer to June. To avoid being blamed of not following the *subak* regulations in planting together[7], they argued that the ploughing of the rice fields was not yet finalised and planting couldn't take place. As the munduk is allowed to make decisions on ploughing on their own, one munduk decided to push back the ploughing of the whole munduk by 15 days. Other farmers cultivated peanuts on 10 are and rice on the rest of the fields. This breaks *subak* law because during the main rice cultivation season

[7] Traditionally, the farmers had to transplant the seedlings within one week, beginning with the pekaseh. However, due to the shortage of tractors and water this is not possible anymore.

(Kerta Masa), all farmers have to cultivate rice.[8] However, it is socially accepted to do this, especially if water shortage is expected.

The *subak-gede* has been integrated into the *subak* system without major problems. Nevertheless, the example above shows that changes on the inter-*subak* level trigger reactions on the farming level. *Subak* laws are broken or interpreted in a way that suited the problems the farmers were facing. However, the *subak* system does not react overly sensitive to these rule breakings. This can be seen as the strength of the system as it leaves space for the farmer to do the fine-tuning, reacting to expected and unexpected problems.

The following section looks more closely at bottom level decisions and their influence on the other two levels, the *subak* and the *subak-gede*. Two phenomena in particular have been observed in the field site which are described below. Both are due to increased off-farm activities/opportunities. These are the abandoning of traditional cropping patterns and the manipulation of water distribution.

The effect on the *subak* through increased off-farm activities/opportunities

The Balinese living standard is higher than in the rest of Indonesia. With it come the expenditures of modern life, like electricity, schooling, medical expenses and petrol for the motorbike. Additionally, the vast Hindu-Balinese ceremonies as well as the financial obligations towards the hamlet[9] are a financial burden for Balinese. Higher income in off-farm employment, mainly casual work in construction, creates incentives for farmers to spend more time off the rice fields. There is a visible shift from on-farm activities as main income source to planting rice as a side business. With an average size of 0.3 hectares the workload is manageable and allows spending time in other occupations. The day-to-day routine visits to the rice fields to check the waterflow is left to the older generation. Most farmers are over 50 years old. Only a few young farmers put up with the low income and status attached to being a farmer. This has ecological and social consequences for the *subak* system.

Abandoning the traditional cropping pattern

The commonly used crop rotation of rice-rice-palawija within the *subak* is slowly but steadily abandoned. The reason for the push towards cultivating rice as many times as possible is that palawija or secondary crops are more labour intensive than rice. Besides, income from secondary crops is only marginally higher if at all. Farmers who have the chance to work off-farm are less willing to spend time on the field. Rice therefore becomes the preferred crop. On the other hand, the farmers who rely on on-farm activities as a principal source of income would like to keep the traditional cropping pattern. They fear the threat of increasing pest population and decreasing soil quality with the continuous cropping of rice only. They argue that shifting away from the “healthy” traditional cropping pattern means neglecting the fundamental Balinese philosophy *Tri Hita Karana* - the balanced harmonious relationship between the supernatural world, the natural environment and the human beings is at stake.

[8] Exception can be made on small fields with water problems if the pekaseh allows it.

[9] Every family within a Balinese hamlet has to contribute financially to the maintenance of buildings which are owned by the hamlet. These include temples, meeting halls, streets.

Naturally there are two side to the coin. On the one hand the concept of balance is central in Balinese thinking. Whereas Westerners mostly thin of the world in terms of opposites the Balinese add the dimension of the centre which balances the opposites.[10] This tripartite of the opposites and the centre constitute the whole. As Eiseman (1990) writes: "This grouping of three, or *Tri Hita Karana*, governs ideology and activities as grand as cosmology, and as humble as building a toilet." The life of Balinese is devoted to maintain the equilibrium between the opposites. If this equilibrium is lost sickness, illness, or even natural catastrophes can occur. On the other hand, fulltime farmers, as described in the next paragraph, instrumentalise the concept of *Tri Hita Karana* to manipulate waterflow for their own gain.

Borrowing of water

As described in the previous section, fixed proportional flow division structures guarantee an equitable share of water amongst all members. Theoretically, the farmers are not allowed to manipulate the division structures. In reality, manipulation takes place.[11] Full time farmers often feel entitled to a greater share of irrigation water. This is especially the case in the early stages of the rice plant where water is the crucial variable. However, there is a socially regulated strict distinction between water stealing and water "borrowing". The manipulation of the water flow is labelled as "borrowing" as long as the farmer stays next to his water inlet and returns the flow to normal before going home. If the water-flow is not returned to normal again a farmer will be accused of stealing water. Full time farmers can spend more time in the rice field and consequently have more time to manipulate the water share if needed than farmers who are busy off-farm.

On the whole, "borrowing" water is an accepted and widely practiced informal institution. In contrast, stealing seldom occurs. Social control and the strong sense of the necessity of cooperation in the rice field hinder the farmers to step over the thin line between "borrowing" and stealing water. In this case, everyday face-to-face interactions between the farmers on the munduk level play a more important role then *subak* regulations. It is not the *subak* fines which the farmers want to avoid, it is the fear of being known as a water stealer within the own social group. It is the social relationships which influence the farmers' decisions and actions regarding cultivation, irrigation management and cooperation in the munduk. As a consequence, informal institutional arrangements become more frequent, not necessarily following the formal regulation of the *subak* system. Water stealing occurs, but is dealt with on the spot by the farmers who are affected.

Conclusion

This paper discusses two examples of how the farming level deals with internal and external pressures on different institutional levels. As Holland (1995) points out, socio-ecological systems constantly try to adapt to internal and external changes. This is also the case with the Balinese *subak*.

On the whole, water is the critical ecological variable in the *subak* system. The availability of water defines the cultivation cycle, impacts on the time the farmers have to spend on the rice

[10] The Balinese still have a notion of polarity called "rwa bineda", but the oppositions are not so extrem and not at all mutually exclusive.

[11] By closing other farmers' inlets and half of the weir just after the individual inlet, the flow of water into the field can be considerably increased.

fields, and influences the yield. Traditionally it was the responsibility of the pekaseh to provide his *subak* with sufficient water by enforcing *subak* law and protecting the *subak* from any outside disturbances. In the present case, however, cultivation cycles were not coordinated in direct communication amongst the *subak*, even though they are sharing a common weir. With the creation of the *subak-gede*, water allocation amongst the *subak* has been institutionalised. However, this comes with the cost that not all *subak* can cultivate rice at the best time of the year.

The decisions made by the pekaseh impacts on the farmer and thus also impacts on the incentives of the farmers. Incentives ask for new informal regulations between the farmers because this is the level were conflicts and disturbances are solved. Although the *subak* laws have conflict resolution mechanisms, they are hardly ever used. They are important to provide a framework, but cultural values such as *Tri Hita Karana* and a strong sense for community and cooperation are the parameters. They set the “rules of the game” with which the farmers make their decisions and fine-tune the *subak* system so famed all over the world.

Improvements to already long existing irrigation systems are important and necessary. However, as several authors (Ostrom, 1992, Boelens, 1998) emphasise, it is important to constantly monitor the reaction of the system and include the individuals who are part of the system’s decision-making. Changes create new incentives for individuals and these new incentives feed back into the system by manipulating the institutional settings and making certain rule-breakings socially accepted.

To understand a system such as the *subak*, one has to understand the inter-relatedness of the different dimensions and the autonomy of these. The Balinese *subak* system is interwoven with social dynamics and cultural values, often not visible at first sight. However, the institutions as the “rules of the game” allow the farmers to make decisions balancing formal regulations with socially accepted actions.

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