5.5 CHAIN OF SOLUTIONS

The attempts to deal with the five impacts mentioned in the previous sections have developed into a solution chain. This chain (see figure 5-9) consists of four branches. The first branch involves the consequences of the impacts of erosions and flooding. The remaining branches involve the consequences of the impacts of the degradation of water quality in the river and natural canals upstream from the dam, at the crossings between the irrigation and natural canals, and of the overloaded trucks. All of the branches except the first one appear to rapidly converge into a single branch.

Considering the first branch of solutions, to prevent erosions and flooding, the construction of prevention structures was planned to be constructed along the riverbank. However, cost was so high that the project was not continued at that time. Later in 2003, the RID proposed a new operation rule. Under this rule, no prevention structures were necessary. In addition, the new rule had some additional requirements. In November 2003, the new operation rule was presented for Cabinet approval, but it was rejected because of its high cost. The proposal was revised and two high-cost items were excluded. The final plan approved by the Cabinet includes implementing three additional requirements; upgrading the sluice gates at the diversion dam, constructing or restoring 14 hydrological stations, and releasing 130 million cubic meters of capital water from two upper dams. The total estimated cost was 70.0 million baht. The new operation rule was tested from December 2005 to January 2006, and there were no reports of erosions or flooding. It appears that the impacts have been solved.

In the second branch, two sets of solutions were implemented. The first one addresses the creation of pollution. A new Effluent Standard for Pig Farms was issued. The government subsidizes 50% of the construction costs for the installation of each

wastewater treatment system. However, the wastewater treatment systems did not function effectively on most farms. This situation led to the PCD hiring a consultant company to perform a detailed study as a basis for making recommendations regarding corrective actions. Unfortunately, according to the results of water samplings taken at the end of the consulting job, the situation was not much improved. The second set of solutions involved modifying the dam structure itself. Three new flood gates are being constructed, and there is a plan to install water-circulation pumps at 6 locations along the river. Since these modifications are currently under construction, their outcomes are still uncertain. However, the sub-district leaders and villagers doubt the success of this set of solutions because of their concerns regarding the hydrological influence of the new diversion channel.

For the third branch of solutions, to address the water quality impact at the crossings between the irrigation and natural canals, design changes were undertaken to increase the size of the under-drainage pipes. However, the water quality impact is still apparent.

For the fourth branch, as yet no corrective actions have been taken to resolve the impact of overloaded trucks. However, it does appear that the access road for the irrigation canal will be in need of major maintenance work earlier than expected.

This solution chain has two interesting features. First, the development of solutions for resolving the erosion and flooding impacts appeared good at first sight, because the estimated cost was reduced dramatically from 669.0 million baht in 2002, to 488.0 million baht in 2003, and to 70.0 million baht in 2004. However, this reduction in cost is due to the change in solution type, from the construction of erosion and flood

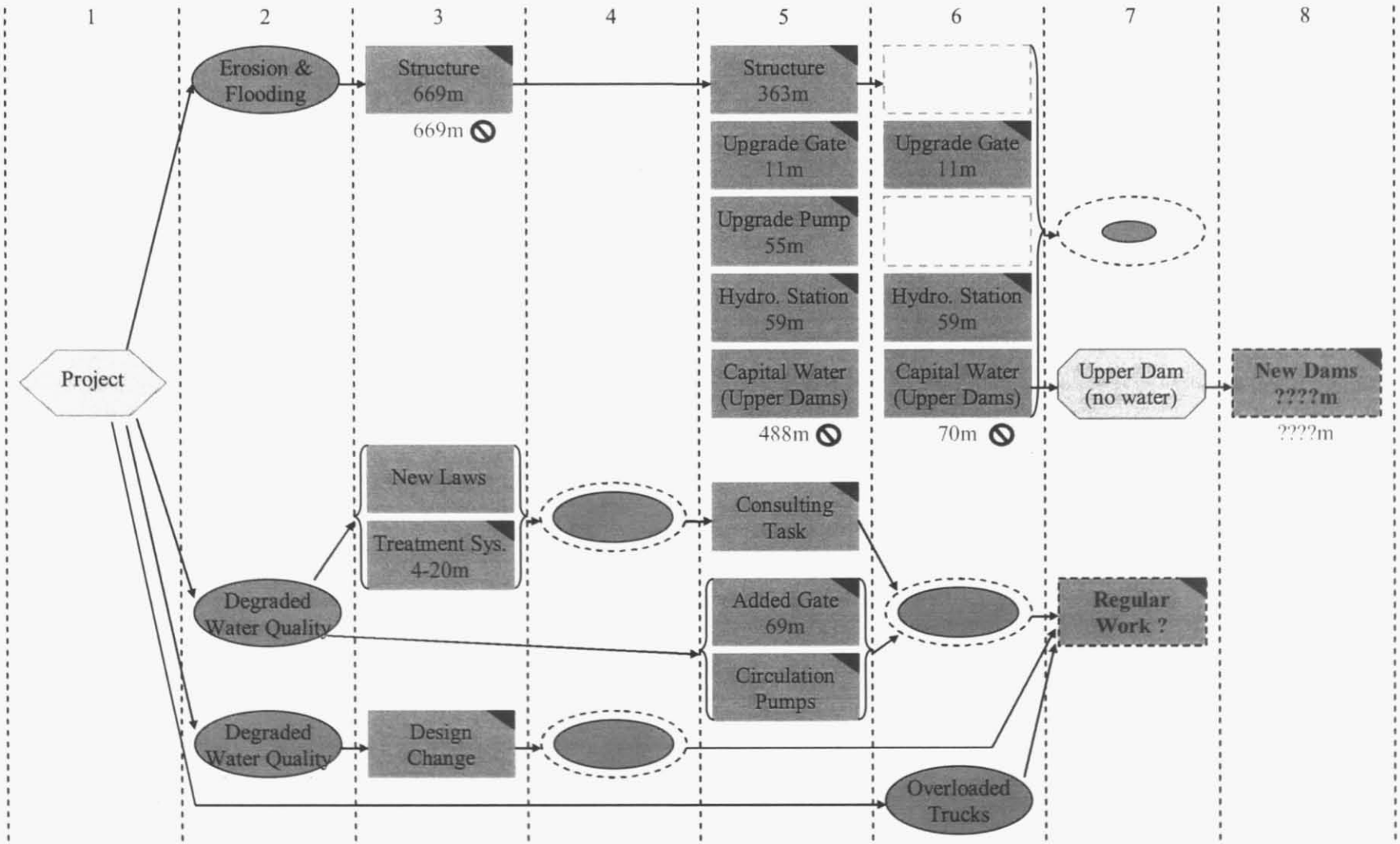


Figure 5-9: Chain of Solutions in the BPKD Case

prevention structures in 2002 to hydrological management in 2004. The hydrological management scheme involves the improvement of the sluice gates at the diversion dam, the construction or restoration of hydrological stations, and the release of capital water from the two upper dams. However, these two upper dams have their own irrigation areas, in which the demand for water may soon increase due to population growth and the acceleration of water consumption by the irrigation project. With a portion of the remaining capital water reserved to flow downstream for the Bang Pakong Dam, water in the two upper dams will be in short supply earlier than expected. Therefore, these two upper dams are not expected to be able to supply sufficient capital water in the near future. Then the Bang Pakong Dam will need to seek capital water from other sources, which may become a key factor justifying the construction of new upper dams. In summary, the impacts of erosions and flooding have been eliminated, but the new impact on a water shortage in the existing upper dams is likely to occur in the near. Accordingly, this new impact may accelerate the construction of new dam projects which typically require a budget of several billion baht – a much greater amount of money than the 669.0 million baht required for the initial solution.

The second interesting feature of the solution chain, with respect to addressing the impact of the degradation of water quality, is that most of the implemented solutions have not achieved their purposes. The previous impacts remain unsolved which means that new solutions will soon be required to resolve the old impacts. Finally, regular expenses may be imposed on the local government. For example, regular dredging work may be necessary for the natural canals both upstream of the dam and at canal crossings. The damage to the road along the irrigation canal and local roads may also entail regular repair work.

5.6 REVENGE EFFECTS OF IMPERATIVE OF SOLUTIONS

As described in the previous chapters, new impacts can arise with the implementation of solutions. For the application of the new operation rule involving hydrological management, the requirement for capital water from the two upper dams is likely to lead to a plan to construct new upper dams in the river basin.

Failing to notice the imperatives of technology pointed out by Winner (1977) does not reveal the full range of potential effects imposed by technology. In the case of BPKD, the capital water is a requirement that should not be ignored. It involves a combination of two characteristics of technology; the disguise of authority noted by Engels (no date) and the revenge effect proposed by Tenner (1996). An examination undertaken by Postol has revealed the revenge effect of Patriot missiles:

> *"Sometimes a practice or device can multiply a problem. According to a study by the political scientist Theodore A. Postol, damage to Tel Aviv during the Gulf War may have actually increased after the United States deployed Patriot missiles as a shield against Scud attacks. More people were injured and more apartments damaged during the Patriot defense than before, though fewer Scuds were launched. Some of the Scuds the Patriots broke up might have landed without damage. According to Postol's calculations, a Patriot hitting a Scud at 5.5 kilometers altitude could produce debris extending over 5 kilometers. A spinning piece the size of a soft-drink can could break through a five-inch concrete slab. So, among other things, the Patriot might have transformed the Scud into smaller projectiles. [Tenner, 1996, pp.10-11]"*

With the application of the new operation rule, the impacts of erosions and flooding will be transformed into water shortages in the areas that would usually benefit from water supplied from the two upper dams. In an opposite effect to reducing the current cost of 669.0 million baht for the construction of prevention structures, the new operation rule will most likely demand a much higher future cost – namely, several billion baht for the construction new dam projects.

5.7 EFFECTS UNDERLYING A SOLUTION CHAIN

However, what is perhaps more important is that a number of effects that occur underlie the whole chain of solutions. The proposed set of questions detailed in Chapter 3, section 3.6, is here applied to the case of BPKD to identify these effects. It is found that a number of the questions are helpful in this particular case.

5.7.1 MEANING OF EXTENDED CHAIN

The first question is 'which resource input is the same for most of the solutions in a solution chain?' In this case, one particular form of input is the work of engineering and construction firms; most of the solutions involve engineering and construction work. The longer the chain is, the more jobs there are. Considering the scale of investment, from 1993 (feasibility study period) to 1999 (completion of the diversion dam), around 2,800 million baht had been spent. By 2002 (completion of the ex post evaluation), the project cost had increased to 3,400 million baht. Currently and in the future, as described in the previous section, it appears that the chain of solutions for the erosion and flooding impacts will necessitate new dam projects, while the chains of solutions dealing with the degradation of water quality and the impact on overloaded trucks will likely necessitate regular canal dredging and road repairs, respectively. These prospective solutions also involve engineering and construction work.

5.7.2 REGULAR SOLUTIONS TO PERMANENT IMPACTS

The third question is 'does a chain of solutions develop into a permanent impact, which can be alleviated but only by a permanent or regular solution?' In this case several solutions have been implemented both concurrently and subsequently to resolve the impact on the degradation of the water quality on the upstream side of the dam. These solutions include a new regulation stating the discharged wastewater standard, a subsidy program for construction of wastewater treatment system in pig farms, the hiring of a consultant company to conduct a comprehensive study on the improvement of the wastewater treatment system performance, the construction of three new flood gates at the closure dam, and a plan to install water circulation equipment at six locations on the estuaries of the natural canals and on the old river channel. However, even with these attempts to find solutions, the water quality remains far below standard.

Considering the series of unsuccessful solutions employed to address the impact of the degradation of water quality, the situation appears to be leading to the necessity of a regular solution for the maintenance of water quality. Tentatively, dredging work may be required to clean natural canals and the old river channel every few years. Such a regular solution entails regular input in terms of both time and money from the responsible institution. Regular canal dredging is typically the responsibility of local administrations. This situation will accordingly lead to the difficulty of how to establish budgeting priorities for to local administrations who have very limited annual budgets.

5.7.3 THE BLURRED BOUNDARY OF INTEREST

The fourth question asks 'are the boundaries of an actor's interests blurred by a series of solutions?' Ihde (1990) discussed the horizonal phenomena on the blurred boundary between nature and artificiality. In his writing, he noted:

"... An even more extreme set of examples arise from chemical transformations, or what I shall call edible technologies. The history of the birth-control pill is instructive in this case. Early users of the pill reported two results: They did experience bodily changes, in that perios pains were experienced differently; and sometimes there were other side effects such as minor nausea. But as with the previously noted fascination with the amplifying transformations of all new technologies, most such side effects were repressed in favor of the exultation over a worry-free ability to engage in a close-to-"nature" or pregnancy-free sexual relations.

Later, delayed side effects were associated with the pill (in some cases, elevated blood pressure, etc.; later, worries over cancers), but these could at best be indirectly experienced. The pill, once taken, functioned as a kind of internal background relation of the most extreme fringe type. As with all edible technologies, the "I am what I eat" phenomenon placed most effects at a distance or were delayed ...

With biological technics, there is reached a new boundary between technology and life where the horizons of nature and artificiality are blurred ... [Ihde, 1990, pp.113-114]"

It is also interesting to observe the blurred boundary of non-physical things; such as the blurred boundary of attitudes or interests. In the case of BPKD project, most of the previous and current budgets for implementing solutions have been allocated to the same government agency – the RID – as that responsible for the performance of the dam. It appears that this practice will be continued with respect to future funding for solutions as well.

With respect to public works in Thailand, it is widely known that some portions of public budgets pass into the hands of the bureaucrats and technocrats who initiate or implement such projects. What is most worrisome is that, for these bureaucrats and technocrats, the boundary between their interests in 'implementing a successful project' and in 'implementing an unsuccessful one to gain further funding for future solutions' might be blurred. Funds for future solutions potentially mean income from bribes and corruption. Therefore, at least from a budgeting point of view, there is no incentive for bureaucrats and technocrats to create a successful project, since they stand to gain more from obtaining further funds for the successive solutions implemented for an unsuccessful project.

5.8 IMPACTS AND SOLUTIONS AS OPPORTUNITIES

Impacts and solutions in the chain present opportunities for some stakeholders. An analysis of the link between an impact and a solution (represented as an arrow in figure 5.9) provides various insights about such opportunities.

There are eight stages of arrows; the arrow from stage 0 to 1, 1 to 2, 2 to 3, 3 to 4, 4 to 5, 5 to 6, 6 to 7, and 7 to 8. The key stakeholders relating to the BPKD project include the Central Government of Thailand (CG), the Royal Irrigation Department (RID), the Japan International Cooperation Agency (JICA), the Office of Natural Resources and Environmental Policy and Planning (ONEP), the Pollution Control Department (PCD), the Department of Livestock Development (DLD), the local administrations (LA), householders (HH), piggery farmers (PF), shrimp farmers (SF), other agricultural farmers (AF), industrial factories (IF), persons affected by erosion and flooding (EF), people in the irrigation areas of the two upper dams (PU), non-governmental organizations (NGOs), engineering and construction companies (EC), and truck entrepreneurs (TE). The relevant

events and stakeholders' actions as described in the previous sections are summarized in table 5-4. Then, their interests and actions are analyzed to allow their coalitions to be revealed as shown in figure 5-10.

At stage [0-1], with the approval of the central government, the RID cooperated with the JICA on the agricultural water development project in the Bang Pakong river basin. The JICA provided free technical assistantship to the RID in performing the feasibility study and preparing tendering documents. Construction on the project was started with national funding in 1996.

At stage [1-2], during operation tests for the project at the end of 1999 and in early 2000, bank erosions and flooding occurred. Soon after that, the color of the river water changed. Immediate negative impacts of such dam projects were unusual in Thailand and attracted interest from the media. NGOs then complained to the RID and the Thai government and demanded urgent corrective actions, and publicized the dam as a symbol for unsuccessful projects. The occurrence of such impacts of the dam project strengthened the NGOs' opposition against similar projects in Thailand.

At stage [2-3], on 23 February 2001, a new Effluent Standard for Pig Farms was issued with the implementation date of 24 February 2002, one year later. During February 2001 and August 2002, a comprehensive ex post evaluation was undertaken by the ONEP. It was the largest formal ex post evaluation ever carried out by a government agency. The study reported that all sectors were polluting the river, including householders, agricultural activities, and industrial factories. The main sources of polluted water were found to be pig and shrimp farms in the area.

Attempts at environmentally friendly shrimp farming had been made in many provinces in Thailand for several years prior to this project. The main difficulty was to

enforcing the strict implementation of the new effluent standard. For environmentally friendly pig farming, under the new standard a subsidy program was offered by the DLD to support the construction of wastewater treatment systems on voluntary pig farms in 2001 and 2002. The PCD and DLD received funding rapidly from the central government for promoting good practices in pig farming. The subsidy program provides partial funding for construction company jobs. However, according to an interview, pig and shrimp farmers sometimes secretly released untreated wastewater into canals and the river. When this activity was uncovered, the pig farmers blamed the behavior on shrimp farmers, and vice versa. It is interesting to note that no NGOs became involved in the wastewater issue related to pig farming. There have been no attempts by NGOs to aid either locals who suffer from pig-farming activity, or those pig farmers who are attempting to implement good farming practices.

The results of the ex post evaluation study suggested the necessity for not only corrective actions with respect to the impacts that have occurred, but also the promotion and monitoring of actions to maintain good environment conditions; these include natural school education projects, tourism at the dam site, environment watchdog volunteers, and protect-the-hometown projects. It appears that the ONEP has used the situation to propose its pet schemes for promoting and addressing environmental conditions and concerns.

Furthermore, villagers requested that local administrations negotiate with the RID to enlarge the under-drainage pipes at the crossings between the irrigation and natural canals. As a result, design changes were carried out at some locations.

Table 5-4: Stakeholders' Interests and Actions

ACTORS	EXPRESSED INTERESTS	ACTIONS
	BPKD:0-1	
CG	Water resource development	Spend national budget
RID	Functions of dam, impact reduction	Supervise planning and construction work
JICA	Technical assistance, success of project	Perform feasibility study, design the project, and prepare tender documentation
EC	Engineering and construction jobs	Get jobs on construction of dam and related facilities
	BPKD:1-2	
CG	Water resource development	-
RID	Functions of dam, impact reduction	Recognize impacts: erosions and flooding, and poor water quality in the river and at natural canals
JICA	Technical assistance, success of project	-
EC	Engineering and construction jobs	-
EF	Safety, damage to agricultural area	Complaint about erosions and flooding
HH	Good water quality for usage	Complaint about poor quality of water
AF	Good water quality for usage	Complaint about poor quality of water
NGOs	Environmental concerns, affected group	Request to RID and CG for urgent actions, Urging use of dam as symbol of unsuccessful projects
Media	Interesting news	Disseminate news on the project's impacts
	BPKD:2-3	
CG	Water resource development	Request ex post evaluation, Subsidize cost of wastewater treatment system, Approve extension of construction period
RID	Functions of dam, impact reduction	Propose extension of construction period, Re-design canal crossings
JICA	Technical assistance, success of project	-
EC	Engineering and construction jobs	Get jobs on wastewater treatment system construction
ONEP	Environmental assessment	Perform ex post evaluation
PCD	Environmentally friendly practices	Announce new regulation, Promote good practices in pig & shrimp farming
DLD	Environmentally friendly practices	Promote good practices in pig farming
EF	Safety, damage to agricultural area	-
HH	Good water quality for usage	Complaint about poor quality of water
PF	Avoid higher production cost	Install wastewater treatment system, Claim that SF and IF cause water pollution
SF	Avoid higher production cost	Claim that PF and IF cause water pollution
AF	Good water quality for usage	Complaint about poor quality of water
IF	Avoid higher production cost	Claim that PF and SF cause water pollution
NGOs	Environmental concerns, affected group	-
Media	Interesting news	-
LA	Well-being of villagers, sufficient budget	Request modification of crossings & uptakes
	BPKD:3-4	
CG	Water resource development	-
RID	Functions of dam, impact reduction	Receive result of ex post evaluation for decisions
JICA	Technical assistance, success of project	-
EC	Engineering and construction jobs	-
ONEP	Environmental assessment	-
PCD	Environmentally friendly practices	Monitoring wastewater treatment performance
DLD	Environmentally friendly practices	Monitoring wastewater treatment performance
EF	Safety, damage to agricultural area	-
HH	Good water quality for usage	Complaint about poor quality of water
PF	Avoid higher production cost	Install wastewater treatment system
SF	Avoid higher production cost	-
AF	Good water quality for usage	Complaint about poor quality of water
IF	Avoid higher production cost	-
NGOs	Environmental concerns, affected group	-
Media	Interesting news	-
LA	Well-being of villagers, sufficient funds	-

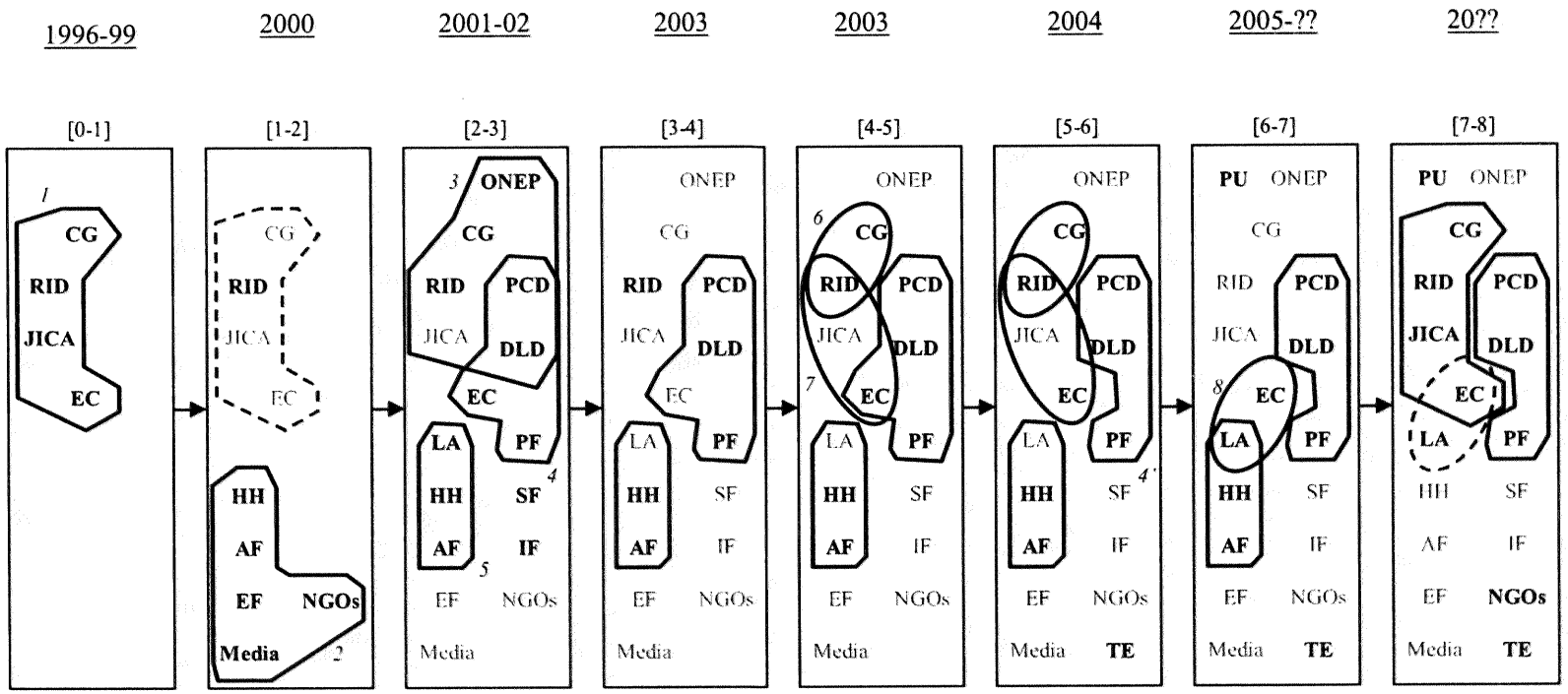
Table 5-4: Stakeholders' Interests and Actions (continued)

ACTORS	EXPRESSED INTERESTS	ACTIONS
	BPKD:4-5	
CG	Water resource development	Disapprove RID's proposal
RID	Functions of dam, impact reduction	Propose new operation rule, Construct three new gates at closure dam, Propose installation of water-circulation pumps
JICA	Technical assistance, success of project	-
EC	Engineering and construction jobs	Get jobs on improving wastewater treatment, Get jobs on constructing new flood gates
ONEP	Environmental assessment	-
PCD	Environmentally friendly practices	Monitor wastewater treatment performance, Hire a consultant for improving
DLD	Environmentally friendly practices	Monitor wastewater treatment performance
EF	Safety, damage to agricultural area	-
HH	Good water quality for usage	Complaint about poor quality of water
PF	Avoid higher production cost	Maintain wastewater treatment system
SF	Avoid higher production cost	-
AF	Good water quality for usage	Complaint about poor quality of water
IF	Avoid higher production cost	-
NGOs	Environmental concerns, affected group	-
Media	Interesting news	-
LA	Well-being of villagers, sufficient funds	-
	BPKD:5-6	
CG	Water resource development	Approve RID's proposal
RID	Functions of dam, impact reduction	Propose new operation rule of dam
JICA	Technical assistance, success of project	-
EC	Engineering and construction jobs	Get jobs on work to upgrade sluice gates, Get jobs on construction of hydrological stations
ONEP	Environmental assessment	-
PCD	Environmentally friendly practices	Monitor wastewater treatment performance
DLD	Environmentally friendly practices	Monitor wastewater treatment performance
EF	Safety, damage to agricultural area	-
HH	Good water quality for usage	Complaint about poor quality of water
PF	Avoid higher production cost	Maintain wastewater treatment system
SF	Avoid higher production cost	-
AF	Good water quality for usage	Complaint about poor quality of water
IF	Avoid higher production cost	-
NGOs	Environmental concerns, affected group	-
Media	Interesting news	-
LA	Well-being of villagers, sufficient funds	-
TE	Avoidance of load checking	Use road associated with irrigation canal

Table 5-4: Stakeholders' Interests and Actions (continued)

ACTORS	EXPRESSED INTERESTS	ACTIONS
	BPKD:6-7	
CG	Water resource development	-
RID	Functions of dam, impact reduction	-
JICA	Technical assistance, success of project	-
EC	Engineering and construction jobs	Get jobs doing dredging and road-repair work
ONEP	Environmental assessment	-
PCD	Environmentally friendly practices	Monitor wastewater treatment performance
DLD	Environmentally friendly practices	Monitor wastewater treatment performance
EF	Safety, damage to agricultural area	-
HH	Good water quality for usage	Complaint about poor quality of water & road damage
PF	Avoid higher production cost	Maintain wastewater treatment system
SF	Avoid higher production cost	-
AF	Good water quality for usage	Complaint about poor quality of water& road damage
IF	Avoid higher production cost	-
NGOs	Environmental concerns, affected group	-
Media	Interesting news	-
PU	Sufficient irrigation water	Complain about shortage of irrigation water
LA	Well-being of villagers, sufficient funds	Allocate or request budget for canal dredging and road repairs
TE	Avoidance of load checking	Use road associated with irrigation canal
	BPKD:7-8	
CG	Water resource development	Consider RID's proposal
RID	Functions of dam, impact reduction	Propose construction of more upper dams
JICA	Technical assistance, success of project	Offer technical assistance
EC	Engineering and construction jobs	Get jobs on construction of new dams
ONEP	Environmental assessment	-
PCD	Environmentally friendly practices	Monitor wastewater treatment performance
DLD	Environmentally friendly practices	Monitor wastewater treatment performance
EF	Safety, damage to agricultural area	-
HH	Good water quality for usage	-
PF	Avoid higher production cost	Maintain wastewater treatment system
SF	Avoid higher production cost	-
AF	Good water quality for usage	-
IF	Avoid higher production cost	-
NGOs	Environmental concerns, affected group	Oppose the proposal for new dams
Media	Interesting news	-
PU	Sufficient irrigation water	Complain about shortage of irrigation water
LA	Well-being of villagers, sufficient funds	Allocate or request funds for canal dredging and road repairs
TE	Avoidance of load checking	Use road associated with irrigation canal

Note: The underlining of texts indicates either a new stakeholder or a new interest.



Legend:

——— Expressed Coalition

- - - - - - Likely Coalition

'**In-black**' stakeholder means the stakeholder that did some actions.

'In-grey' stakeholder means the stakeholder that did not do any actions.

Abbreviations:

CG (Central Government of Thailand), RID (the Royal Irrigation Department), JICA (the Japan International Cooperation Agency), ONEP (the Office of the Natural Resources and Environmental Policy and Planning), PCD (the Pollution Control Department), DLD (the Department of Livestock Development), LA (the local administrations), HH (householders), PF (piggery farmers), SF (shrimp farmers), AF (other agricultural farmers), IF (industry factories), EF (persons affected by erosion and flooding), PU (people in the irrigation areas of the two upper dams), NGOs (non-governmental organizations), EC (engineering and construction companies), and TE (truck entrepreneurs)

Figure 5-10: Coalition Relationships among Stakeholders

However, at stage [3-4], the new crossing designs still resulted in the degradation of water. Also, it was found that the wastewater treatment systems installed on pig farms during 2001 and 2002 did not function effectively for several reasons, including the lack of a suitable construction area or an area with an inappropriate shape, and poor soil strength.

Accordingly, at stage [4-5], the PCD hired a consultant company to develop suggestions for improving the performance of the wastewater treatment system. To address the impacts of erosion and flooding, the RID proposed a new operation rule for the dam. However, it is interesting to note that the RID also proposed the construction of unnecessary structures for the prevention of erosion and flooding, with the rationale that this could totally eliminate public misunderstanding about the impacts of the project. However, this proposal was rejected by the Cabinet. Otherwise, the 363.0 million baht requested in funding would have been a good source of income for construction companies and also of possible bribes for various RID's officials, as is typical in public works projects.

At stage [5-6], the costly proposal was revised by the RID, and then presented again for the Cabinet's approval. A number of components were eliminated, and the estimated cost was reduced from 488.0 million baht to 70.0 million baht. It was approved. At this time, overloaded trucks began using the road along the irrigation canal in order to avoid a weigh station.

Table 5-5: Impacts and Solutions as Opportunities

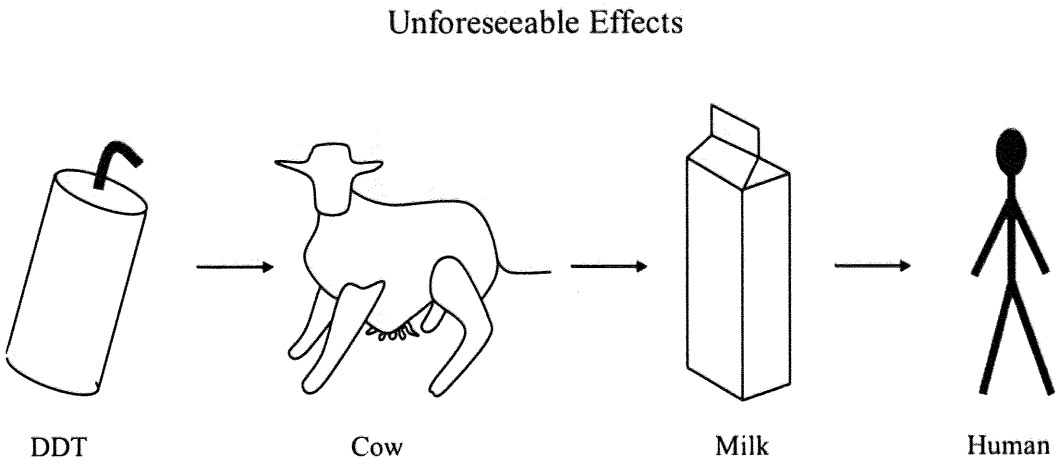
#	Source of opportunity		Whose opportunity?	What action?	What opportunity?	Who/What might suffer?	Concept of technology
	What impact?	What solution?					
1	Erosion & Flooding	-	NGOs	Project as symbol of failure	Stop dams	RID	Unforeseen effect, Instrumentalism
			ONEP	Include pet proposal	Promote good environment	National Budget	Unforeseen effect, Instrumentalism
	-	Prevention Structures	-	-	-	-	-
	-	New operation & Prevention Structures	RID	Include unnecessary prevention structures	Avoid public misunderstanding, Gain more funds	National budget	Boundaries, Instrumentalism
	-	New operation rule	-	-	-	-	-
	Water shortage at upper dams	-	RID	Propose construction of new dams	Gain more funds, Bribes	National budget	Imperatives, Instrumentalism
	-	New dams	EC	Bid for jobs	Jobs	National budget	Self-directing. Concentration of power
2	Poor water quality	-	NGOs	Make it symbol of failure	Stop dams	RID	Unforeseen effect, Instrumentalism
			ONEP	Include pet proposal	Promote good environment	National budget	Unforeseen effect, Instrumentalism
	-	Wastewater treatment system	EC	Get jobs	Jobs	National budget	Self-directing. Concentration of power
	Unsolved poor water quality	-	-	-	-	-	-
	-	Consultant task	EC	Get jobs	Jobs	National budget	Self-directing. Concentration of power
	-	Construction of 3 new flood gates	EC	Get jobs	Jobs	National budget	Self-directing. Concentration of power
	-	Design change	EC	Additional jobs	Jobs	National budget	Self-directing. Concentration of power
	Unsolved poor water quality	-	-	-	-	-	-
	-	Dredging work	EC	Get jobs	Jobs	Local budget	Self-directing. Concentration of power
3	Overloaded trucks	-	TE	Use irrigation-canal road	Avoid weigh station	Road users	Imperatives, Flexible interpretation
	-	Road repairs	EC	Get jobs	Jobs	Local budget	Self-directing. Concentration of power

At stages [6-7] and [7-8], more construction jobs will become available through dredging work in the natural canals and the river, and also through repair work on the road along the irrigation canal. Furthermore, under the new operation rule, the requirement of capital water from the two upper dams will accelerate the construction of new upper dams. Therefore, engineering and construction companies are likely to benefit from several billion baht in funding in the near future. Opportunities arising from impacts and solutions are summarized in table 5-5.

5.8.1 INSTRUMENTALISM IN IMPACTS OF TECHNOLOGY

The erosions and flooding are unforeseeable impacts, and thus are one of the technological ambiguities proposed by Ellul (1962) (see figure 5-11). The degradation of water quality is an opposite effect to the objective of this project in providing good water; this is an example of the revenge effect proposed by Tenner (1996). In the conventional understanding of instrumentalism, a technology is used as a means to achieve an end. This case study demonstrates that not only a technology itself but also the impacts of applying a technology can be a means to achieve an end – but a different kind of an end.

Accordingly, the impacts resulting from the technological ambiguities and revenge effects of a technology were utilized by some stakeholders to further their own interests. It appears that the ONEP utilized them, in using the ex post evaluation as a basis for including other programs to further promote good environmental conditions and concerns in the area. The NGOs utilized them to convince the public that the diversion dam should be permanently suspended or totally removed, so that it would become a symbol for or a recognized example of unsuccessful projects.



"... DDT, a chemical which in 1945 was thought to be a prodigiously successful means for the destruction of all kinds of vermin and insects. One of the most admirable things about DDT was that it was said to be completely innocuous toward human beings. DDT was sprinkled over the whole surface of the globe. Then, by accident, it was discovered that in certain areas veal cattle were wasting away and dying. Research revealed that DDT in oily solution causes anemia. Cattle had been dusted with DDT in order to get rid of insects; they has subsequently licked themselves clean and ingested the DDT. The chemical in question passed into their milk and by this route found its way into oily solution, i.e., in the milk fat. Calves suckled by such cows died of anemia, and it is needless to add that the same milk was ingested by human infants ... [Ellul, 1962, pp.420]"

Figure 5-11: Unforeseen Link between Cause and Effect

5.8.2 INSTRUMENTALISM AND BLURRED BOUNDARIES

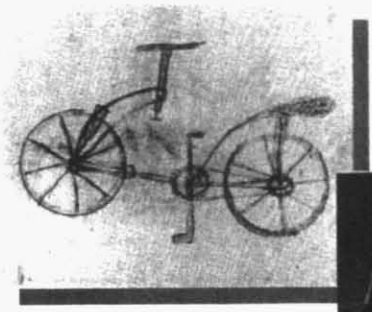
With reference to the boundary concept proposed by Ihde (1990), the project created a blurred boundary between erosions that occur naturally and those that occur due to the operation of the diversion dam. This might cause the locals to believe that every erosion and flooding incident occurring after the completion of the dam is due to its operation. This possible public misunderstanding – an impact of the project – appears to have been used by the RID as a justification for proposing the construction of the unnecessary prevention structures, probably so they could enjoy additional funding.

5.8.3 FLEXIBLE INTERPRETATION OF IMPERATIVES

Although intended as a maintenance route for the responsible agency and a transportation route between the agricultural fields and markets for the locals, the road along the irrigation canal was used by overloaded trucks transporting goods and products between Bangkok and other provinces in the eastern region. This situation has occurred due to the power of technology derived from its technological imperatives as noted by Winner (1977) and its flexible interpretation as pointed out by Pinch and Bijker (1987) and Ihde (1990) (see figure 5-12).

5.8.4 IMPERATIVES OF SOLUTIONS

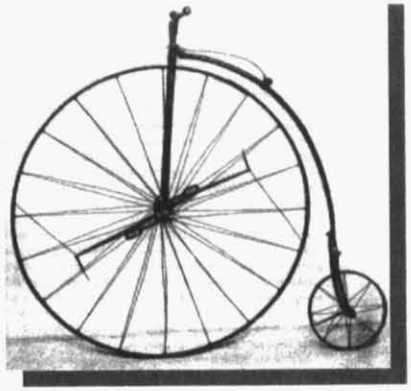
Ignoring the concept of technological imperatives suggested by Winner (1977) may leave relevant parties blind to the potential impact of the new dam operation rule proposed by the RID. An imperative of this new operation rule is to require capital water from the two upper dams. As described above, this imperative could allow the RID to justify the proposal to construct new upper dams in the near future.

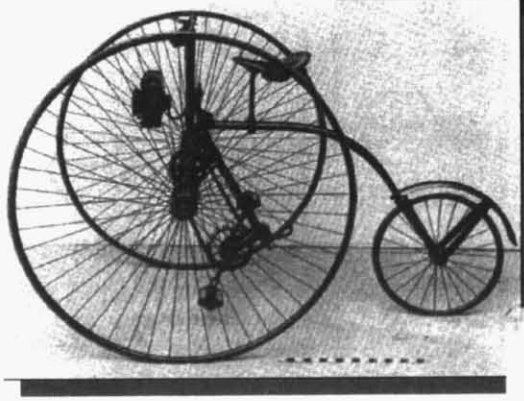


The bicycle-like machine (probably drawn by one of Leonardo da Vinci's pupils)
[Bijker, 1995, pp.21]

The Ariel bicycle patented in 1870
[Bijker, 1995, pp.31]

The ladies model Ariel in 1874
[Bijker, 1995, pp.44]





The Doubleday and Humber Tricycle
[Bijker, 1995, pp.55]

The American Star Bicycle in 1881
[Bijker, 1995, pp.67]

The Whippet safety bicycle in 1885
[Bijker, 1995, pp.74]

Figure 5-12: Flexible Interpretation in the Evolution of Bicycles

5.8.5 TECHNOLOGICAL FIX: A CURSE OF TECHNOLOGY

As can be observed repeatedly along the chain, engineering and construction companies consistently gain jobs from efforts to implement solutions; for example, consulting jobs in the ex post evaluation, the construction of wastewater treatment systems on pig farms, the consulting task for improvement of the wastewater treatment systems, the construction of three flood gates at the closure dam, the design changes of crossings, the expected road repairs, the anticipated dredging work in the natural canals and the river, and the probable construction of new upper dams. As a provocative claim about self-directing of technology by scholars, an impact due to technology can be solved only by a technical fix. Impacts of the BPKD project have been being resolved by many technical fixes as mentioned above. Technical fixes strongly require special skills or scientific-technical knowledge; therefore, only specialists or experts can do the tasks. In this particular case, engineering and construction companies are the promising entities who suit required skills. This creates a *concentration of power* around efforts of solutions, as once critiqued by Wartofsky (1992). Furthermore, the concentration of power results in *concentration of benefits* for a particular group – jobs for engineering and construction companies in this case.

5.9 ONE IMPLICATION OF OPPORTUNITIES

During the development of a chain, there are successive solutions and new impacts; both present opportunities for some actors. To increase these opportunities, those actors may attempt to either influence the preferred solution or enlarge the impact. This section provides a speculative discussion of the strategies that various actors in this case might have used to increase their opportunities.

NGOs typically want to publicize the negative impacts of a dam project such that local and public opinion against the project can be accumulated. In this case, the NGOs have encouraged the use of the dam as a symbol of unsuccessful projects. The RID would suffer significantly if the locals and the general public were convinced by the NGOs. The RID has therefore undertaken every task possible to ensure that the dam can be operated successfully so that such opposition is decreased. It is possible that the more the NGOs disseminate information on the negative impacts, the more the RID spends on solutions. As observed in this particular case, most of the solutions require expertise; thus, the engineering and construction companies which provide expertise in various tasks have been gaining jobs. Unintentionally, the NGOs actions are therefore indirectly benefiting the engineering and construction companies.

It is interesting to consider why the RID was so sensitive to possible public misunderstandings of the impacts of the project that the construction of technically unnecessary prevention structures was proposed along the riverbank. Their estimated cost was 321.8 million baht. Moreover, the RID proposed to increase the height of these structures by 0.15 meter, with the additional cost of 41.6 million baht. Optimistically, there appear to be the good reasons of eliminating possible public misunderstanding and at the same time ensuring people's safety from natural erosions and flooding. However, pessimistically, the potential for obtaining bribes from the new funding may have encouraged some RID officials to make the proposal.

As described in previous sections, the capital water required for the new operation rule could lead to the necessity of more upper dams in the river basin. The cost of such new dams would be extremely high. It must be considered that either the technocrats or

the consultant companies who suggested this new operation rule may have intentionally created the requirement for capital water in order to benefit from the future necessity.

5.10 AN EXAMINATION OF A NEWLY CREATED STAKEHOLDER

The implementation of a technological solution that has resolved the impacts of a given infrastructure development project and has satisfied opposing stakeholders would, however, not render the project successful if it creates a new impact and has introduced a new opposing stakeholder from another perspective. This section is devoted to a particular lesson learnt in this case study from the political phenomenon where technological impacts and solutions have introduced new stakeholders and have encouraged the formation of coalitions among stakeholders in solution chains. Analyzing this political phenomenon provides a useful lesson for future infrastructure development planners.

It should be noted that a new stakeholder can be introduced due to either the first or the second notion of technological politics: who governs and what governs (see both figure 5-10 and table 5-6). As examples, with respect to the notion of who governs (see coalition No.4 in table 5-6), the attempt to treat wastewater from pig farms introduced three new stakeholders into the solution chain; these are the Pollution Control Department (PCD), the Department of Livestock Development (DLD), and piggery farmers (PF). It is noted that with respect to the wastewater treatment work, there exists a coalition among the Pollution Control Department (PCD), the Department of Livestock Development (DLD), piggery farmers (PF) and engineering and construction companies (EC) (see stage [2-3] in figure 5-10).

Table 5-6: Newly Created Stakeholders and Notions of Technological Politics

Coalition No.	New Stakeholder(s) Introduced into Chain	Inspiration for Coalition	Reason for Coalition's Dissolution
1	CG, RID, JICA, EC	Initial Project *[who governs]*	Construction Completion
2	HH, AF, EF, NGOs, Media	Erosion and Flooding, Degraded Water *[what governs]*	Operation Suspension, Riverbank Repairs *[who governs]*
3	ONEP	Ex Post Evaluation *[who governs]*	Completion of Ex Post Evaluation
4	PCD, DLD, PF	Wastewater System *[who governs]*	-
5	LA	Degraded Water *[what governs]*	New Operation Rule *[who governs]*
-	SF, IF	Degraded Water *[what governs]*	-
6	-	New Operation Rule *[who governs]*	Proposal Approved
7	-	Construction Works *[who governs]*	Construction Completion
4'	-	Wastewater System *[who governs]*	-
-	TE	Route for Trucks *[what governs]*	-
8	-	Dredging Work and Road Repairing *[who governs]*	-
-	PU	Water Shortage at Upper Dams *[what governs]*	-
1	-	New Dam Projects *[who governs]*	-

Under the notion of what governs (see coalition No.5 in table 5-6), the impact of water degradation introduced the local administrations (LA) as a new stakeholder in the solution chain. It is noted that the impact of water degradation which was caused by the diversion dam forced the local administrations (LA), householders (HH) and other agricultural farmers (AF) to cooperate with each other in requesting corrective actions from the Royal Irrigation Department (RID) (see stage [2-3] in figure 5-10).

The interesting point noted in this particular case study and that could be applicable to other future infrastructure development projects, is that a technological solution can introduce a new stakeholder at a new location beyond the area of the initial project. In this case study (see stage [6-7] and [7-8] in figure 5-10, and table 5-6), the new diversion dam operation rule can be expected to resolve the impact of water degradation

and to satisfy the local administrations (LA), householders (HH), and other agricultural farmers (AF). However, the new operation rule is expected to create a new impact of water shortages at the upper dams and thus to introduce a new group of stakeholders – the affected persons living in the irrigation areas of the two upper dams (PU).

Considering this situation, it is apparent that the Bang Pakong Diversion Dam Project has extended its impacts into the area of the upper dams. Therefore, it is not appropriate to evaluate this project using the conventional evaluation approach which is based on the initial project area in isolation. This implies a need for an alternative project evaluation approach for those infrastructure development projects that could extend their impacts into a new location or area.

5.11 SUMMARY

This chapter illustrates the chains of solutions associated with a non-functioning dam in Thailand. Its immediate impacts in the form of river bank erosions and flooding have prompted the suspension of its operation. The main impacts include bank erosions, saltwater flooding, the degradation of water quality in several locations, and improper behavior by the drivers of overloaded trucks. These impacts have developed into a chain.

There are two interesting features in this chain. First, although they address the impacts of erosions and flooding, the series of solutions is likely to lead to greater costs. Second, while addressing the impact of the degradation of water quality, a series of unsuccessful solutions is likely to result in some form of regular solution, which will entail regular expenditure.

During the development of the chain, various actors obtain or seek for opportunities. As examples, the engineering and construction companies gained many jobs from the RID and PCD, and the RID is probably not averse to being offered more funding for solutions.

CHAPTER 6

SUMMARY, CONTRIBUTIONS, AND FUTURE RESEARCH

6.1 SUMMARY OF CONTENT

This dissertation develops the chain solution concept. In brief, an infrastructure development project involving a combination of various technologies generates unexpected impacts. Usually, a serious impact requires some kind of solution. In many cases however, a solution cannot fully resolve a particular impact. In addition, the solution, itself an application of technology, may then generate further impacts – either expected or unexpected ones. Thus, further solutions will be required for either remaining impacts, or new expected impacts, or new unexpected impacts, if any.

The cyclical phenomenon of needing to devise one solution after another may continue to occur in series for a long time, in which case the solutions develop into a chain. This technological trap, a 'chain of solutions' created by the unexpected impacts of an initial infrastructure project, is a form of technological politics that influences people to make decisions in a certain way. The expansion of a chain of solutions is driven by both notions of technological politics; who governs (the achievement of political power by the elites through the use of technology) and what governs (the generation of a new social order by technology itself).The chain solution concept offers a potential means of determining how societies are being dominated by technology. The present research involves an empirical study which has sought to demonstrate the evidences supporting the chain solution concept and its importance through two case studies.

The major benefit of analyzing a chain of solutions is that it provides an alternative means of identifying the secondary effects of infrastructure projects. Secondary effects are redefined as effects that emerge during the development of a chain, of which there are two types: effects created by individual solutions and effects underlying a solution chain.

The effects created by individual solutions provide evidences of the revenge effects raised by Tenner (1996). They become apparent in several phenomena. First, instead of achieving its own purpose, a solution sometimes increases the impact it was designed to resolve. Second, the new impact a solution creates is more severe than the one it has resolved. Third, whether it achieves its own purpose or not, a solution generates a new impact.

The effects underlying a solution chain emerge in such a way that the longer a chain is, the greater the effects are. They can be detected through a set of questions developed on the basis of a number of theoretical reflections; they include encouraged usage, disguise of authority, and horizonal phenomena. The questions are the following: (1) Which resource input is the same for most of the solutions in a solution chain? (2) Do the new impacts created by a series of solutions have a similar foundation to the initial impacts they aimed to resolve? (3) Does a chain of solutions develop into a permanent impact, which can be alleviated but only by a permanent or regular solution? (4) Are the boundaries of an actor's interests blurred by a series of solutions?

This study also asserts the proposition – elaborated on the basis of the critiques of Ellul, Marcuse, and Jonas – that, inseparable from any threat it presents, an impact of technology can also suggest an advantage-taking behavior for an individual or a group of persons, through either the impact itself or its successive solutions. Stakeholder analysis

is used as a tool in identifying such advantage-taking behaviors. The analysis is performed in order to analyze two features, namely, the coalitions and opportunities among key stakeholders.

Two case studies, the Sabo dams at Mt Merapi in Indonesia and the Bang Pakong Diversion Dam Project in Thailand, are examined in order to demonstrate the existence and importance of the concept and proposition presented in this dissertation. The case study analyses also demonstrate practically the realities of theories and concepts related to non-neutral powers of technology that have been developed in the field of the philosophy of technology for understanding the secondary effects imposed by infrastructure development projects.

6.2 CONTRIBUTIONS

First, this study introduces the 'chain structure' as a new form of technological politics in infrastructure development projects. The chain structure is developed on the basis of philosophical theory relating to non-neutral powers of technology in association with two notions of technological politics. These two notions are (1) the achievement of political power by the elites through the use of technology (who governs) and (2) the generation of a new social order by technology itself (what governs). Analyzing the chain structure reveals the self-generating patterns of a series of solutions and also provides various insights regarding the advantage-taking behaviors of key stakeholders.

Second, this study attempts to expand the research frontier of decision-making science by bridging two disciplines: engineering and the philosophy of technology. The discipline of engineering generally considers a narrow scope of technological impacts, while the philosophy of technology lacks rigid methodologies that enable its practical application. This research combines the strengths of both disciplines and opens up a new

way of looking at the secondary effects of technology by using infrastructure development projects as an example.

Third, the chain structure offers insight for identifying the secondary effects of infrastructure development projects. Through observing and analyzing chains of solutions in the case studies, two types of secondary effects are realized: effects created by individual solutions and effects underlying a solution chain. Thus, the chain structure potentially provides a means for project planners to perform more comprehensive planning and also evaluating impact assessment. It also reminds executing agencies of the need for careful assessment in implementing various solutions.

Fourth, an advance analysis of chains during project planning can help to predict and avoid advantage-taking behaviors of various stakeholders as the solution chain develops. As shown in the case studies, the opportunities exploited by advantage-taking stakeholders can be increased with the occurrence of either solutions or impacts in a chain. However, proactive intervention in response to the results of the analysis of advantage-taking behaviors will enhance the success of infrastructure development projects.

Fifth, as demonstrated in this thesis, the importance of chains of solutions signals the necessity for better practices in project evaluation. Traditional project evaluation is not effective because it is based only on the initial project's objectives and impacts, without a consideration of chain effects during project operation. The concept provides a new perspective on project evaluation for several reasons. First, solutions are also sources of impacts, and they should not be neglected. A solution itself can bring about three categories of impacts: remaining impacts, new expected impacts, and new unexpected ones. Thus whether an initial project is successful (the case in Indonesia) or unsuccessful (the case in Thailand), it can subsequently become unsuccessful because of solutions

which are implemented. This raises a question regarding the scope for evaluating the success of an infrastructure development project. Second, and more importantly, some effects are strengthened along a chain of solutions; the longer a chain is, the stronger they become. In the case of negative ones, they continue to subvert development sustainability. Third, a serious unexpected impact allows a decision maker no 'do nothing' alternative, because of the absolute necessity of a solution. In such circumstances, the investment cannot be stopped. This differs from those financing situations in which a decision maker can decide to stop investing at any time. This indicates that further consideration is necessary with respect to employing various fundamental financial concepts and analytical tools in evaluating infrastructure development projects.

Sixth, this study demonstrates the practical application of theories and concepts relating to the non-neutral powers of technology in developing the thesis concept and proposition, in analyzing the causes of initial impacts, in understanding secondary effects, and in observing advantage-taking behaviors relating to infrastructure development projects. This indicates that these theories and concepts provide useful insights. This type of knowledge is not currently emphasized in training and education programs for most engineering disciplines. The development of interdisciplinary knowledge between the philosophy of technology and engineering is vital for a better understanding of the interrelationship between technology and society.

6.3 FUTURE RESEARCH

Findings and discussions in this study signal at least three interesting issues that remain for future research. First, the chain concept suggests a broadening of the scope of project evaluation. Second, the necessity of successive actions sets up a particular kind of decision making – decision making without a 'do nothing' alternative. Third, the practical

application of philosophical concepts in the case studies presented in this study indicates a possible modified framework for project planning.

6.3.1 SCOPE OF PROJECT EVALUATION

The importance of the solution chain phenomenon elaborated in this study helps to identify two types of secondary effects: effects created by individual solutions and effects underlying a solution chain. These secondary effects are not taken into account in current evaluation practice in the development of infrastructure projects. Therefore, it is recommended that the scope of project evaluation be broadened. The next questions are: How is consideration of the solution chain phenomenon to be incorporated in project evaluation? and, At what length of chain should be considered?

Life cycle cost analysis, a fascinating concept employed in product design and decision making, may provide an effective basis for incorporation of the solution chain concept. Life cycle cost analysis in product design seeks to calculate the cost over the entire life span of a product, ranging from planning, research and development, production, operation and maintenance, to disposal. Applying life cycle cost analysis to the solution chain concept would require some good examples of infrastructure projects that have reached the end of their life.

In the United States, dam removal has served as an acceptable solution for dam owners and communities, especially in the case of unsafe and obsolete dams. More than 465 dams have been removed since 1912. This practice will soon be employed in other countries and continents where the construction of dams started later than in the United States. In this study, the solution chain concept is elaborated on the basis of case studies about dams. Examining the solution chain concept through the life cycle cost analysis of dam removal will be a useful extension of this study. However, the solution chain concept

can also be applied to other types of infrastructure projects. Therefore, further research on the removal of other kinds of infrastructure projects will be appropriate as well. It should be noted that the solution chain concept applies not only to successive solutions but also to various kinds of successive actions such as correctives, preventive measures, mitigation, restoration, aid programs, and secondary phases of an initial project.

6.3.2 DECISION MAKING WITHOUT A 'DO NOTHING' ALTERNATIVE

Chains of solutions present a unique situation in decision making, in which a decision maker has no 'do nothing' alternative, because a solution is absolutely necessary to address a serious impact of an infrastructure development project.

At the planning stage of an initial infrastructure development project, a decision maker is able to compare several alternatives with the 'do nothing' alternative. However, after a serious impact occurs due to a completed project, a solution is urgently required. Therefore, the availability of the 'do nothing' alternative disappears at the operation and later stages of such a project because some remedial actions must be taken.

This kind of process is different from that in financial decision making where a decision maker can stop investing at any time. Decision making without the 'do nothing' alternative may require some modification of the fundamental principles of decision making, particularly in relation to necessary solutions and secondary effects, such as uncertainty and irreversibility. It can be expected that such modifications will contribute to redefining the factors of uncertainty and irreversibility associated with infrastructure development projects.

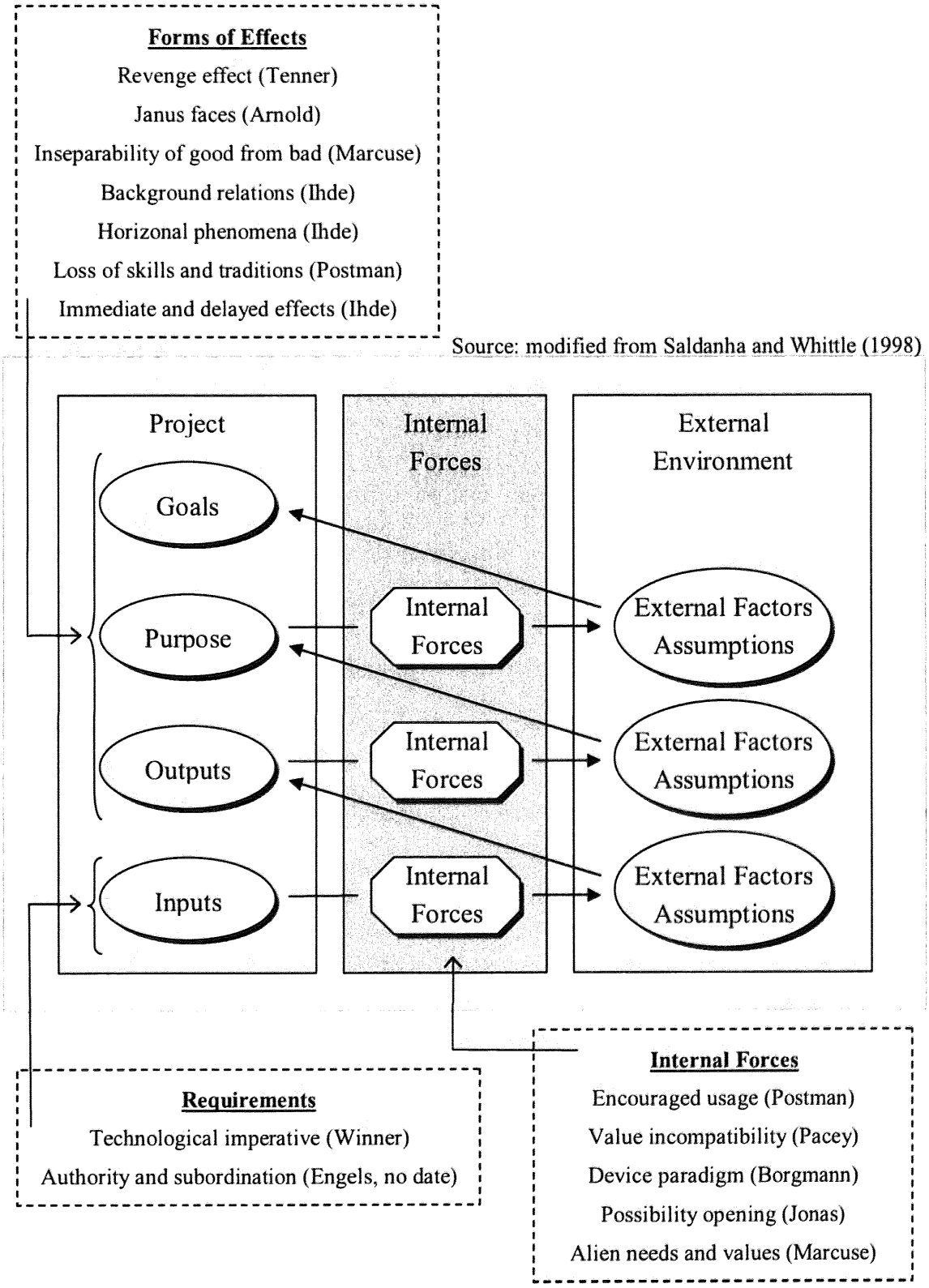


Figure 6-1: Prospective Applications of Concepts relating to Non-Neutral Powers of Technology in the ADB Logical Framework

6.3.3 MODIFIED FRAMEWORK FOR PROJECT PLANNING

The practical application of philosophical concepts relating to the non-neutral powers of technology indicates that insufficient consideration is given in project planning to the internal forces generated by a project itself. Typically, it is claimed that the failure of a project occurs due to externalities which are out of the control of project planners. However, further research may challenge this conventional understanding by arguing that some externalities are actually influenced by the internal forces of an infrastructure development project (see figure 6-1).

For example, the output of a project may involve some internal factors that encourage the usage of natural resources, disturb local communities by impacting on their living conditions, induce shifts in the values in local cultures, and so forth. These internal factors may thus stimulate changes in the external assumptions of the project. Then, these changed assumptions may in turn weaken the purpose and goal of the project.

Furthermore, various philosophical concepts are also helpful in the project planning phase for considering the requirements of project inputs and the forms of potential effects related to project outputs, purposes, and goals. Lists of these philosophical concepts are presented in figure 6-1.

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APPENDIX A

FIGURES AND PHOTOS RELATING TO THE SABO DAMS AT MT. MERAPI

Geoff Mackley (24 January 2001)

Geoff Mackley (28 January 2001)

Figure A-1: Volcanic Eruptions at Mt. Merapi

Jack Lockwood (26 September 1982)

www.vsi.esdm.go.id (1996)

Figure A-2: Debris Flows at Mt. Merapi

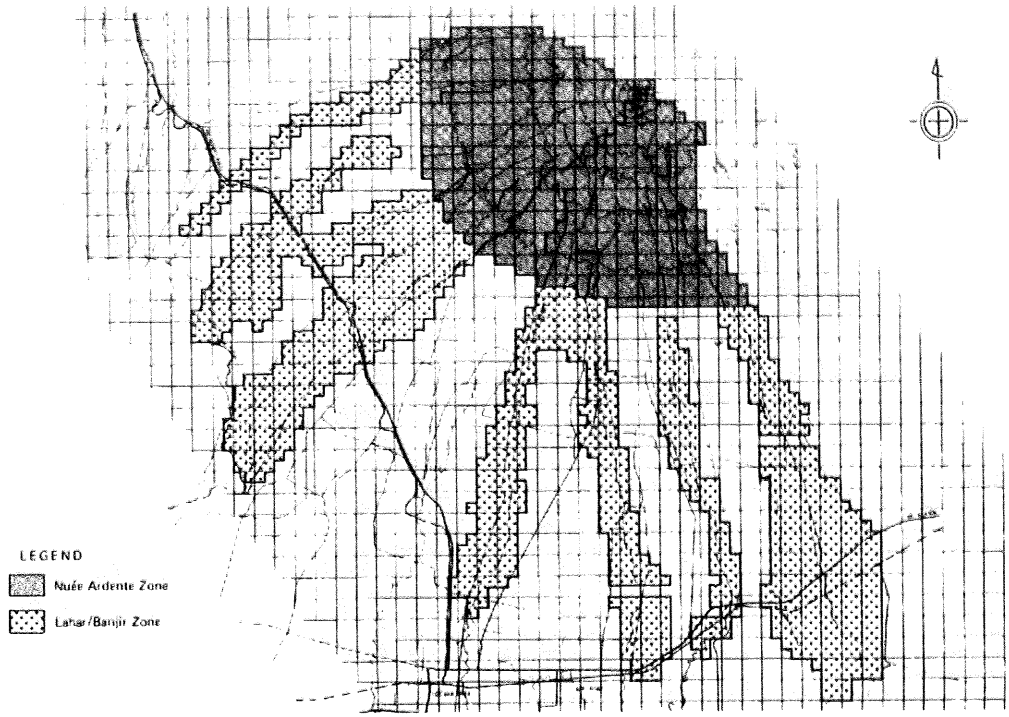


Figure A-3: Merapi Volcanic Hazard Map
(Source: JICA, 1980)

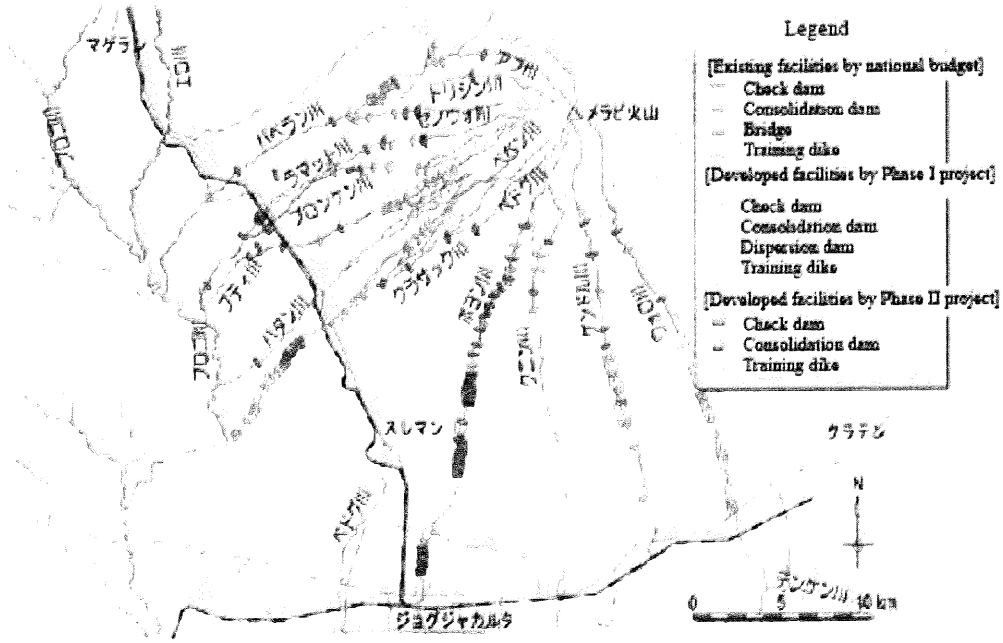
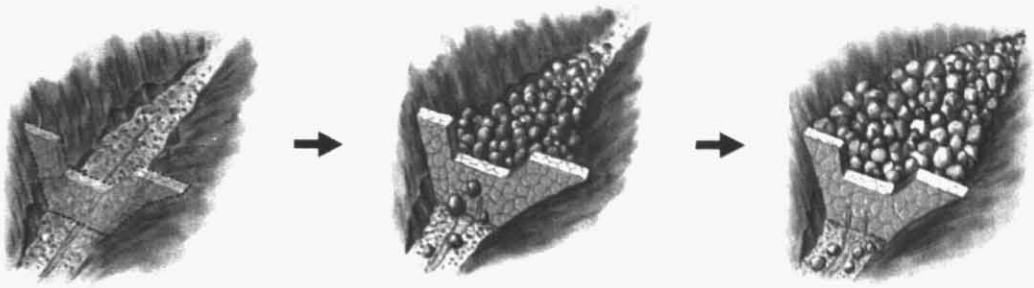


Figure A-4: Location of Sabo Facilities at the Mt. Merapi
(Source: JBIC, 2003)



www.sabopc.or.jp

Figure A-5: Sabo Dams

Check Dam Consolidation Dam Training Dike

Figure A-6: Sabo Facilities at the Mt. Merapi
(Source: JBIC, 2003)

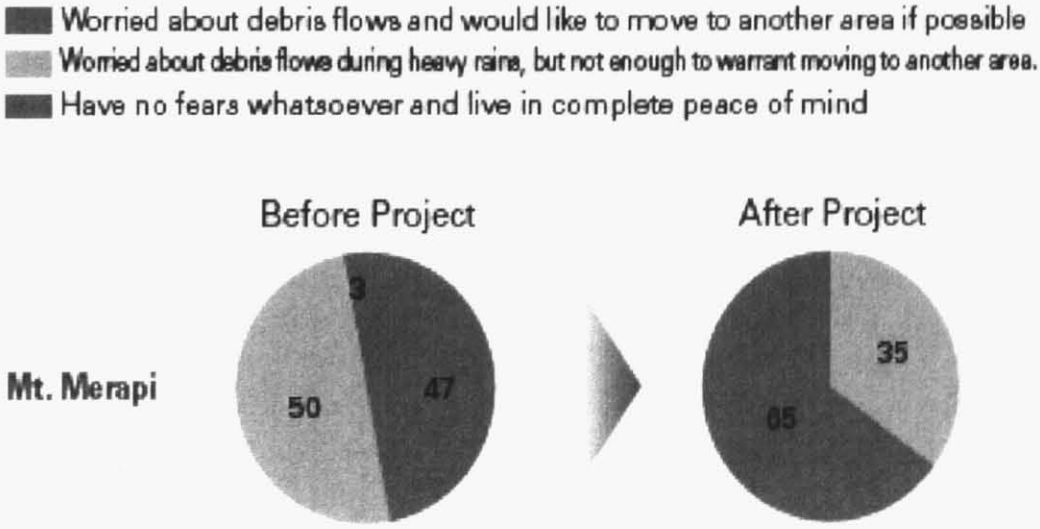


Figure A-7: Assessment of Security in the Region - Before and After Project
(Source: JBIC, 2003)

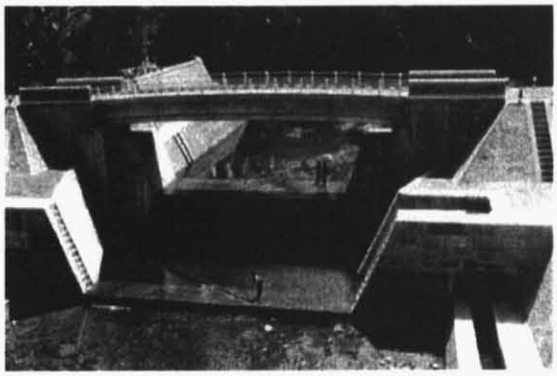
Figure A-8: Sand-quarrying Activity in Some Parts of Forest
(Source: Hartono M. D., 2004)

Figure A-9: Sand-quarrying Activity in Upper Reaches of Rivers
(Source: Hartono M. D., 2004)

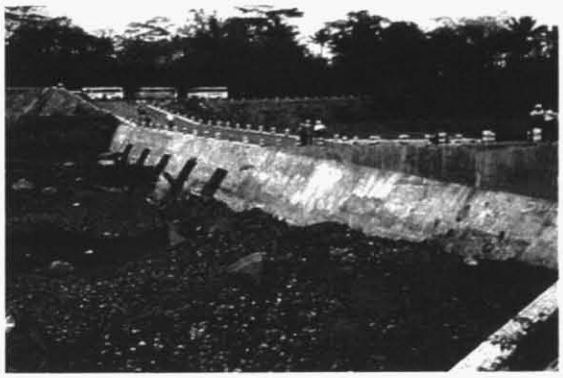
Figure A-10: Sand-quarrying Activity at Sabo Dam
(Source: JBIC, 2003)

Dam on the Apu River, Merapi (JBIC, 2003)

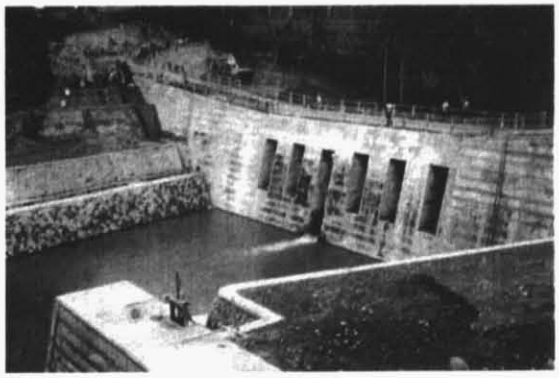
Dam at Boyong River, Merapi
(JBIC, 2003)



Dam at Lamat River, Merapi
http://ptbck.com (1993)



Dam at Boyong River, Merapi
http://volcano.und.nodak.edu (2000)



Dam at Lamat River, Merapi
http://ptbck.com (1995)

Figure A-11: Sabo Dams with Attached Road at the Mt. Merapi

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[Figure A-11]
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[Figure A-11]
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APPENDIX B

FIGURES AND PHOTOS RELATING TO THE BANG PAKONG DIVERSION DAM

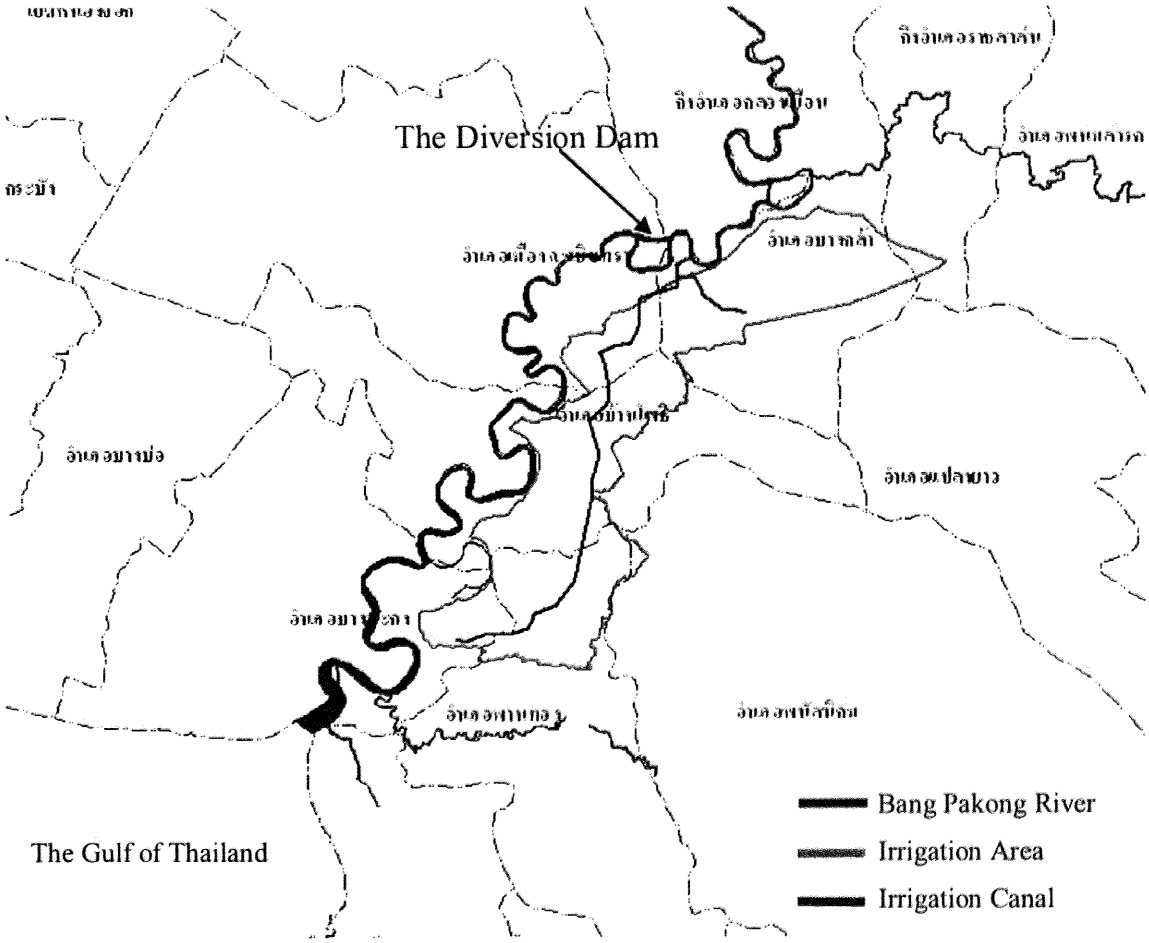
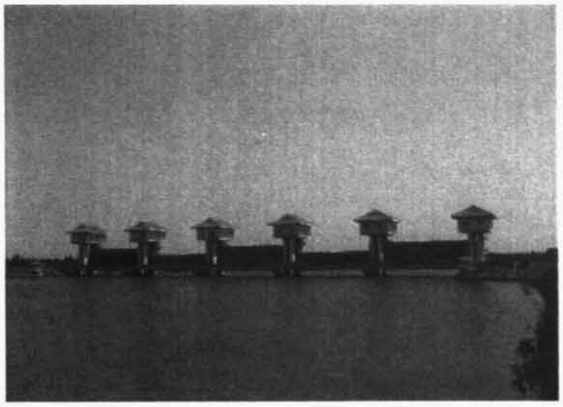


Figure B-1: Location of the Bang Pakong Diversion Dam Project
(Source: ONEP, 2002)



Diversion Dam

Diversion Dam, a close look

Diversion Channel

Road Bridge

Closure Dam (ONEP, 2002)

Irrigation Canal

Figure B-2: Main Components of the Bang Pakong Diversion Dam Project

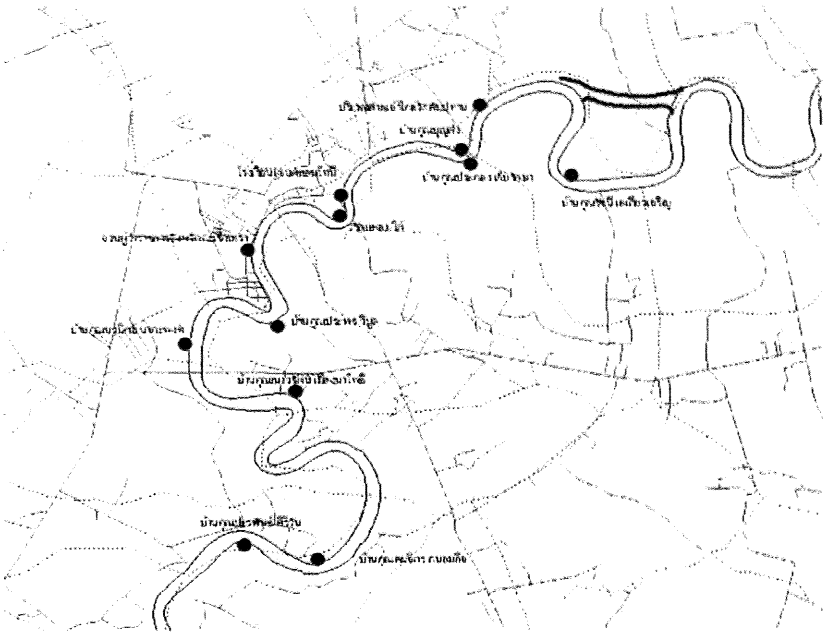


Figure B-3: Locations of Bank Collapses
(Source: ONEP, 2002)

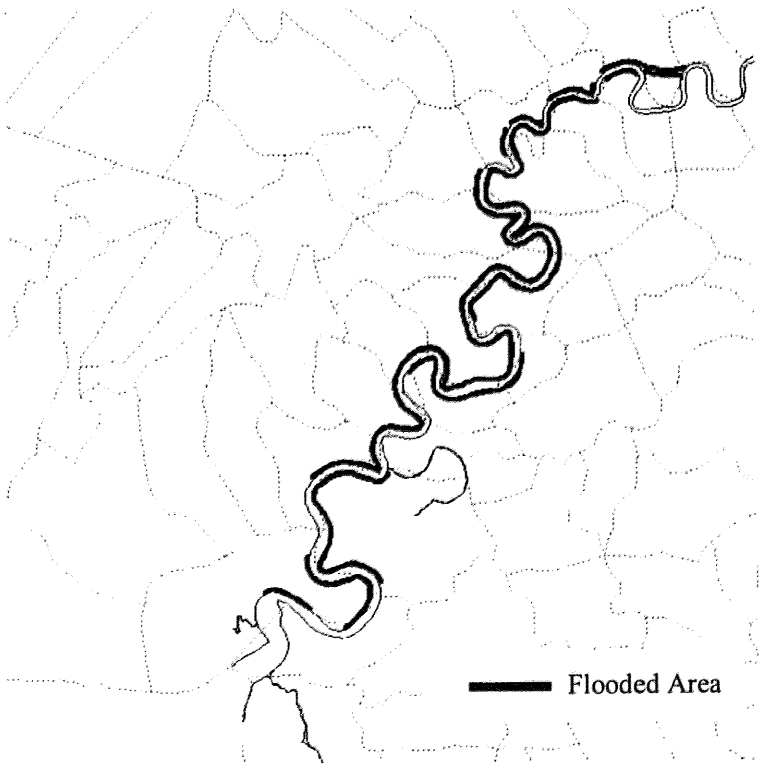
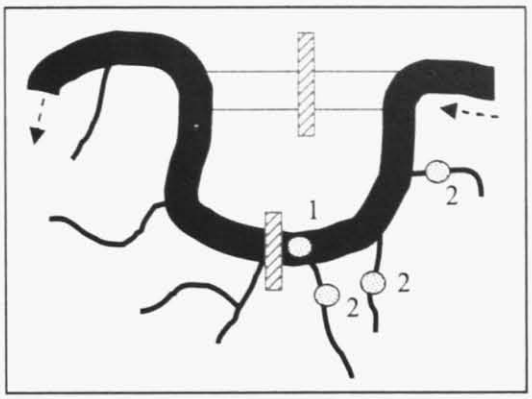


Figure B-4: Locations of Flooding
(Source: ONEP, 2002)



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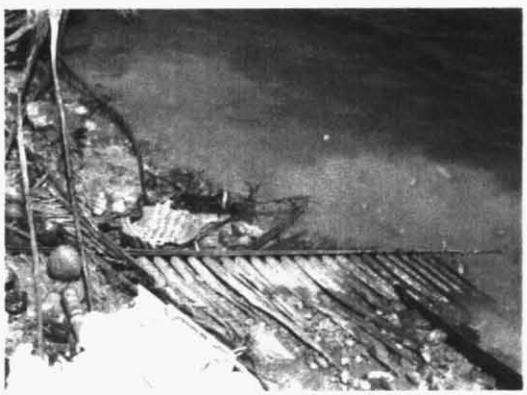

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Figure B-5: Degraded Water in the River and Natural Canals Upstream

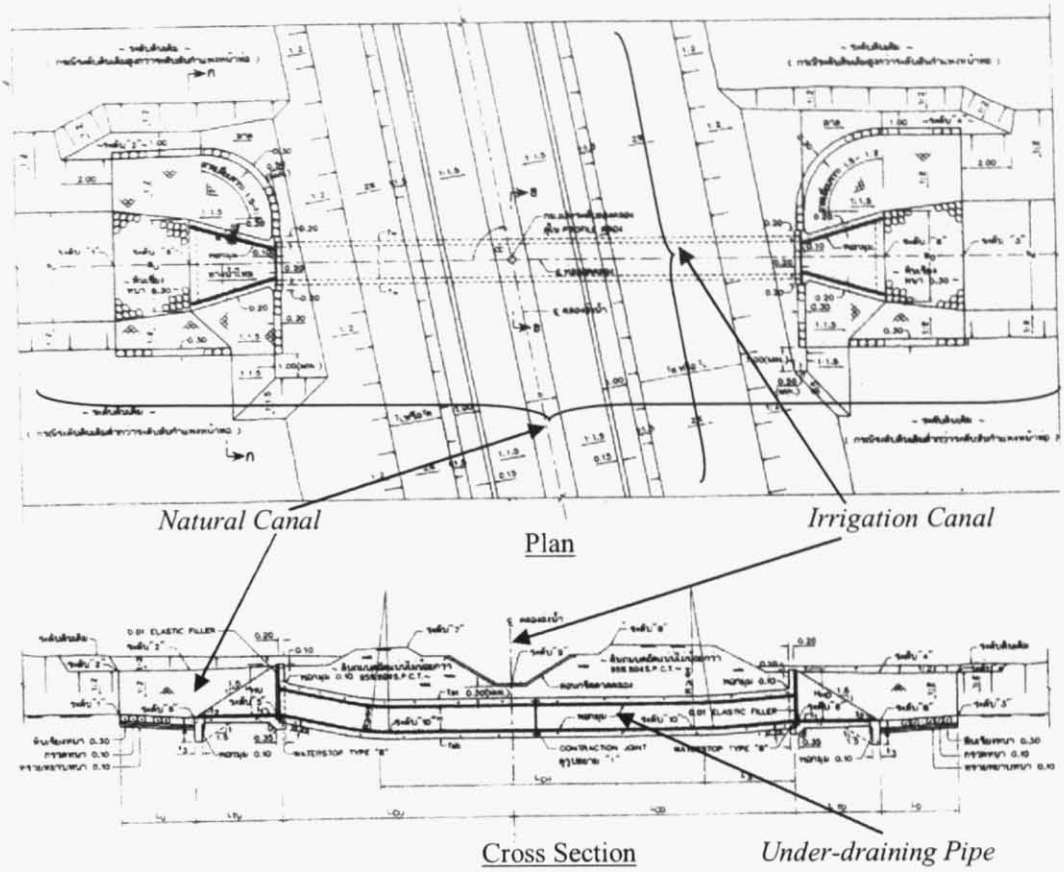


Figure B-6: Drawings of Crossings between Irrigation and Natural Canal

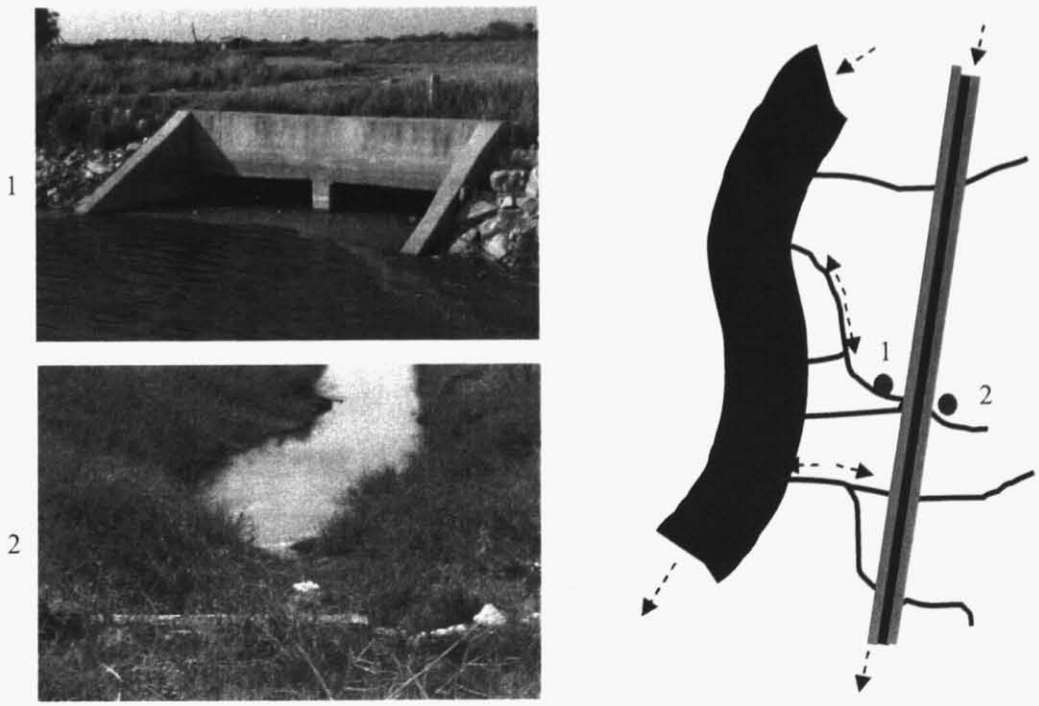
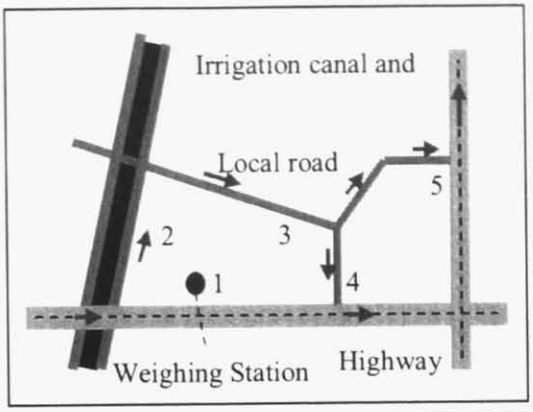


Figure B-7: Degraded Water at Crossings between Irrigation and Natural Canal



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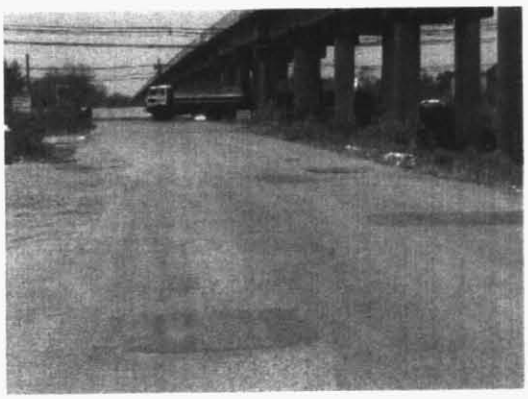

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Figure B-8: Avoiding Route for Overloading Trucks