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Challenges to community participation in watershed management: an analysis of fish farming activities at Saguling Reservoir, West Java – Indonesia

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Abstract

Community participation is a precondition of integrated watershed management. However, during the implementation phases, some people may not participate in or share the benefits of watershed management. There are several reasons for this and the following paper seeks to show the response by fish farmers from Saguling Reservoir, West Java, Indonesia, to environmental problems and the concept of integrated watershed management. The study indicates that while farmers have a moderate understanding of interrelated environmental problems, there is little willingness to share the benefits of investment in watershed management. Nevertheless participation in solving local environmental problems can be developed and incorporated in watershed management plans.

Keywords: Aquaculture; Community participation; Indonesia; Lake management; Water pollution; Watershed management; West Java

1. Introduction

Incorporation of stakeholder participation in watershed management in order to achieve better watersheds has become a major topic of discussion among scientists, planners, government and non-government organizations in Indonesia. This is probably motivated by the poor results recorded in many watershed projects. Johnson, Ravnborg, Westerman & Probst (2001) reveal that many watershed developments around the world emphasize coercion and subsidies and have often performed poorly or resulted in failure because they fail to take into account the needs, constraints and practices of local people.

In most southeast Asian countries, watershed protection has been the overt objective of a great deal of government policy dealing with management of upland areas (Swallow, Garrity & van Noordwijk, 2001). In many cases, watershed projects ask the poor people who use upper watersheds to provide an environmental service for their wealthier neighbors in lower watersheds (Kerr, 2002). When this is not accompanied by appropriate compensation to the people in upland areas, watershed projects face difficulties during implementation.

Difficulties in the implementation of watershed management also relate to the complex characteristics of the watersheds: multiple communities may use upper and lower reaches for multiple purposes; watershed resources provide different services to different users; and users are affected differently by resource use decisions (Kerr, 2002; Johnson *et al*., 2001).

To make watershed development more successful and sustainable, participation of the stakeholders, for example local people, is therefore an important issue. Development should therefore also involve, not only people in the upper reaches, but also those in the lower reaches. Thus the present study describes the perceptions of people of environmental problems and their willingness to share the benefits of watershed management investment in the Upper Citarum Watershed, West Java, Indonesia. In order to obtain an understanding of the needs, constraints and practices of the people, the study focuses on those living in the lower reaches and deals with a community engaged in aquaculture activity in Saguling Reservoir. In the context of watersheds, the reservoir is located in the lower reaches of the Upper Citarum Watershed (Figure 1).

2. Scope of the study

The Saguling Reservoir is located about 30 km to the west of Bandung. Commissioned in (1985, the main purpose of the reservoir is to generate electricity. It also functions to control floods and serve as a venue for tourism. The development of Saguling Reservoir involved acquisition of around 6,000-hectares of land, displacement of 3,038 families from the inundated area and affected another 7,626 families living in the inundation-free area but with land and source of income in the inundated area.

In response to dam construction-related social problems, the government (i.e. Perseroan Terbatas Perusahaan Listrik Negara/PT. PLN, or the State Electric Company in cooperation with the West Java Provincial Fishery Office), the International Center for Living Aquatic Resources Management (ICLARM) and the Institute of Ecology (IOE)-Padjadjaran University, developed the floating net cage culture (FNCC) aquaculture system at Saguling Reservoir as part of the resettlement program (Figure 2).

The FNCC aquaculture system development in Saguling Reservoir is considered to be an appropriate way to reduce related social problems that appeared as a consequence of the displacement of the people. Costa-pierce (1997) regards the resettlement schemes for the Saguling Reservoir project as highly successful, particularly because aquaculture projects located at the reservoir created jobs for resettlers as well as provided them with better incomes. Nakayama, Yoshida & Gunawan (2000) suggest this may answer the growing concerns of many people concerning ecological and social issues relating to dam construction. Criticism of this kind was noted by the World Commision on Dams (2000).

Apart from its weaknesses involving many affected people as owners (Gunawan, 1992; Nakayama *et al*., 2000; Nakayama, Yoshida & Gunawan, 1999), FNCC activity has continued to grow and has even exceeded maximum estimated numbers (PT. PLN, 1998). Nevertheless, FNCC is a high-risk

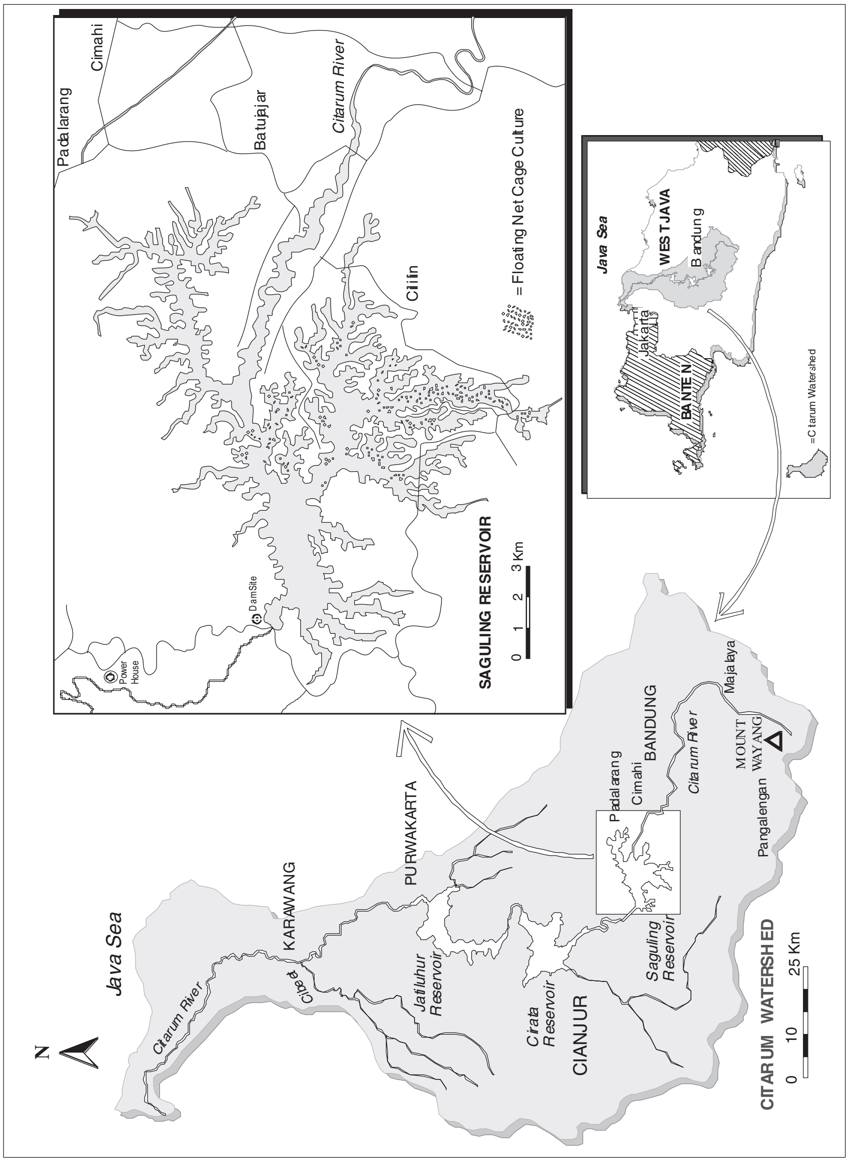

Fig. 1. Location of the Saguling Reservoir.

Fig. 2. Floating net cage culture in Saguling Reservoir.

aquaculture activity (Gunawan, 1992). Water quality-related massive fish mortality is the dominant problem facing fish farmers and the number of fish deaths have risen as fish production increased.

In the context of watersheds, the Saguling Reservoir, particularly its water quality, is highly dependent on catchment conditions. Toxic and nutrient-rich content water from the urban and industrial area in the Bandung Plain and agricultural activities in the upland area of the Upper Citarum Watershed that flows through to the reservoir via the Citarum River have witnessed hyperthrophic conditions in the reservoir (Soemarwoto, Roem, Herawati & Costa-Pierce, 1990; PT. PLN, 1998; Institute of Ecology (IOE), 1997–2002). This hyperthrophic condition may lead to economically unfavorable conditions in FNCC aquaculture activities.

One proposed solution to the problem of degraded water quality in Saguling Reservoir is to improve the environmental condition of its catchment area. Integrated watershed management should therefore be planned and implemented. However participation of stakeholders remains a precondition within this integrated management system. PT. PLN (1998) argues that public involvement is crucial. Further, it stresses that watershed management will only take place if people understand the necessity for the measures and behave accordingly. In this respect, environmental awareness of the general public is possibly the most important issue, especially in the long term. Without public awareness, most of the measures will not produce the expected results. According to Pretty & Shah (1999) and Johnson *et al.* (2001), this notion is in line with the assumption stating that local people are unaware of the environmental problems and are ignorant of causes and consequences. In contrast to this assumption, they argue that more often than not, this turns out to be false.

With regard to the notion of community participation in the management of the upper watershed, this paper discusses the relationship between the understanding of the environmental problems and the willingness to share the benefits of the watershed conservation program among the fish farming community in Saguling Reservoir, as well as factors causing this situation. Specifically, the study describes the present status of water quality, the current status of FNCC development and the perception of fish farmers concerning the environment and their response to the conservation and management of the Upper Citarum Watershed.

3. Methods

The study was conducted by interviewing a sample of 155 randomly selected fish farmers using an interview schedule. Prior to interviewing the selected sample, interviews with purposively selected informants were carried out to obtain information regarding the general patterns of fish cultivation systems, problems and other related issues. Observations were also made to confirm or gather data that could not be collected through interview. Information on the physical characteristics of the area was collected from secondary sources. In analyzing the data, statistical analysis of the correlation between variables was applied to indicate the association between one variable, that is, the willingness to participate/pay and other related variables, such as the perceptions of fish farmers concerning the lake environment, experience of fish mortality in the past, etc.

4. The Saguling Reservoir

4.1. Water quality status of Saguling Reservoir

The Saguling Reservoir has an unusual morphometry that may contain very high potential for the development of capture and culture fisheries. However, the reservoir ecosystem is currently threatened by sewage pollution from the Bandung-Cimahi-Padalarang urban complex. This has caused a less than optimal environment as indicated by the low dissolved oxygen (DO) required for optimum fish growth or toxic substances, which often exceed lethal thresholds and pose risks to aquaculture activity. It is a hypertrophic lake (Soemarwoto *et al*., 1990; PT. PLN, 1998). In line with this, based on quarterly monitoring data, the IOE (1997–2002) reported that the water quality status of the Saguling Reservoir in 1999–2002 was below standard. Government Regulation No.20/1990 notes that, in general, the water quality status of the reservoir is not suitable for fishery activities and is only suitable for industrial purposes.

Pollutants from industrial and urban complexes play a very significant role in causing the hyperthrophic condition of Saguling water. By 1997, it was estimated that the number of industries located in Bandung District exceeded 500 and were mostly textile factories. Saguling water is also polluted by agricultural waste from the upland area of the Upper Citarum Watershed. In this regard, PT. PLN (1998) estimates that nitrogen and phosphorous potentially removed by erosion from the soil of the basin of the Saguling Reservoir ranged from 6,460 to 187,652 tonne/yr and from 3,060 to 21,992 tonne/yr, respectively. This is much higher than the estimated nitrogen and phosphorus from drawdown agriculture in Saguling, which stand as 7 tonne/yr and 1.5 tonne/yr, respectively. Hart, van Dok & Djuangsih (2002) argue that nitrogen and phosphorous are considered to be the main contributors to the excessive plant growth and cyanobacterial problems observed in Saguling.

The huge estimated amounts of nitrogen and phosphorus seem to be consistent with the condition of the Upper Citarum Watershed, which is currently under a heavy burden owing to the intensification and expansion of upland agriculture activities for cashcrops. This is especially so over the last two decades (Gunawan, Parikesit & Abdoellah, in press) and has created severe soil erosion and sedimentation problems. In line with this, the estimated volume of soil erosion in a subwatershed of Upper Citarum Watershed is now 203 tonne/ha/year (Pacific Consultant International, 1998).

The problem of eutrophication in Saguling Reservoir is a common phenomenon occuring in lakes and/or rivers. Swallow *et al*. (2001) reveal that nutrient transport is a major concern in river basins that drain into lakes, such as Lake Victoria in East Africa. Similarly, Cameron (1997) wrote that the periodic outbreak of potentially toxic blue-algae in the Hawkesbury River, Australia, is a result of nutrient-enriched run-off.

4.2. Floating net cage culture development

As part of the resettlement program, FNCC commenced in 1986 at Saguling Dam shortly after the area was inundated for the generation of hydroelectric power. Although it was new to the people, it did not take long for them to adopt this system of fish raising (Gunawan, 1992). Figure 3 shows that FNCC numbers increased considerably within a ten-year period. The number of fish cages rose from 44 in 1986 and reached a peak of 8,199 in 1997 (Saguling-Cirata Technical Implementation Unit, undated; PT. PLN, 1998). As indicated by these figures, the number of cages remained constant at 4,225 during 1993–1996. Nevertheless, it is also believed that the number of cages increased during that period. Lack of recording seems to be the cause of this statistic remaining constant. By 1997, total FNCC in Saguling Reservoir exceeded the threshold recommended number of 4,870 cages. This recommended number is based on the assumption that 1 ha is sufficient for one fish cage.

PT. PLN (1998) reported, in 1997, that the total number of fish farmers owning FNCC stood at 1,042, with 27.8% owning up to four cages, 41.3% owning up to eight cages and the rest owning more than eight cages. It was also reported that some individual fish farmers owned more than 80 fish cages, even in 1991 (Gunawan, 1992). However the percentage of fish farmers owning between four and eight fish cages appears to remain stable, as elaborated below.

From 1998 onward, the total number of fish cages decreased. Many farmers quit this activity or, at least, let some of their cages go uncultivated. The Saguling-CirataTechnical Service Unit reported that in 1998 the number of fish cages in Saguling Dam was 6,932, belonging to 864 farmers. In line with this, the study indicates that by the middle of 2002, 54% of the sample group of farmers failed to cultivate about one-third of the cages (405 cages), compared to the total number of cages held by all respondents (1,234 cages).

Two major factors have led to the decrease in the number of fish cages, forcing farmers not to optimize usage of the cages:

1 Financial ability was affected by the monetary crisis that began to engulf Indonesia in 1997–1998. With regard to the FNCC activity in Saguling Reservoir, the crisis foreshadowed a significant rise in production costs, although it also increased fish selling prices. As shown in Table 1, in 1991–2002, seed price increased from 321% to 571% and feed price rose by 524%, while fish prices increased by only 290%. This implies that the increase in production costs (seed and feed), which was not accompanied by an increase in fish price at a relatively similar rate, led to a reduction in intrinsic profit value.
2 Occurrence of fish mortality caused by degraded water quality seems to have restrained farmers from optimal stocking of fish seed in their cages in order to avoid greater losses. Prior to the survey, in 2002, a new problem emerged: farmers raising common carp also incurred massive fish mortality as a result of the virus *Cyprinid herpes* and/or bacteria *Aeromonas*. This also influenced farmers not to stock their cages with these fish species, or at least reduce the amount of fish seed stocked in the cage. This issue is elaborated below.

Table 1. Price of seed, feed and fish (common carp) in 1988, 1991 and 2002.

Component	1988*	1991*	2002			
	IDR (kg)	IDR (kg)	88–91 (%)	IDR (kg)	88–02 (%)	91–02(%)
Seed	1,932	2,800	133	9,000–16,000	466–828	321–571
Feed	460	550	123	2,880	626	524
Fish	1,632	2,000	122.5	5,800	355	290

*Source: Gunawan (1992).

4.3. Massive fish mortality: a major problem in FNCC

The salient problem faced by fish farmers in FNCC activities is the massive fish mortality rate, particularly the common carp (*Cyprinus carpio*) and has occurred almost every year from 1986-1997. Figure 3 shows the incidence of fish mortality and the trend to increased numbers of dead fish in that period. The incidence of massive fish mortality was not officially reported in the period 1998–2001. However, interviews with key informants reveal that fish deaths still occurred and were experienced by individual fish farmers during this period, although figures were not as great as those recorded in 1993 or 1995. In line with this, the results of the survey indicate that 92.9% of fish farmers in the sample claimed they had suffered the effects of fish mortality, of which 34.8% had invested or re-invested in this aquaculture activity in 1998–2001. However, this incident was neither reported to, nor monitored by the government.

As mentioned earlier, the significant decrease in the incidence of major fish mortality seems to correlate with financial problems caused by the monetary crisis that restrained farmers from stocking cages with maximum levels of fish seed. Unintentionally, this also reduced the possibility of massive fish mortality. Cultivation of other pollutant-tolerant fish species such as *Oreochromis nilotica* or *Pangasius* has also led to a significant effect on the decrease in fish mortality. Nevertheless, large-scale fish mortality can still occur. In July 2003, the study witnessed a massive fish mortality; the estimated number of dead fish was more than 100 tons.

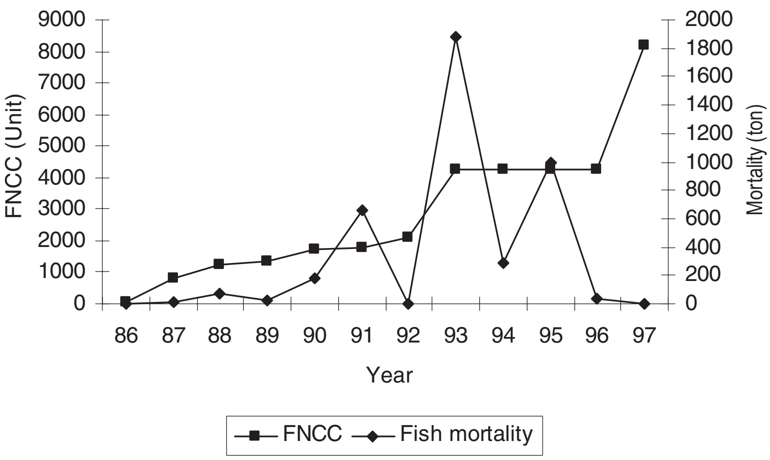

Fig. 3. FNCC growth and fish mortality, 1986–1997.

Before 2002, large-scale fish mortality was a water-related problem. But in 2002, the incidence of fish mortality was also related to other factors, such as the virus *Cyprinid herpes* and/or the bacteria *aeromonas*. In August 2002, the study found that 65.8% of the sample fish farmers suffered from virus/bacteria problems. The average number of dead fish was 841 kg.

With regard to water-related fish deaths, there are multiple dynamic mechanisms and biochemical processes enhancing the massive fish kills. While some of them can occur simultaneously, all are unpredictable (PT. PLN, 1998). In general, there are three causes of fish mortality: (1) dynamic causes, such as direct mixing of toxic substances carried by massive inflows of water from the Citarum river and other tributaries following storms and rain; (2) autopollution causes, where large amounts of organic sediment rich in nitrogen, phosphorus and sulfur accumulate under cages and can lead to outgassing of toxic hydrogen sulfide and methane gases which can bring anoxic water to the surface; and (3) biological causes, such as concurrent low oxygen and high concentration of non-dissociated ammonia (NH_3).

The number of fish reported dead between 1987 and 1997 stood at 4,839 tons. During this period, 35 cases of large fish kills were reported at Saguling Reservoir; 66% during typically wet months, October to March and 34% during April through September. Fish kills occur more frequently during the early hours of the day (4.00 a.m. to 6.00 a.m.). This is most possibly a result of the night consumption of dissolved oxygen (O_2) by the plankton and production of CO_2, both of which increase the depletion of O_2 (PT. PLN, 1998).

5. Floating net cage culture survey: involvement, perception and response of fish farmers

5.1. Socio-economic status of fish farmers

FNCC development was intended for people affected by the resettlement program. In relation to this, Gunawan (1992) indicates that, in 1991, the majority of fish cages in Saguling Reservoir were owned by local people. The present study shows consistent data indicating that the majority of farmers included in the sample are local people, particularly those affected directly or indirectly by construction of the dam. Table 2 shows that 74.8% of the sample fish farmers were those who—or whose parents—lost their agricultural land and/or houses.

For the majority of fish farmers, investment in aquaculture has become a major economic activity that supports their family: 70.3% have no agricultural land and rely solely on FNCC and other off-farm or FNCC-related activities for income, while the remainder (29.7%) own agricultural land as another income source, with areas ranging from less than 0.1 ha to more than 1 ha. The present study reveals that in 2002, the majority of fish farmers own/utilize from five to eight cages (Table 3). PT. PLN (1998) observed that owing to a monetary crisis—as confirmed by the study, the crisis has caused a significant

Table 2. Percentage of respondents affected by Saguling dam development in 1983–1985 (n = 155).

Loss of agricultural land	Loss of house/home garden: Yes	No	Parents'own	Total
Yes	25.9	9.0	0.6	35.5
No	0.6	25.2	0	25.8
Parents' own	0	5.8	32.9	38.7
Total	26.5	40.0	33.5	100.0

Table 3. Percentage of FNCC and land ownership, and year of involvement. (n = 155).

Year of involvement	Number of fish cages				Total
	1–4	5–8	9–12	12–28	
1987–1991	7.8	14.8	9.7	6.5	38.8
1992–1996	7.7	10.3	4.5	4.5	27.0
1997–2001	9.7	18.7	3.2	2.6	34.2
Total	25.2	43.9	17.4	13.5	100
Land ownership					
0	19.4	29.7	14.8	6.5	70.3
< 0.1 ha	1.3	1.3	1.3	–	3.9
< 0.25 ha	0.6	3.2	–	0.6	4.5
< 0.5 ha	0.6	7.1	0.6	0.6	9.0
< 1.0 ha	1.3	1.9	–	2.6	5.8
≤ 1.0 ha	1.9	0.6	0.6	3.2	6.5
Total	25.2	43.9	17.4	13.5	100

increase in feed price that was not accompanied by similar increase rate of fish price and the decrease of profit intrinsic value (see Table 1)—a fish farmer needed about eight cages to support his household economy. This number is double the number considered to be sufficient when FNCC was introduced, that is, four cages. Gunawan (1992) reveals that in 1991, ownership and effective utlization of three cages was sufficient to support a family of five household members. Meanwhile, PT. PLN notes at least one-quarter of fish farmers are unable to rely solely on FNCC to support their families and 19.4% of the 25.2% sample of fish farmers with 1–4 fishcages are landless.

5.2. Experience of fish mortality

As mentioned earlier, the major impediment to aquaculture faced by fish farmers is the occurrence of massive fish mortality. During 1986–2001, 91.6% of the sample fish farmers experienced fish mortality caused by the degradation of water quality. Of these, 60% experienced fish mortality on one to five occasions, with the remainder (31.6%) recording between five and ten occasions. Minimum average dead fish was 393 kg, compared to a maximum average of 2,678 kg. The incidence of fish mortality was also caused by the virus *Cyprinid herpes* and/or the bacteria *aeromonas*. Table 4 presents factors causing fish mortality as experienced by the fish farmers. Despite the losses recorded by so many fish farmers from this massive fish kill, as reported by the PT. PLN (1998), by the end of 1997 large scale fish deaths were accepted by fish farmers as tolerable and as an acceptable risk.

Table 4. Percentage of respondents experiencing fish mortality, 1986–2002 (n = 155).

Fish mortality related to:	%
Water quality	27.1
Water quality and bacteria/virus	64.5
Bacteria/virus	1.3
Have no experience	7.1
Total	100.0

With regard to water-related problems and fish mortality, 74.8% of sample fish farmers perceive climatic change as a factor preceding fish kill; compared to turn-over (27.1%) and pollution from upstream areas (5.8%). In addition to pollution from upstream areas (exogenous factor), the density of fish cages (endogenous factor) is another factor that may degrade ambient water quality. Regarding this, 55.5% of sample fish farmers perceive that the density of fish cages is too high, especially when the water level is low. This may lead to a lack of oxygen, which is needed by the fish to live and grow optimally. Of the 55.5% respondents who claimed the density of the cage was too high, 49.0% located their fish cages in the center of FNCC activities. This is in line with observations carried out in 1991 (Gunawan, 1992); Costa-pierce (1998); PT. PLN (1998).

5.3. Perception of water quality

In line with data contained in PT. PLN (1998) and the IOE (1997–2002), 72.9% of respondents claim the water quality of Saguling Reservoir has become worse. The remainder (27.1%) consider it to be good enough, or to have experienced no substantial change, although sometimes they claim it is polluted by waste from the upstream area. Concerning sources of pollution, the majority of fish farmers state that industrial waste and garbage from the upstream area are the main factors, with unconsumed fish feed and garbage from FNCC representing additional factors causing water pollution (Table 5).

5.4. Perception of interrelationship between upstream and downstream areas

Water quality is perceived as worsening by a majority of fish farmers. Very few farmers in the sample revealed an understanding of the interrelationship between upstream and downstream areas, saying only that degradation of the upper watershed will affect the environmental condition of the Saguling Reservoir. A little less than half of the fish farmers pointed to the industrial activity in the upper area as a cause of pollution in the Saguling Reservoir. The majority of respondents did not know of the relationship and even said there was no relationship, or that the problem in the upper area did not impact on the Saguling Reservoir (Table 6).

Table 5. Perception of sources of pollution in Saguling Reservoir.

Source of pollution	%
Industrial waste/garbage from Citarum River (n = 155)	68.3
Unconsumed fish feed (n = 155)	37.4
Waste/garbage from FNCC (n = 155)	42.6

Table 6. Perception of the interrelationship between upstream and downstream areas (n = 155).

Perception	%
Degradation in upper area hampers lower area	0.6
Industrial waste flows from upper Citarum to Saguling	47.1
Do not know	44.5
No relation, no effects	7.8
Total	100

Table 7. Perception on sustainability of the FNCC (n = 155).

Perception	%
FNCC is sustainable, there are still good locations	28.4
FNCC is sustainable, there are fish species tolerant to water pollution	20.6
FNCC is sustainable, there are efforts by the government to make it	0.6
FNCC is unsustainable	11.0
Fish farmers should continue whatever the condition, no choice	27.7
Do not know	11.6
Total	100

5.5. Perception of FNCC sustainability

It is recognized that FNCC is a high risk aquaculture activity. In relation to this, sustainability of the FNCC becomes important. However, this study indicates that only a few fish farmers consider FNCC activity to be unsustainable. The majority of the sample of fish farmers are sure that FNCC will be sustainable as there are still good locations in the reservoir to locate their fish cages, or because there are certain fish species that are tolerant of degradation in water quality. Only a quarter of the sample revealed they are not sure about the sustainability of their business, but add they have no choice but to continue this activity, regardless of the condition of the reservoir environment (Table 7).

5.6. Perception of rehabilitation of the upper watershed

Although understanding of upstream and downstream relationships is not so clear and a majority do not understand it, almost all respondents revealed that efforts to conserve the upper Citarum watershed are considered as good and will protect the environment from degradation, help avoid floods and (especially) will generate better water quality flowing to the Saguling Dam. But 51.9% of the sample stated that rehabilitation of the catchment is an obligation of the government.

In relation to FNCC activity, 68.4% of respondents said conservation of the upper Citarum will improve water quality of the reservoir and will be, in turn, conducive for FNCC development, improvement in fish growth and reduction of fish mortality. Other respondents (25.2%) agreed with the conservation of the upper watershed, but doubted whether there was empirical evidence showing better water quality. In addition, a few considered conservation of the upper watershed has nothing to do with their aquaculture activities.

5.7. Willingness to participate and to pay

Ecologically, rehabilitation and better management of the Saguling catchment is believed to generate benefits in the improvement of water quality in the Saguling Reservoir. In this respect, the fish farmers were asked about their willingness to participate and to pay for the program, with 74.2% saying they are willing to participate in such a conservation program, while 25.8% said they are unwilling to participate.

Although the percentage of those who are willing to participate can be considered high, 51% of the 74.2% are unwilling to pay. Of these, 14.8% argue that they are unwilling to pay because of financial problems, 24.6% say that results of the program are intangible or that the government should provide evidence before taxing farmers, 1.9% reveal that it is obligation of the government and the fish farmers have the right to good water quality and 9.7% did not provide a clear answer. Their willingness to participate is expressed in several forms, inluding taking care of the reservoir environment by not discarding garbage from the cage into the reservoir, or by participating collectively in maintaining water quality-related activities around the reservoir.

Those who expressed unwillingness to participate (25.8%) argue that industries should bear the cost of rehabilitation of the Saguling catchment in order to improve the degraded water quality caused by their activities (9%), others claim it represents a government obligation to the people affected by construction of the dam (5.1%), with the remainder saying that fish farmers lack the ability, including financial ability, to solve the problem (11.7%).

5.8. Multivariate analysis

Notwithstanding the incidence of fish mortality, perceptions of water quality, the interrelationship between upstream and downstream areas, density and sustainability of FNCC, rehabilitation or conservation of the upper watershed and other related variables mentioned earlier, the fish farmers responded positively to the idea of conservation and integrated management of the Saguling catchment. However, it must also be noted that the majority are not willing to pay for, or to share the benefits of the program. Table 8 presents the correlation between several variables. In general, none or only weak associations are indicated between these variables.

Eight indicators are used to show the correlation between demographic and socio-economic conditions, perceptions of the fish farmers and their willingness to participate in and willingness to pay for the watershed conservation program. The demographic and socioeconomic factors include level of formal education (Education), fish cage ownership (FNCC), year of involvement in aquaculture (Year) and incidence of fish mortality experienced by the fish farmers (Fish death). Individual perceptions of fish farmers include perceptions on density of the fish cage (Density), water quality of the Saguling Reservoir (Water), upstream–downstream relationships (Up-downstream) and sustainability of aquaculture activities (Sustainability).

As indicated in Table 8, it is apparent that for demographic and socioeconomic variables, only the year of involvement and experience of fish mortality share a correlation with willingness to participate or willingness to pay. Longer established fish farmers are more likely to be willing to pay for watershed

Table 8. Multivariate analysis.

Variables	Density	Water	Up–downstream	Sustain-ability	W.T. Part[d]	WTP[e]
Education	0	0.001	0.020[c]	0.008	0.003	0.08
FNCC	0.116	0.029	–	0.243	0.011	0.029
Year	0.232[b]	0.20	0.086	0.009	0.004	0.043[b]
Fish death	0.018[c]	0.031[b]	0.0	0.009	0.059[a]	0
Density	–	–0.256[a]	0.176[c]	0.051[a]	0.074[a]	0.004
Water	–	–	0.322[a]	0.025[b]	–0.124	–0.030
Up–downstream	–	–	–	0.150	0.004	0.41[b]
Sustainability	–	–	–	–	0.043[b]	0.024

[a] significant at $p < 0.01$; [b] significant at $p < 0.05$; [c] significant at $p < 0.1$; [d]willingness to participate; [e]willlingness to pay.

management and farmers who have experienced many cases of fish mortality are more likely to be willing to participate in watershed management, although they are not willing to pay for the cost of management. Educational levels and number of fish cages owned do not correlate with willingness to participate and willingness to pay. This means there is no difference between farmers whose educational backrounds are high or low and those with many or few fish cages, in their willingness to participate and to pay. In this regard, the majority of both groups expressed unwillingness to pay for the cost of watershed management.

Of the four variables concerning the perceptions of farmers, perception of water quality does not correlate with the variables "willingness to participate and willingness to pay", yet it does correlate with variables associated with perceptions of upstream–downstream relationship and on sustainability of FNCC activity. Regarding this, those fish farmers who consider water quality of the Saguling Reservoir to be worse are more likely to perceive that upstream areas affect the condition of downstream areas (the Saguling Reservoir) or that FNCC activity is unsustainable, if nothing is done to improve the condition. However, there is no difference between fish farmers who perceive water quality as worsening and those who do not, in revealing their willingness to participate in and to pay for the cost of watershed management.

In relation to the variable perception on fish cage density, farmers who stated the density to be too high are more likely to be willing to participate in watershed management, but there is no difference between those who say that density is too high or tolerable in expressing their willingness to pay. A similar case occurs with the variable perception of the sustainability of FNCC activity, which correlates with the variable willingness to participate, but not with the variable willingness to pay.

Of the four variables relating to the perceptions of the fish farmers, only the variable perception on the upstream–downstream relationship indicates a correlation with the variable willingness to pay, although it does not correlate with the variable willingness to participate in watershed management. In this regard, fish farmers who claim that the upstream area affects the condition of the downstream area are more likely to be willing to pay for the cost of the watershed management.

6. Discussion

The preceding analysis shows that the FNCC activity taking place in the Saguling Reservoir, which was developed as part of the resettlement program for people affected by construction of the dam, continues to grow and has become an attractive new economic activity. Nevertheless, several problems appear to hamper development. The major problem is the massive water-related fish mortality caused by both exogenous and endogenous factors. Pollutants from the upstream area, an exogenous factor, play a very significant role in the degradation of water quality. It is therefore suggested that an integrated watershed management is required to improve the environmental condition of the Saguling catchment. In this regard, participation of stakeholders living in both the upper and lower reaches, for example fish farmers, is required for management to succeed.

Participation implies that stakeholders will work together to set criteria for sustainable management, identify priority constraints, evaluate possible solutions, recommend technologies and policies and monitor and evaluate impacts (Johnson *et al*., 2001; see also Mitchel, 1997). With reference to participation by the people, under the best circumstances, downstream landowners and those who use the upper reaches should agree to share the net benefits of watershed investments, so upstream users would be willing to supply environmental services to downstream users, with all parties able to benefit. Projects are unlikely to result in conservation and productivity benefits where agreements cannot be reached (Kerr, 2002). To be willing to share the benefits, people in the lower reaches should be aware of interrelated environmental problems and of the benefits they would obtain if the environmental condition of the upper watershed is improved.

In the case of aquaculture activity taking place at Saguling Reservoir, the study found that although fish farmers have a relatively moderate understanding of environmental conditions, particularly the water quality of the lake, they are relatively aware of factors causing the water quality to degrade, which in turn leads to the correspondingly high fish death rate. They are also willing to participate in a program intended to improve the quality of the environment and which would specifically provide them with a better quality of water. However, in contrast to this finding, the majority disagree when it comes to sharing the benefits of watershed investment and are not willing to pay the required cost of watershed rehabilitation. There are several reasons for this:

1 Financial problem experienced due to the prolonged economic crisis seems to be a justifiable reason for fish farmers to disagree with the notion of sharing the benefits of watershed investment.
2 A significant number of fish farmers consider that the problem of water quality degradation in Saguling Reservoir is caused by industrial activities in the upper reaches area. Therefore, industrialists should be responsible for the problems they have created—and must pay for the cost of rehabilitation—rather than the fish farmers, or other groups affected by the degradation and which lack the ability to restore the environment. This is consistent with the notion that coordination or collective action is often required, but it may be difficult to implement because benefits and costs are distributed unevenly (Kerr and Chung, 2001).
3 The third argument raised by the fish farmers is a demand for evidence of better management of the catchment area. This is similar to the statement in Kerr (2002) and Johnson *et al*. (2002) that watershed projects are characterized by a long gestation period, difficulty in perceiving project benefits and in the management of intangible aspects, where up to a certain point, the outcomes of changes in natural resource management practices are incremental and often not immediately observable.

In spite of an unwillingness to share the benefits of watershed investment, fish farmers have still agreed to participate, particularly in the rehabilitation of the lake environment, by making sure their fishing activities do not exacerbate the exogenous-affected degraded water quality. The problems experienced and observable environmental conditions seem to have improved their understanding of the deterioration of the lake environment. In addition, the financial problem that has forced fish farmers to stock less fish, thus giving rise to less fish density, has also led unintentionally to a reduction in the incidence of major fish death.

In general, the study indicates that it is not simply a lack of understanding of the need to manage the watershed that has seen fish farmers fail to agree to share the benefits of management. Awareness is not enough, although without it stakeholders cannot be expected to be willing to participate and share the benefits. Awareness can be developed, or, as the study shows, empirical evidence can also be used to teach the fish farmers to be aware of environmental conditions.

Kerr (2002) reveals that given the uneven distribution of benefits, successful watershed development requires development of institutional mechanisms to ensure that all parties benefit. With regard to the management of the Upper Citarum Watershed, the Saguling case implies that at a macro level, institutional mechanisms need to be developed to cover social, economic and political factors. At the same time, efforts to understand issues at a micro level must be carried out, particularly in relation to community participation in the management of the local environment.

7. Conclusions

The findings of this study suggest that although stakeholder participation is required to achieve the expected results of watershed management, there are also several reasons why many people may not be willing to share the benefits of management. With regard to community comprehension of environmental problems, the study also suggests that any unwillingness to share is not due simply to a lack of understanding. There are other factors that influence their lack of response to the concept of integrated watershed management. This shows that in order to develop policies on integrated watershed management at the macro level, a much fuller understanding of micro-level ecological and socio-economic conditions needs to be incorporated.

Given this situation, institutional mechanisms that include social, economic and political mechanisms, should be developed to link both the upper and lower reaches of the watershed. Within such institutional mechanisms, incentive and disincentive mechanisms or the "polluter pays" principle could be applied. For example, tax incentive could be given to industries, located in the upper reaches, which run their business in an ecologically friendly way.

In the local context, direct stakeholder participation can be developed to solve local problems by involving the fish farmers in maintaining the lake environment. Meanwhile, the government and the lake authority should intensify monitoring of the FNCC aquaculture development, to avoid overpopulation of the FNCC unit. In this regard, enforcement of the lake management-related regulations is also required.

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