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Regulatory Pricing of Water and Sewerage Services in Metro Manila

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Abstract
Contingent valuation method was used to come up with regulatory pricing of water and sewerage services in Metro Manila. The ability to pay analysis for sewerage services was based mainly on the 2000 Family Income and Expenditures Survey conducted by the National Statistics Office (NSO). Estimates of willingness-to-pay were based on surveys conducted in Barangays Wawa, Western Bicutan, Calzada of Taguig; and Barangay San Juan in Tanay, Rizal in November 2003. Both water and sewerage fees are collected as one bill by the Manila Waterworks and Sewerage Systems (MWSS).

1. Introduction
The Taguig Sewerage System involves construction of four drainage/flood retention ponds into Sewage Treatment Plants (STPs) in line with the flood control project of the Department of Public Works and Highways (DPWH) in coordination with the Manila Waterworks and Sewerage Systems (MWSS). The STPs allow treatment of sewage in Taguig before discharge to Laguna de Bay during the dry season. Covering the areas of Taguig and Pateros, the STPs will treat the dry weather drainage/sewage flow at least 1.5 times the dry weather flow during wet season. With the new facilities, a new pricing system that would cover utilization both water and sewerage services was estimated.

2. Results

Household or Family Income
The National Statistics Office (NSO) prepared a “2000 Family Income and Expenditures Survey” which presents information on family income and expenditures for regions and selected urban areas in the Philippines. Taguig was one of the selected municipalities covered in the 2000 survey. Tanay, Rizal was classified under Region IV. The information collected provides one indication of the ability of the households to pay for the services of the proposed sanitation and sewerage project.
The average and median annual incomes for Taguig and Tanay, Rizal were compared with other regions in the Philippines for 2000. Compared to other municipalities in the country, Taguig and Tanay, Rizal have more high income families. The average income of households in both locations is lower than the NCR average, though. The same is true for the median income.

Family Income Expenditures for Water
The NSO 2000 survey of family expenditures for water was the primary source of information of this section. This section estimated the historical and current ability to pay for water, for the purpose of estimating future ability and willingness to pay for water and wastewater services.
The NSO Survey showed that in the year 2000, the average annual expenditures for water in the Taguig and Tanay, Rizal was PhP 2,504 and PhP 2,064, respectively. The same survey revealed that fuel, light and water comprised 6.3% of the family expenditures. Most previous studies have worked on this aggregate figure and assumed that water rates represent approximately one-third of the total.

On the average families living in other areas of the Philippines reported earning less income but paying more for water than did the average family in Taguig and Tanay, Rizal in 2000. These communities spent a higher proportion of their income for water: 1.27% in Taguig and 0.84% in Tanay, Rizal, as compared to the NCR (0.52%). However, the national average is higher at 1.34%. This is due to the high average annual income received by households in Taguig, Tanay and in the NCR. Water consumption is not responsive to income changes.

**Future Ability to Pay for Water and Sewerage Services**

Families living in the Taguig and Tanay, Rizal have traditionally reported paying between 0.84 to 1.27% of their annual income for water and sewerage services.

Average family income in these communities has increased in real terms (inflation adjusted) from 1997 to 2000 by: 14.4% in Taguig, and 30.6% in Tanay, Rizal. This represents an annual growth rate of 4.8% in Taguig, and 10.2% in Tanay, Rizal. Higher family income in the future will result in higher per capita consumption, and an increased ability and willingness to pay for water and to connect to the sewerage system. That greater ability and willingness to pay will be partially offset, however, by higher prices. If real incomes in these communities grow at an average annual rate of 4.8% in Taguig and 10.2% in Tanay, then the estimated average family income of PhP 230,719 (in Taguig) in 2000 will grow in real terms to approximate PhP 278,310 by the year 2004. In Tanay, the estimated average family income in 2000 was PhP 246,286 which will grow in real terms by PhP 363,217 in 2004. Median household incomes will also increase at the same time. By the year 2004, “real” ability-to-pay, will be about 36.12% higher in Taguig and 47.67% in Tanay than in 2000. The average family in Taguig that could afford to pay PhP 209 per month for water in 2000 will be able to pay PhP 284.50 per month by the year 2004. In Tanay, the average family that could afford to pay PhP 172 per month for water in 2000 will be able to pay PhP 254. However, since the real price of water in 1997 prices should not change, the average family will have an extra PhP 75.50 in Taguig, and PhP 82 in Tanay, per month left over after paying for its present water charge. The said amounts can be spent for the additional sewerage service.

**3. Willingness to Pay for Sewerage Services**

*Socio-economic Survey of Taguig STP Communities*

The 2003 survey of Barangays Wawa, Western Bicutan, Calzada of Taguig, and Barangay San Juan in Tanay, Rizal reported that 42% of households interviewed were willing to pay for the price increase in their water charges for a sewerage system. Ten percent of the respondents gave no response while 48% were not in favor of the price increase. The respondents were informed that the payment will be incorporated in their water bill.
The results of the survey show that sanitation is given a low priority and attracts only a small proportion of the total funding to the sector. The low level of demand for and willingness to pay for sanitation among respondents in the project areas stem from a lack of understanding of the effects of good sanitation on health. The Bank should further promote health education and ensure that it is an essential component of its WSS program both to stimulate demand and WTP for sanitation and to maximize the health benefits of the project.

The respondents were further asked about their general feeling about the proposed price increase in their water charges. The general feeling about the price increase is as follows: 15% were happy; 63% were not happy; 21% were neither happy nor unhappy; while the rest did not comment at all.

Among the respondents who admitted they were happy with the price increase in their water bill to accommodate sewerage services: 57% reasoned out that the price increase would mean better quality service; 12% said it was low with respect to their incomes; 12% declared that the current charge is low; while 10% didn’t say anything.

Of the respondents who were unhappy with the price increase, 44% disagreed with any price increase, 28% said there was no increase in family income and the price increase would lessen their household budget, 13% thought that the MWSS would just pass on its expenses to its customers. Other reasons indicated were: no budget allocation, additional household expenditure, while some said that the it is the obligation of the government to shoulder the price increase.

Sewerage fee charged by the MWSS at present is 50% of the water charge for all customers connected to the MWCI sewerlines. The survey results showed that none of the respondents was aware of this. The figure they gave ranged from PhP 180 to 500 a month. Although the response given is true, they however, were not aware how this amount was arrived at. The MWSS has been releasing to the press information about its water tariff, one of which was posted in the Manila Standard dated August 10, 2003. This reflects that more information dissemination is needed.

As part of the Socio-economic Study of the Environmental Impact Assessment study, willingness-to-pay (WTP) surveys were undertaken in Barangays Wawa, Western Bicutan, Calzada of Taguig; and Barangay San Juan in Tanay, Rizal. One purpose of this study was to estimate the willingness to pay for an increase in the water bill for sewerage services. The analysis of willingness-to-pay was based on the contingent valuation method. Using this method, survey information is evaluated to determine the relative value the respondents place on various services.

A simple average of the four communities provides a rough indication of what the expressed WTP amount might have been for Barangays Wawa, Western Bicutan and Calzada in Taguig; and Barangay San Juan in Tanay in 2003.
The estimated average WTP in 2003 is: PhP 20 per month, or approximately 8.31 % and 9.58 % of their average water bills of Taguig and Tanay, respectively.

This amount can be adjusted to estimate 2004 price levels using the 6.3 % inflation rate for fuel, light and water in Metro Manila, so that the 2003 prices should be raised to make them current with 2004 prices.

Estimated average WTP in 2004 pesos is: PhP 21.26 per month per household or approximately 8.84 % and 10.18 % of the average water bills in 2003 of Taguig and Tanay, respectively.

4. Future Willingness-To-Pay

By the time the first households begin connecting to the new sewage system, real incomes will have changed, and ability-to-pay as well as willingness-to-pay will have increased accordingly. A projection of future willingness-to-pay has made taking these expected changes into account, and using the following assumptions:

Low priority is given by the affected families to the sewage in their household expenditures. Information education campaign and awareness on the benefits that they will gain from safe piped-water and sanitation services should be conducted to change their perception and willingness to pay for such service.

Households which have signified that they would be willing to pay for sewerage service estimated it to be equivalent to as much 8.84 % and 10.18 % of the water bills of households in Taguig and Tanay, respectively. This amounts to PhP 21.26 on the average for each water connection.

Ability to pay was estimated to be as much as PhP 20 a month or approximately 8.31 % and 9.58 % of their average water bills of Taguig and Tanay, respectively.

Historically water bill payments accounted for 1.09 % of average family income in the Taguig, and 0.84 % in Tanay. Future water bills are expected to do the same.

If the combined payment for water and sewerage services does not exceed 0.84 % and 1.09 % of average family income of households in Tanay and Taguig, respectively, most families will be able and willing to pay for sewerage.

The relatively low willingness to pay of Taguig STP families at 8.84 % and 10.18 % of the average water bills in 2003 of Taguig and Tanay, respectively as compared to the 50 % that MWSS is presently collecting is an indication that communities located adjacent to these but may be indirectly affected by the proposed project will have to be included in the price increase.

To remain within stated limits of willingness to pay expressed as percent of the average family, the average payment for sewerage services should be approximately 0.84 % and 1.09 % of the average family income in Tanay and Taguig, respectively.
Real incomes in the Taguig STP communities will continue to grow at 6.3% annually from 2000 to the future. If sewerage connections will start by year 2004, projected average family income in that year will be about PhP 278,310 and PhP 363,217 in Taguig and Tanay, respectively in constant 1997 prices. If payments at that time do not exceed PhP 329.92 per month or PhP 3,959 per year for Taguig; and PhP 254.25 per month or PhP 3,051 per year for Tanay in constant 1997 prices, they will be within the limits of most families expressed willingness-to-pay as a proportion of total income.

Therefore, in year 2004, average household consumption in the Taguig STP communities was assumed to be willing-to-pay for sewerage service, expressed in constant 1997 prices as: PhP 251.55 a month in Taguig; and PhP 254.25 a month in Tanay.

Higher income families will have a greater willingness to pay to be connected to the sewerage system. To the extent that the sewerage system serves property owners in areas with higher than average incomes, the willingness-to-pay will be higher than the figures above representing the average household.

An information awareness campaign will definitely shift the willingness-to-pay decisions of households.
Environmental Manager Trainee and Certification as The Pollution Control Program Implementation in West Java Province

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Abstract
The Increasing of the humans and industries activities are the main cause of the water environmental quality and quantity degradation in Indonesia. Citarum River in West Java, for example, its function as the drinking water and power sources has been threatened because of the significant degradation in its quality and quantity. Various treatment efforts have been conducted either by government or stakeholders but have not shown an optimal result. The approaches that have been conducted are pollution control through stipulating standard quality that has mandatory character, ISO standardization and industrial commitment to government programs (Proper and Clean River Program). Environmental Pollution Control Manager (EPCM) represents one of the individual reinforcement programs to improve the capability of human resource that has responsibility in industrial pollution management with certification program. This program has been initiated since 2002, representing as the first program in Indonesia cooperating with JETRO (Japan External Trade Organization). Legal formal of this program is The West Java Provincial Regulation No. 3/2004 concerning Water Quality Management and Water Pollution Control Of Contamination mentioning “each person or agency which conducting waste disposal to water sources must have certified person in charge and operator of Waste Water Treatment Plant (WWTP)”. This program is conducted by certification agency (independent) with supervision from West Java Government. It is held regularly once in a year. In 2005, the program has been followed by 61 participants and increase to 83 participants in 2006. Besides conducting training and test, it is also conducted text book up dating, socialization to industries in entire area of West Java, Training of Trainer and also refreshment to the previous participants.

Key words: Pollution Control Manager, Waste Water Treatment Plant, Environmental degradation

1. Introduction
West Java Province geographically is located between 5°50' - 7°50’ and 104°48 LS - 104°48 BT with its regional boundary north side on Java Sea and DKI Jakarta and eastside boundary on Central Java Province, between Indonesia Ocean in Southside and Banten Province in Westside. It has a tropical climate, with temperature 9°C in top of The Pangranggo Mountain and 34°C in Coast North, rainfall average is 2000 mm per year, but in some mountains are between 3000 to 5000 mm per year.

West java region has more than 35 watersheds of both big and small scale, 20 watersheds run in northward and 15 in southward.
The biggest and the most important river in West Java is Citarum River, with total area of 6.080 km², length of 269 Km, rain fall of 2.300 mm/year. The usage of Citarum river are drinking water source for many cities such as Jakarta, Kabupaten Bekasi, Kabupaten Karawang, Kabupaten Purwakarta, Kabupaten Bandung, and Bandung City; main supplier for 3 big dams (Saguling, Cirata and Jatiluhur) for electricity generator. Those 3 reservoirs produce electrical energy of 5.000 giga watt hour (5x10⁹ KWH)/year, equal to 16 x10⁶ ton/year fuel energy and as irrigation source for 300.000 Ha paddy field. On the other hand, alongside Citarum River has approximately 1000 industries causing Citarum River facing many complex problems such as (1) decreasing of Citarum River water quality and quantity, generally caused by industrial waste, domestic waste, agricultural waste and animal husbandry; (2) depletion of carrying capacity due to land covering change, mixed land use between industrial and domestic will make bigger pollution loading; (3) decreasing of Citarum River level in dry season and increasing in wet season because decreasing of catchments area in upper stream.; and (4) lack of institution coordination in Citarum watershed, because Citarum River passing 7 Kabupaten in West Java Province, with many interest there.

Relation between average Citarum Upstream water quality, for some chemical and bacteriological parameters with the distance (upstream-downstream) in Wangisagara, Sapan, Cijeruk, Margahayu dan Nanjung shown in a pictures.

Changing in Citarum River quality significantly occurred after Sapan station. This station placed in Upstream Citarum River from Wangisagara direction after passing the farm, residential, and industrial zone. The inset picture below show the comparison between landscape image of year 1994 with 2001, LAPAN interpretation (2001).

Picture 1. River pollution contribution in Sapan Station
Dissolve Oxygen (DO) at Wangisagara is 5.76 (mg/L), it still fulfill the regulation (West Java Governor Decree No. 39/2000) which is above 3 mg/L. DO decreased after 12 km from Wangisagara (Sapan) into less than 2 mg/L, it had a little increasing at Cijeruk (10 km after Sapan), and decrease again at Margahayu (10 km from Cijeruk) and Nanjung (13 km from Margahayu) into less than 2 mg/L. BOD and COD parameter are increasing after Sapan station, there are 10.34 and 20.73 mg/L at Wangisagara, getting more and more increase into 85.18 and 145.35 mg/L at Sapan, and decrease into 17.95 and 45.38 mg/L at Najung.

Fecal coli number show different pattern, there are 8.511 / 100 mL at Wangisagara, 9.500 / 100 mL at Sapan, and significantly increase at Cijeruk (315.468 /100 mL), and increase constantly to Margahayu (446.728 /100 mL) and 429.818 /100 mL at Nanjung.

From the analysis, the cause of the increasing number of BOD, COD, and Fecal Coli are the direct contamination from the untreated waste of residential, industrial, agricultural, and animal husbandry along the Citarum River.

One of the problems solving on Citarum river quality degradation is by improving human resources that will manage and responsible to the industrial pollution with certification program called Environmental Pollution Control Manager (EPCM).
2. About EPCM in West Java province
West Java Government has been cooperating with JETRO (Japan External Trade Organization) for Environmental Pollution Control Manager (EPCM) program since 2002. Environmental performance from industry is highly determined by ability of its personnel which is concerned in the management effort of industrial environmental impact. Besides requiring personnel owning knowledge, skill, and adequate behavior, it is also concerning about involvement of the competence personnel that have to be institutionalized in a functional organization which has the division of role, duty and responsibility. To reach the target, West Java Government obligates industries causing water pollution, air pollution, land and ground contamination as well as noise trouble and vibration to have Environment Pollution Control Organization.

Environmental pollution control organization in the industry consists of Environmental Manager, Technical Coordinator and Operator of waste installation. The duty of the Environmental Manager is to conduct effectiveness and performance of all pollution control; the technical coordinator must be have responsibility to the technical pollution control and the duty of operator of waste installation is controlling the waste disposal facilities such as waste water treatment, emission and incinerator.

Environment pollution control organization in the industry must have written document about organization structure with role, responsibility, and authority for every personnel, job description and standard operational procedure. Environment pollution control organization has to be registered to West Java Government, which is West Java Environment Protection Agency (West Java EPA). After that, West Java EPA submits information concerning the environment pollution control organization to environmental institution in local government (Kabupaten/City). West Java EPA authority is to observe organization performance and can substitute the personnel if the industry has poor performance.

3. EPCM implementation in West Java province

3.1 Regulation
We have 3 Acts as an legal formal for EPCM implementation which are The Act of Environment No 23 Year 1997, The Act of Manpower No 13 Year 2003, and based on that act, West Java Province made regulation of waste water pollution control and is acted by governor decree on environmental human resources and West Java Provincial Regulation No. 3/2004 concerning Water Quality Management and Water Pollution Control Of Contamination mentioning that "each person or agency which conducting waste disposal to water source must have certified person in charge and operator of Waste Water Treatment Plant (WWTP)".

3.2 Objective
EPCM objectives are to Support the government in the effort to control industrial environmental impact; Forming an acceptable and applicable EPCM training and certification scheme to various stakeholder group including industrial owner and management, community, government, legislator, professional groups and training agent; Provide added value to human resources involved in the industrial pollution control field and provide formal recognition of the profession of environmental
manager; Create a fair and transparent certification mechanism to be managed by stakeholder; Encourage training provider to develop related and supporting training program.

3.3 Outcomes
Expected outcomes of implementation EPCM are creating basic concept of PCM standard competency; PCM classification and qualification; certification mechanism; required training program and institutional scheme included accreditation mechanism for training providers; Implementation of strategy and planning; included development of legal framework, capacity building of independent certification body and long term implementation plans; Training curriculum and methods; Format of examination and certificate; Develop the training manual and textbook.

3.4 Institutions
Institutions involved in EPCM certification implementation consist of Advisory Board, Supervisory Board, Certification and Training Agencies. Certification Body handling by Association Industry of Indonesia (APINDO) and Environment Professional Association (IATPI).

3.5 Certification Mechanism
The industrial WWTP operator/coordinator who have an educational background, at least diploma degree in environmental engineering and 2 years professional experience, can directly register to take examination. If he/she unable to full fill those requirements the applicant has to take training before taking examination.

Curriculum of The Training consists of nine materials, which are EPCM Background, Liquid Waste and Water Environment Preservation Regulation, Role and Responsibility of Water Pollution Control Manager, Water Environment Management, Liquid Waste Management, Liquid Waste Management Technology, Liquid Waste Characteristic Analysis, Sludge Treatment, and Water Pollution Emergency Action.

The Pilot activities (training session, examination, and certification) in 2005 followed by 61 participants, which 53 participants were graduated and 8 participants were not graduated. In 2006 the participants increase to 83 participants, which 79 participants were graduated and 4 participants were not graduated.

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<th>Percentage of Certification Graduation in 2005</th>
<th>Percentage of Certification Graduation in 2006</th>
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<tbody>
<tr>
<td>Graduated: 86%</td>
<td>Graduated: 95%</td>
</tr>
<tr>
<td>Not graduated: 14%</td>
<td>Not graduated: 5%</td>
</tr>
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3.6 Monitoring, Evaluating, and Reporting
Supervising and monitoring conducted by The Board in coordination with the environmental control institution in Kabupaten/City and The Certification Body. The Board can process any disobedience according to the existing law and regulation.

4. Conclusion
The Environmental Pollution Control Managers (EPCM) program is the first pilot project conducted in Indonesia concerning human capacity development for pollution control in industry. The West Java Government expect that EPCM program can control industrial pollution in Citarum River, considering its big role as the drinking water and power sources. Next step will be EPCM implementation in air pollution, hazardous waste, noise and vibration control. Supervising and monitoring is the success key for this program beside the support from all stakeholders, such as industry, local government, NGO’S, University, and Professional.

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Innovative Partnerships in the Protection and Management of the Marine and Coastal Resources of Manila Bay

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Abstract
Manila Bay is a semi-enclosed estuary facing the South China Sea which provides a source of food, livelihood, employment, and recreation to about 23 million Filipinos. Its sustainability is continually threatened by over-exploitation of resources, illegal and destructive methods of harvest, habitat destruction, pollution, siltation and sedimentation, and multiple-use conflicts.

To address the complexity of this environmental issues affecting the bay, the Manila Bay Environmental Management Project (MBEMP) was therefore established under the Department of Environment and Natural Resources -Environmental Management Bureau (DENR-EMB) with support from GEF/UNDP/IMO Regional Programme for Building Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) to oversee and steer the participation of all concerned agencies, sectors and the civil society in arresting these threats, and realize a vision of clear, safe and wholesome Manila Bay.

The partnerships of the concerned agencies resulted in the development of plans and programs which will lead towards sustainable development of Manila Bay:

1. Manila Bay Coastal Strategy
2. Refined Risk Assessment.
3. Integrated Environmental Monitoring Program.
5. Manila Bay Oil Spill Contingency Plan
6. Integrated Information Management System
7. Environmental Investment
8. Coastal Land and Sea -Use Zoning Plan
9. Stakeholders participation
1. Introduction
The Manila Bay is the country’s major hub and international gateway to the political, economic and social center. It is a natural heritage, a witness to the panorama of Philippine history and the venue of significant events that have helped shape the country.

The Bay, with its semi-enclosed estuary facing the South China Sea, represents a vital national asset, providing a source of food, livelihood, employment, recreation, to an estimated 23 million People, consistent with its character of being a major source of economic benefit for the country. Hand in hand with the surrounding provinces, cities and towns, the Bay contributes a very significant share of the country’s gross domestic product (GDP) and accounts for almost one third of the country’s agriculture, and fisheries production. Its supports fisheries and aquaculture as major sources of livelihood as well as development activities in manufacturing, shipping and ports, agriculture and commerce.

The sustainability of the Bay and its diverse ecosystem is however continually threatened by a variety of watershed, lowland and sea-based human activities, which contribute to the decline in its environmental quality. Overexploitation of resources, illegal and destructive methods of harvest, habitat destruction, pollution, siltation and sedimentation, uncontrolled development and the conflicting use of limited available resources cause pressures on the bay.

Essential in the process to address the complexity of these environmental issues affecting the Bay, is the development of innovative partnerships that would bring together all agencies, institutions and the civil society to carefully plan and implement programs under a common framework toward the rehabilitation and restoration of the Bay and its watersheds.

The Manila Bay Environmental Management Project (MBEMP) was therefore established under the DENR-Environmental Management Bureau with support from GEF/UNDP/IMO Regional Programme for Building Partnerships in Environmental Management for the Seas of East Asia (PEMSEA) to oversee and steer the participation of all concerned agencies, sectors and the civil society in arresting these threats, and realize a vision of clear, safe and wholesome Manila Bay. A Technical Working Group (TWG) coordinates and collaborates initiatives which are responsive to issues in components of the project. The TWG is composed of representatives from relevant National Government Agencies, concerned Local government units, academic and scientific institutions, NGOs/POs, and even the civil society. A project coordinating committee was also created to provide policy guidance and directions to the various activity of the project (Fig.1).
Figure 1. Manila Bay Environmental Management Project Organizational Structure.
2. Current efforts towards sustainable development of the bay

2.1 Development of the Manila Bay Coastal Strategy

One of the early achievements of the projects was the development of the Manila Bay Coastal strategy, a product of stakeholders consultations throughout the regions to formulate a shared vision on the future of the bay.

The MBCS clearly identified the various risks and challenges the Manila Bay area faces. Water pollution tops the other major issues like overexploitation of resources, siltation and sedimentation, habitat degradation, multiple and conflicting uses.

The commitment to pursue this shared vision for Manila Bay was affirmed by over a hundred representatives from the government, private sector, financing institution and other stakeholder groups through the Manila Bay Declaration signed on October 24, 2001.

2.2 Refined Risk Assessment

The Refined Risk Assessment is a scientific and technical assessment of the resources and the physico-chemical features of the Bay as it relates to the ecosystems and human health.

Retrospective risk assessment conducted, established that there is a clear evidence of declines for fisheries, shellfisheries and mangroves. For coral reefs, there were accounts indicating a decline in quality and cover of these reefs.

For prospective risk assessment, the study found out that numerous environmental parameters of the waters of the Manila Bay exceeded acceptable levels. The parameters that showed excessive levels are: Total and Fecal Coliform, phosphates, heavy metals such as mercury, lead, zinc and copper.

Based on these findings, future actions and interventions for the Manila Bay must address the above concerns.

2.3 Operational Plan for the Manila Bay Coastal Strategy

The Operational Plan developed by an interagency and inter-sectoral Technical Working Group (TWG) is the translation of the Manila Bay Coastal Strategy into actions plans and programs in three (3) areas of concerns namely:

1. Protection of the waters in Manila Bay and its tributaries (rivers and lakes) and ensure that they are safe for various uses (recreation, irrigation, Fisheries and other living resources, source of potable water).

2. Protection restoration and sustainable development of resources, habitats, natural areas, and historical, cultural and religious and archeological sites.

3. Promotion of partnerships and ensure the implementation of good environmental governance as means to achieve the sustainability of the bay region.
2.4 Integrated Environmental Monitoring Program
The Integrated Environmental Monitoring Program (IEMP) developed is a cross-sectoral and sustainable integrated environmental monitoring program. The program comes with a 5-year action plan which among others identifies the agencies or the institutions where applicable monitoring capacity may be tapped. The development of the 5-year action plan involves a pilot study integrating the different monitoring programs being undertaken by various stakeholders under one monitoring plan. The adopted IEMP design focused on the identified priority parameters, contaminants, habitats and resources as well as data gaps and sources of uncertainty in the Refined Risk Assessment (RRA).

A Memorandum of Understanding (MOU) defining the roles and responsibilities of participating agencies for the implementation of the Integrated Environmental Monitoring Plan was forged by concerned agencies on November 13, 2006.

2.5 Integrated Information Management System
The Integrated Information Management System (IIMS), developed is a relational database with geographic information system (GIS) linkage. This handles data set such as information on Marine and Coastal resources, socio-economic and demographic features of Manila Bay.

A web-based IIMS for Coastal and Marine Environment was installed in the three (3) Site Management Offices (SMOs) of the Manila Bay Environmental Management Project (MBEMP) to effectively and efficiently facilitate the input, storage and retrieval of data in support of the activities of the MBEMP on environmental monitoring, environmental resource valuation, oil spill contingency planning, coastal strategy development and its operational plan, coastal use zoning and public awareness.

Such development of the system paved the way to the establishment of the Manila Bay Area Information Network for DENR, a sub-set of the network among agencies in the Manila Bay Area. The DENR also adopted IIMS as a common database platform nationwide, with initial implementation in DENR Regions 4-A and 3 and NCR.

The Manila Bay Atlas which is a collection of geographic maps or charts which features the natural resources, economic activities and the risk and challenges facing the Manila Bay area was also developed.

2.6 Oil Spill Contingency Plan
Using the results of risk assessment and environmental monitoring as inputs, an oil-spill contingency plan was developed for Manila Bay to strengthen the coordination of relevant agencies for a timely and effective response to oil spills. Key habitats, resources and species, which are at risk from oil spills are being identified, and sensitivity mapping and response strategies are being developed. Concerned national government agencies, local government units (LGUs) and the private sector (ports, shipping and petroleum industries) worked on this contingency plan, with the Philippine Coast Guard (PCG) taking the lead. In this way, preparedness and cooperation are being instilled.
2.7 Environmental Investment
Public – Private Partnerships (PPPs) was adopted as an alternative delivery mechanism in the development and implementation of investments in environmental facilities and services, particularly those identified in the coastal strategy and operational plan. Through PPPs, the LGUs, which have the mandate but not the technical and financial capacity; the private sector, which has capital technology and business expertise; and the communities, which need service, are brought together to tackle the challenges of having essential facilities that are technically viable, environmentally sound and financially acceptable.

Using PPP approach two (2) feasibility studies on integrated solid waste management system were developed.

2.8 Stakeholders’ Participation (Civil Society Participation)
Another key component of the MBEMP is the information, education and communication (IEC) drive to increase awareness among the government, the communities and the public, in general, about the risks, the current state of the ecosystems and the environment, and the corresponding ecological and socioeconomic consequences. Creating public awareness through participation is being carried out in the course of mobilizing various stakeholders in activities such as coastal cleanup, mangrove reforestation, bird counting and tree planting.

As part of its advocacy and stakeholders participation program, a memorandum of undertaking (MOA) was forged between the DENR and the Manila Yacht Club-101st Squadron of the Philippine Coast Guard Auxiliary to contribute to the implementation of the Manila Bay Coastal Strategy. The MOA serves as a platform for technical cooperation between DENR, the Coast Guard Auxiliary and the Manila Yacht Club in the development and implementation of pollution and mitigating activities for Manila Bay, such as regular clean-up activities with the students from various schools and universities.

Through the various IEC activities, people’s consciousness concerning the interconnectivity among ecosystems and with human activities, as well as the need for active participation and collaborative efforts to solve multiple-use conflicts and to address the lack of policy an functional integration in the management of the bay and the adjacent coastal and watershed areas, is being raised.

2.9 Coastal Land and Sea-Use-Zoning Plan (CLSUZP)
The Coastal Land and Sea-Use-Zoning Plan was developed, with the Province of Bataan as a pilot site. The development of the (CLSUZP) considered both the biophysical/environmental elements and socio-economic factors affecting Bataan. The objective for its development is to demonstrate the application of coastal land and sea-use-zoning in resolving multiple resource-use conflicts in the coastal area. This will also provide a regulatory framework of permitting and prohibiting coastal activities according to designated use of coastal space and to serve as a model for coastal zoning for other coastal provinces within Manila Bay.
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The Perbadanan Bekalan Air Pulau Pinang Sdn Bhd (PBAPP): A Good Example of Corporate Social Responsibility of a Private Water Company in Malaysia

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Abstract
The story of Perbadanan Bekalan Air Pulau Pinang Sdn Bhd (PBAPP), a privatized water company in Penang, Malaysia, show-cases how privatization can be successful. More importantly, PBAPP is undoubtedly one of the most successful privatized water companies in the country, both in terms of its annual profits as well as its key performance indicators and its commitments towards corporate social responsibility. Its partnership with Water Watch Penang in the area of awareness, education and conservation testifies to its commitment towards social as well as environmental responsibility. Due to its success, PBAPP has been quoted both by government, NGOs as well as global water players as the “benchmark” for water companies.

1. Introduction
The Perbadanan Bekalan Air Pulau Pinang Sdn Bhd (PBAPP) is a privatized water company in Penang, Malaysia. It is the sole subsidiary of PBAHB\(^1\) which was incorporated in Malaysia on March 1, 1999 to undertake the role of the successor company in the corporatisation exercise of the water authority in Penang State. PBAPP was subsequently granted a license by the Penang State Government pursuant to Part IV, Section 16 of the Water Supply Enactment 1998 to operate as the water supplier in the state. Despite the resistance from some NGOs and the public towards water privatization in Malaysia in general, PBAPP is a good example of how water supply can be privatized. The company has adopted a holistic approach towards managing the water supply in Penang State, from handling the sourcing of raw water, treatment of water, distribution and the billing of consumers (http://www.pba.com.my/ 13 Feb 2007). PBAPP has also committed itself towards its Corporate Social Responsibility by contributing towards water conservation and supporting as well as working closely with NGOs, especially Water Watch Penang (WWP) (www.waterwatchpenang.org) in its conservation programmes.

Historically, the supply of water for Penang State was fragmented under the City Council of Georgetown (for Penang Island) and the Public Works Department Penang (for Mainland Penang or Seberang Perai). In January 1, 1973, the roles was taken over by Pihak Berkuasa Air Pulau Pinang (PBA) pursuant to the Penang Water Authority Enactment 1972. With that, PBA was established in 1973 as statutory body to manage and regulate the water supply in the state.

\(^1\) PBA Holdings Bhd (PBAHB) was incorporated in Malaysia on May 25, 2000 as a public limited company under the Companies Act, 1965 and having its registered and principal place of business at Level 32, KOMTAR, 10000, Jalan Penang, Pulau Pinang. PBAHB is an investment holding company with a single subsidiary, namely Perbadanan Bekalan Air Pulau Pinang Sdn Bhd which is involved in the business activities of the water suppliers in the state of Pulau Pinang. PBAHB was listed on the Main Board of the Bursa Malaysia (Malaysian Stock Exchange) on April 18, 2002.
Pursuant to the approval of the Penang State Government in August 1997 and the approval from the Economic Planning Unit in June 1998, PBA was corporatised as Perbadanan Bekalan Air Pulau Pinang Sdn Bhd on March 1, 1999 under the Penang Water Authority (Successor Company) Enactment 1998.

2. Key Performance Indicators
Since privatization, PBAPP has consistently shown impressive water performance indicators. It is probably the most successful water company in Malaysia, having been quoted not only by the Malaysian Government but also consistently by NGOs (Netto, 2005; Chan, 2006a). PBAPP’s supply coverage is 100% in urban areas and 99% in rural areas, and Penang water rates/tariffs are amongst the lowest in Malaysia. (An average of RM0.31 for the first 35 cu.m [Domestic] and an average of RM0.94 for first 500 cu.m [Trade] [RM1.00=US$0.28]). Despite the fact that Penang is a water stressed state, i.e. a state with few water catchments and about 80% of its water comes from the Muda River which has its catchment in another state, PBAPP has done well to ensure that water supply in Penang State is amongst the most efficient, if not the most efficient in Malaysia. The PBAPP is constantly planning for the future as the state's population grows and prospers towards vision 2020 as the company supports the Penang State Government's plan to cultivate sustainable development and a green environment. In 2004, PBAPP implemented an Environmental Management System (EMS) at the Batu Feringghi Treatment Plant and the Teluk Bahang Dam. Subsequently, the company also obtained ISO 14001:2004 certification dated 1 March 2005 for the "Management and treatment of raw water and the supply of potable water in the above two facilities". PBAPP is now seeking similar certification for the 8 other treatment plants and 2 other major dams in the State of Penang. PBAPP is continuously striving for excellence. The company is keeping up to its promise of “meeting all your water supply needs”, not just in the quality of its supply but also through continuous public awareness and education. The PBAPP’s website (www.pba.com.my) is a comprehensive collection of relevant information regarding the quality of Penang’s drinking water supply along with helpful tips about murky water, where water comes from, the most effective course of action to take during water stress, and how safe is Penang’s drinking water, etc. Perbadanan Bekalan Air Pulau Pinang (PBAPP) is committed to “continuous improvement” in water supply for the State of Penang, in accordance to international ISO 9001:2000 certifications from UKAS (United Kingdom) and DAR (Germany) for the “treatment and supply of water with customer services.” Table 1 shows the various performance indicators.
Table 1. Performance Indicators and Statistics of PBAPP (Source: www.pba.com.my).

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of dams</td>
<td>6</td>
</tr>
<tr>
<td>Total raw water storage capacity</td>
<td>46,013 million litres</td>
</tr>
<tr>
<td>No. of treatment plants</td>
<td>10</td>
</tr>
<tr>
<td>Design capacity of treatment plants</td>
<td>1,166 million litres</td>
</tr>
<tr>
<td>No. of treated water reservoirs</td>
<td>50</td>
</tr>
<tr>
<td>No. of treated water towers</td>
<td>30</td>
</tr>
<tr>
<td>Volume of treated water supplied daily</td>
<td>759 million litres</td>
</tr>
<tr>
<td>Total daily water consumption</td>
<td>612 million litres</td>
</tr>
<tr>
<td>Percentage of non-revenue water (NRW)</td>
<td>20%</td>
</tr>
<tr>
<td>Total length of mains and pipelines (100mm in diameter and above)</td>
<td>3,407km</td>
</tr>
<tr>
<td>Supply coverage</td>
<td>100% in urban areas, 99% in rural areas</td>
</tr>
<tr>
<td>Domestic water tariff (1st 35,000 litres)</td>
<td>RM0.31 per 1,000 litres</td>
</tr>
<tr>
<td>Trade water tariff (1st 500,000 litres)</td>
<td>RM0.94 per 1,000 litres</td>
</tr>
</tbody>
</table>

3. Corporate Social Responsibility and Partnerships with NGOs

Since 1999, PBAPP has initiated a partnership with WWP. This is an annual water awareness, education and conservation programme in Penang State fully sponsored by PBAPP and carried out by WWP. The objectives are: to create and promote greater awareness of the importance of the environment and the vital resources that the environment produces for humanity; to inculcate in all Penangites the habit of loving and treasuring the environment, ultimately making them environmentally-friendly people; to reach and educate the young, especially school children and also the adults (the general public) about the importance of the environment and its conservation; to change peoples’ habits from being apathetic towards the environment to being caring towards the environment (for example changing them from “water wasters” to “water savers” and by doing so we change a “Water Wasting Society” into a “Water Saving Society”); to ensure that Penang’s water resources are sustainable in the long run via the efforts/activities of government, industry, NGOs and the public; to promote internationally and locally the image of the Malaysian Government as one that is “Caring Towards The Environment” and also one that is “Accommodating In Allowing The Private Sector, NGOs and the Public to play a significant role in environmental management”; to realize the Government’s commitments towards sustainable development in the long run, especially in terms of a Malaysia with a clean and healthy environment, and a clean and healthy population.

Since 1999, WWP and PBAPP have jointly organised and celebrated World Water Day (WWD) which falls every year on 22nd March. For example in 2006, WWD was held in Penang on 2 April 2006. This event was jointly by WWP together with PBAPP Sdn Bhd, Rotary Club of Penang and Avago Technologies at the Penang Youth Park. A total of 99 schools took part with 217 students and 20 teachers. The estimated total number of accompanying parents is 70 and total number of members of the public attending is more than 200 people. A total of 12 organizations put up water exhibition booths during this event to increase public awareness about water and related issues. The event was officiated by the Chief Minister of Penang with many other politicians, government officers, staff of PBAPP, members of Rotary Club Penang, staff of
Avago Technologies, staff of Penang Municipal Council (MPPP), and other VIPs. Many activities were organised throughout the day, including the opening ceremony, declaration of World Water Day by YAB, talks on water conservation, press conference with members of the press, water quizzes, water painting competitions, prize giving, water exhibitions and water guessing competitions and visits to waterfall treatment plant. The total number of people attending is officially noted at 498 but those that did not register may be around 200 to 300. Altogether, it is estimated that at least 900 people attended this event. In addition, the PBAPP Sdn Bhd’s waterfall treatment plant was also open to the public. It is estimated that at least 100 people visited the plant.

PBAPP and WWP, together with Ford Motor Company (through its Environmental Conservation Grants) also jointly produced a water education VCD in April 2006. The VCD was launched at the WWD celebrations on 2 April 2006. This is a 20 minute VCD on water education produced by WWP and jointly sponsored by PBAPP Sdn Bhd and Ford Foundation. The VCD was given out at RM1 a piece during WWD 2006 at the Penang Youth Park. The VCD was also sold at all WWP functions and activities in 2006. A total of 2000 VCDs were made. WWP plans to distribute the VCDs to all schools in Penang State.

PBAPP and WWP also partnered the Excel Point Community Care Kids Joy Club “Easter Colouring Contest on 16 April 2006”. The event was held at 2-4-5 Pekaka Square, Lebuh Pekaka Satu, Sg Dua 11700 Penang. PBAPP contributed some of the prizes. YB Goh Kheng Sneah, ADUN Batu Uban officiated and gave away the prizes. A total of 301 children took part in the three categories of the contest: (i) Category A (Ages 4-6); (ii) Category B (Ages 7-9); and Category C (Ages 10-12). The number of parents who accompanied their children also totaled more 200. The organizers of the event totaled about 30 staff of EPCC. The total number of schools involved is estimated at more than 50, many coming from as far as Batu Ferringhi and Balik Pulau.

PBAPP and WWP also worked with schools. On 21 April 2006, it jointly organized the SMJK Chung Hwa Confucian “Educational Quiz 2006”. A total of 200 students took part in this quiz. WWP provided facilitators, questions and contributed some of the prizes. WWP facilitators gave educational talks about the importance of water before the quiz.

PBAPP and WWP has a monthly programme for schools on river awareness and education. For example on 29 July 2006, a Sg Air Terjun river catchment awareness programme was carried out with apartment children in the Batu Uban area. This activity was organized with a number of condominiums and apartments in the Batu Uban area. A total of 50 children (with many accompanying parents) were first briefed on the importance of rivers and then taken on a river walk around botanic gardens along the Sg Air Terjun. The group was taught about the functions of the forest as a water catchment as well as for biodiversity, tourism and other functions. The group was treated to a lunch snack. After lunch, a river clean-up was conducted. The group was also taught how to measure river water quality via pH, dissolved oxygen, temperature, dissolved solids, etc. All participants enjoyed themselves and WWP T-shirts and other souvenirs were handed out to each participant.
PBAPP and WWP also work with universities. On 5 August 2006, a “Penang National Park Programme and Importance of Teluk Bahang Dam as a future source of water supply” was carried out for Universiti Sains Malaysia (USM) undergraduates. This is an awareness and education programme for university students. The students have to write a report after they finished the activity. A group of about 200 undergraduates of Universiti Sains Malaysia were taken into the Penang National Park (PNP). Bus was provided by USM. WWP provided the facilitators. The students were briefed by WWP facilitators on the history and process of how the PNP was gazetted, the importance of the PNP and what they thought would be most important in the conservation of the park. The group hiked into the park and stopped at Pantai Kerachut for lunch. Along the route, the group encountered many clean streams and some tests of water quality were performed. The discharge and cross-sections of the small streams were also measured as part of the exercise. Students were taught that inside the PNP, the water quality of streams was very good. After the hiking, the group was taken to the Teluk Bahang Dam. They were briefed on the importance of the dam and how the PNP was a catchment for this dam.

A Local Awareness and Water Saving Seminar was held in N-Park Condominium, Penang on 18 November 2006 (Chan 2006b; Chan 2006c). This was part of PBAPP and WWP’s aim of reaching all segments of the public and teaching them to save water, WWP organized this event for apartment owners and residents, given the fact that N-Park Resort Condominium is a big user of water. A total of 120 apartment owners and residents took part in this event, organized by WWP. Many also brought along their children (about 20 children were counted). WWP presented two papers titled “The Water Situation in Malaysia and Penang: Why The Need To Save Water” and “Water Watch Penang - What We Do and How N-Park Residents Can Reduce Water Use”. The participants were enthusiastic, took part in the discussion actively and gave many useful comments. Those taking part were all registered and accounted for. It is expected that by the end of the test period, N-park residents would reduce their water demand/use by about 10%. This being the case, N-park Condominium will be used as the “bench-mark” for replication of the project in all other condominiums and apartments in Penang, and Malaysia.

4. Future Activities
Future water conservation activities planned by PBAPP and WWP are as follows: (1) 2007 State-Level Celebration on World Day for Water 2007 in one of the shopping malls in Penang (The target is the newly opened Queensbay Mall), tentative dates are over 2 days, i.e. 24 March (Saturday) and 25 March (Sunday) 2007;(2) Dissemination of 2000 copies of water education VCD by WWP-PBAPP-Ford Foundation for distribution to all schools in Penang State & also to be distributed during World Water Day 2007; (3) Reprint of 1000 copies of New Water T-Shirt Bearing WWP-PBAPP Sdn Bhd logos for distribution during World Water Day 2007 as well as to be used in all 2007 WWP-PBAPP Activities; (4) Reprint of 3000 copies of School Exercise Books with WWP-PBAPP logos for distribution during World Water Day 2007 as well as to be used in all 2007 WWP-PBAPP activities; (5) Production of 3000 copies of School Note Pads with WWP-PBAPP logos and Water Conservation Tips for distribution during World Water Day 2007 as well as to be used in all 2007 WWP-PBAPP Activities; (6) Production of 1000 pieces of WWP-PBAPP Mugs for distribution during World Water Day 2007 as well as to be used in all 2007 WWP-PBAPP Activities; (7) Production of 3000 pieces of Rubber Wrist Bands (A very “in-thing” amongst the young) that carries WWP-PBAPP logos and “Save Water” message for

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distribution during World Water Day 2007 as well as to be used in all 2007 WWP-PBAPP Activities; (8) Production of 3000 pieces of Writing Pens with WWP-PBAPP logos for distribution during World Water Day 2007 as well as to be used in all 2007 WWP-PBAPP Activities; (9) State-wide Inter-School Water Crossword Puzzle for primary school children (Category 1) and lower secondary school children (Category 2). The puzzle words are all related to water. Issues such as the water cycle; water resources management; water conservation; water pollution and its management; water and life; water and ecosystem; and all other topics related to water. Prizes and certificates will be awarded to the top 5 winners in each category and 10 consolation prizes in each category. In the event of more than 1 correct entry, the winner will be determined by a lucky draw. The competition will be on a monthly basis with one competition per month. The puzzle will be printed and sent to all schools via the Ministry of Education Penang; (10) Production of a Water Educational Poster Calendar (2000 copies). The calendar will have water saving tips, the role of PBAPP Sdn Bhd & WWP, photos of rivers, water treatment plants, the importance of water and water conservation in Penang, and other water conservation aspects. All schools in Penang will be given the poster calendar free; (11) Water Awareness and Education Fieldwork for school children. This is an ongoing activity to expose and educate school children on the importance of water. The target group is school children under 15 years of age, i.e. from primary to lower secondary. Every month, a school will be selected whereby 40 students and two teachers will be taught water quality monitoring of rivers in Penang, learn about the entire water treatment process (via visiting a plant), do river clean-up, and upload the data collected and stories of the fieldwork on to the respective school’s websites. In this way, schools can learn about water and rivers, learn ICT on website management, and also interact with students from other schools; (12) Publication of booklet titled “101 ways to save water” to be distributed to all schools in Penang; (13) State Level Domestic Consumers Water Usage Survey under the Ministry of Energy, Water and Communications (KTAK) and Federation of Malaysian Consumers Association (FOMCA)’s “National Water Awareness and Saving Campaign”. This is a national campaign on water saving whereby WWP is a partner responsible for the Penang State activities. Currently a State-wise water saving campaign survey is under way. FOMCA is also carrying out surveys in all other states in the country. The campaign targets a 10 % reduction is water use at the end of 2 years.

5. Conclusion
Contrary to popular misconception, not all privatization of the water sector is necessarily bad for the public. When carried out professionally with transparency, accountability and efficiency, private water companies can be successful and profitable. The story of Perbadanan Bekalan Air Pulau Pinang Sdn Bhd (PBAPP) demonstrates that water privatization can be successful. The success of PBAPP is widely recognized, not just amongst local government authorities and NGOs but also in the Asian region. PBAPP is so successful that it has ventured overseas and won many contracts. PBAPP’s success is backed up by its annual profits as well as its key performance indicators and its commitments towards corporate social responsibility. Its partnership with Water Watch Penang in the area of awareness, education and conservation testifies to its commitment towards social as well as environmental responsibility. PBAPP has many water conservation programmes with WWP targeting the schools and the general public. Not surprisingly, due to its success, PBAPP has been quoted both by government, NGOs as well as global water players as the “benchmark” for water companies.
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http://www.pba.com.my
http://www.waterwatchpenang.org
Lessons on Water Management, Past to the Future


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Abstract

The dry zone of Sri Lanka has been the home of one of ancient “hydraulic civilizations” in monsoon Asia. Mahaweli River development project started in 1970 is the largest water resource management project in Sri Lanka. 33 km long Huruluwewa feeder canal was constructed under the Mahaweli development project to feed Huruluwewa tank, which was initially constructed by King Mahasen (325 – 352 AD). Yet during the design period land development and land used planning was not taken to account. After a decade the project objectives of feeding the Huruluwewa tank was unachieved. Now the stakeholders were trying to take actions to manage the situation and supply sufficient water to Huruluwewa tank. Yet now the situation becomes critical with improper catchment management practices. This paper discusses the percent situation of the water management system compared with the ancient water resource management techniques.

1. Introduction

Sri Lanka is an island located in the Indian Ocean with an extent of 65 525 km$^2$. The country has 103 river basins, while Mahaweli is the largest river system, draining about one sixth of the country. The central hills receive over 3500 mm of rain annually while the dry zone of the country receives rainfall less than 1500 mm annually. This non uniform nature of the rainfall pattern and the prolonged dry periods made it necessary for the early colonizers (2000 years ago) of the country to consider irrigated cultivation in dry zone (DZ) of the country. This was triggered by the hot dry conditions and high evaporation rates for available limited surface water. Civilization based on tanks (man made irrigation reservoirs) is uniquely highlighted in the history of Sri Lanka. This paper discusses the present water management practices in Sri Lanka compared with ancient technologies.

The DZ of Sri Lanka has been the home of one of ancient “hydraulic civilizations” in monsoon Asia (Wittfogel, 1957). It consists of interconnected minor irrigation tanks collectively referred to as a cascade. A cascade is defined here as “a connected series of tanks organized within a micro-catchment of the DZ landscape, storing, conveying and utilizing water from an ephemeral rivulet” (Madduma Bandara, 1985) and is considered as one of the traditional land water management systems which has obviously been developed on the basis of catchment ecosystems. Those cascades were formed not only as water storage and irrigation practice but also with proper land use planning and operation and maintenance system.
The Mahaweli River diversion project was the largest development project carried out in the Nation’s history. The project included the construction of a series of large dams along river Mahaweli and its’ tributaries. The master plan for the development of the Mahaweli river basin, with the expectation of both hydropower generation and irrigated agriculture in the dry zone (DZ) of Sri Lanka, was prepared during the 1950’s and 1960’s with the help of United Nation Development Program and Food and Agriculture Organization. The project was to be implemented over a 30-year period, starting from 1970. Yet in 1977, the initial project plan was altered and accelerated Mahaweli development project was conceptualized aiming to complete the four major dams of Victoria, Kotmale, Randenigala and Rantembe (refer figure 01) within a short period of five years. Huruluwewa feeder canal (HFC) was constructed under the Mahaweli development project in 1970s’ to feed Huruluwewa tank (HT) which was initially constructed by King Mahasen (325 – 352 AD).
Figure 1. Reservoirs of Mahaweli development project and other two ancient tanks (Huruluwewa; HT and Mahakanadarawa; MT) discussed in the study.
2. Indigenous tank cascade system and land management

In order to establish sustainable agriculture in dry zone, earliest attempts (since 2200 years ago) at irrigation were made through construction of dams across ephemeral streams and diverting water from perennial streams. Those surface water sources fed several tanks throughout the cascade. This system enabled the reuse of irrigation water many times down stream before ending in the ocean. It can be clearly explained by the famous saying, “Let not a single drop of water received from rains go waste into the sea without benefiting the man and the beast” - King Parakramabahu (1153-1186). Under tank cascade systems land use planning was done with agro-ecological approach. The un-irrigable upland areas were used for residential activities and shifting cultivation (Chena in local language). In those uplands subsidiary food crops which did not require much water were cultivated (Goonasekere and Gamage, 1999). Apart from the food product those shifting cultivation lands provided wood, stumps, debris etc. for the villagers. Village (refer figure 2) was located at a higher elevation and protected with the tank serving as a buffer from the wild animals. The catchment was protected with forest cover and runoff water was filtered by the tree belt of specially selected plants at the entrance to the tank. The water hole caught the sediment transported from the upper catchment and provided water for cattle and wild animals without polluting the tank. The interceptor located immediately downstream of the dam reduced seepage from the tank, provided additional safeguard for the dam, prevented entering of salinity to the paddy fields and was used as a wetland agro-forestry system which included medicine, fuel wood, fruit, fodder, fencing material and reeds providing raw material for the traditional mats.

Cultivable area (farm land; figure 02) was determined by capacity of the tank and it was properly located after the interceptor. This immediately determined the size of the community. Beyond the farm land another tank was placed downstream, where the construction of the next dam was feasible. Downstream Water hole and grass-tree belt was used to filter the water drained from the farm lands. Once a series of tanks constructed a cascade was formed.

3. Huruluwewa feeder canal (HFC) issue

The 33 km long HFC (refer figure 01) was designed to convey 4.3 m³/s of water throughout the year to the HT (Lahmeyer, 2004). The canal discharges the water into Yan Oya (a natural stream) which crosses three minor tanks including Thalkote, Hiriwadunna, and Habarana (TH&H) with command areas of 80, 64, 40 ha respectively (Mahaweli, 2005). At the project planning stage, the land around the banks of the canal was undeveloped and project planners of 1960s and 1970s
ignored the future land development possibilities and water requirement for those lands (figure 4). Hence the project planners assumed that the majority of the flow (except minor losses such as seepage and evaporation) would reach the HT. Yet the HT water budget shows a very low inflow to the tank (figure 5) starting from 1995, more than a decade after the HFC construction (MASL, 2005).

Mahaweli Authority of Sri Lanka (MASL), Department of Agrarian Services (DAS) and Irrigation Department of Sri Lanka (IDSL) are managing the major three components, HFC, TH&H and other minor irrigation schemes, and Huruluwewa Tank respectively. Lack of interaction among those institutions is a problem. When the MASL releases water to HFC the water passes through tanks managed by farmer organizations (FO) under DAS. At the beginning under those tanks (TH&H) the cultivated area was limited due to less water availability. Yet when the HFC passed through those tanks the water availability was not a constraint any more. It destroyed the concept of “tank capacity controlled farmland area”. Farmers encroached the land as they can. It continued up to the dam in some places (figure 3) by removing the “interceptor” (refer figure 2) which acts as a salt trap. This has made a severe impact on the sustainability of the farm lands.

On the other hand the lands around the HFC were developed by taking water from HFC. Since HFC is a contour canal along most of its path, farmers on the low side started to take water out with siphons (now the lands are developing on the high side also using solar pumps). Once the water taken by putting a siphon generally water is allowed to flow out continuously to sustain the siphon function. This wastes considerable amount of water than well designed outlet irrigation canal which can be used as a discharge control device.

Cultivation in DZ of Sri Lanka is mainly done in two seasons. The rain fed “Maha” season starts from November and stretches about five months while dry “Yala” season starts from April and
stretches about 4 months. The designed flow rate of 4.3 m³/s gives a water flow of 44.6 MCM (million cubic metres) for a four months cultivation-season and 55.7 MCM for a cultivation season of five months.

![Diagram showing inflow data to Huruluwewa tank in Yala-Maha two seasons](image)

Figure 5. Inflow data to Huruluwewa tank in Yala-Maha two seasons

In many occasions the HFC flow is far below the designed flows due to water pilferage. The inflow graph (figure 5) shows the catchment inflow has a greater value than the HFC inflow at the initial stage. Catchment’s inflow may vary due to catchment development. Mahakanadarawa tank (MT) (refer figure 1) constructed by the same King who constructed the HT has a command area of 3200 ha which is almost similar to the cultivated land in its catchment area under minor irrigation tanks. Rehabilitation of those tanks has a significant effect on the inflow to the MT. Table 1 summarize the effect of rehabilitation in the catchment area and required flow rates from the outside resource (feeder canal from Mahaweli development project) for the cultivation of total land in command area in both seasons (Yala and Maha).

Table 1. Inflow requirement for the full cultivation and minor tank rehabilitation percentage data extracted from Kariyawasam et al., 1984.

<table>
<thead>
<tr>
<th>Mahakanadarawa tank catchment improvement percentage / (%)</th>
<th>Required net inflow / (m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.00</td>
</tr>
<tr>
<td>20</td>
<td>0.00</td>
</tr>
<tr>
<td>40</td>
<td>1.78</td>
</tr>
<tr>
<td>60</td>
<td>2.22</td>
</tr>
<tr>
<td>80</td>
<td>2.66</td>
</tr>
</tbody>
</table>

Surface water inflow reduction into HT (as shown in figure 05 for last 10 years) can happen due to catchment development and removal of forest cover as illustrated in the similar of study for Mahakanadarawa Tank (MT).

Due to water scarcity in HT command area the farmer organizations (FO) of HT campaigned to adopt a water management plan for the HFC. Hence in late 1990s’ FO of both HT and HFC, IDSL, and MASL got together and discussed ways to solve the issue. Finally the parties agreed for a water management plan, which provides more water than before to the HT. The increment
of HFC flow to HT is apparent in the figure 05. Yet the agreement was just an informal agreement among the organizations. It improved neither the water controlling structures nor land use planning of the area. Hence even now a considerable amount of water is wasted due to unauthorized tapping of water.

4. Conclusions
Ancient water management systems were not only used as irrigation schemes. The designers considered the available water resources, topography of the land, and sustainability of the system by considering the environmental aspects. Improper management of water resource systems including poor catchment management and land use planning reduces the productivity of water resources. Future land developments must take these facts into account at the project planning stage itself. Water management policy must be coupled with land management and land development.

Acknowledgments
The authors wish to acknowledge all the officers who contributed data for the preparation of this document in HFC office, MASL; HT office, IDSL and all the consultants and research assistants of the Moragahakanda–Kaluganga EIA study team who shared their experiences during the field visits.

References
Community Water Quality Monitoring Programme in Malaysia

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Abstract
Fresh water is predicted to become the principal limitation for sustainable development within this century. The economic, social, environmental and public health implications of decreasing water quality are a worldwide threat. In Malaysia, rivers provide 97% of drinking water. So the status of rivers especially the water quality is vital for water management. Rivers also reflect the health of the surrounding land because they are the collection point for water flowing from all around. Therefore monitoring water body (river) is equivalent to taking care of our own health. Today, it is recognised worldwide that strong community participation is a key factor in river basin management approach. As major stakeholders, local community can be trained to become watch dogs of water bodies in their vicinity. Community water quality monitoring is a low cost approach that is reliable and sustainable.

1. Introduction
Water is the basic element of life; without it life would not exist. It is second most important resource for man, and yet it is taken for granted because water is everywhere and it flows freely when we turn on the tap. The usage for water increases as population grows until the demand sometimes overshoots the supply or availability.

Although the quantity of water on Earth is same all the time (same as in dinosaur age, 60 million year ago), the quality of the water that is available has drastically changed. Every time we use water, we affect it in some way. Every watershed is affected by what takes place on the land. Once used, water flows out as quickly as it comes - down the drain and into our rivers. The gunk and grease that is flushed down into the drain unthinkingly every day will ultimately find their way to a nearby river. In other words, we are poisoning the very resource that gives us life. Therefore acquiring knowledge on ecosystem especially river basin will ensure efficient and effective management of rivers and water.

2. River Basin
A river basin is a geographic area defined by the flow and movement of surface water. In a river basin, because of the elevation and contours of the land, all water flows to the same water body, such as a stream, pond, lake, wetland or estuary. River basin boundaries occur along high points in the landscape that separate different stream networks. Hydrologists sometimes refer to river basins as catchments or drainage basins. The term watershed is used synonymously with river basin. They come in various shapes and sizes.

In Malaysia, there are 1,800 rivers comprising 150 systems that run up to 38,000 km. As in many parts of the world, water from rivers and streams in Malaysia is used extensively for domestic needs, agriculture, aquaculture, industry and hydroelectric power as well as provide recreational use. Rivers are important as they support nation’s economic development, social
and cultural needs, religious beliefs and the natural environment. Clean water body and the riparian area in its vicinity support diverse and delicately balanced natural aquatic ecosystems.

3. River Pollution
Generally, river water is potable (fit for human consumption) with minimum treatment, if it is not affected by human activities. However, rivers are now used as disposal routes for liquid and solid waste. While river pollution issues need to be and are being addressed by the government, such fundamental aspect of water supply requires the understanding and participation of end users. Water pollution occurs when a body of water is adversely affected by addition of small or large amounts of materials (pollutants) to the water. Pollutants may be divided into two types - point and non-point, depending on their source. Generally, controlling non-point sources is more complex than dealing with point source pollution.

Statistics published by the Department of Environment (DOE) for the year 2004 reveal 8% of our rivers to be polluted, 44% slightly polluted and remaining 48% to be clean. This is a clear indication that river basins in Malaysia are facing serious environmental problems. Studies indicate that residential, agricultural and industrial wastes are 3 main sources of river pollution in Malaysia. Degradation of water quality due to pollution causes adverse effects to aquatic life forms, disturbs the balance of life and reduces the bioavailability of potable water.

The burden on rivers to supply fresh water is likely to increase as demand is growing at 4% annually and is projected to reach 20 billion m$^3$ by the year 2020. Since rivers form 97% of our fresh water resource, this is an indication that water supply would have to be treated extensively in future and the cost would have to be absorbed by the public. This fact alone is enough to give us a wake call on the need for careful water quality monitoring to keep our rivers clean.

4. River Monitoring Programme
River basin ecosystem such as streams, rivers, lakes, ponds, wetlands and estuaries are the lifeblood of our environment. They provide homes for wildlife; aquatic animals and plants; water supplies for homes and industries; and places of recreation for all of us. In addition, rivers reflect the health of the surrounding land because they are the collection point for water flowing from all around. Therefore the ultimate goal of river monitoring is to sustain or improve the health of its ecosystem for the use of inhabitants of the earth. One of the ways to achieve such goal is by creating awareness and educating various target audiences including school students and the general public on issues related to water quality monitoring and river ecosystems. Awareness need to be created on determining the current health of a river and the impact it receives from the cities. Data need to be collected on the quality of river water and such data would have to be made available to the community and the decision makers.

Water quality and quantity are two most important monitoring factors and are intimately linked although not often measured simultaneously. Water quantity is often measured by water level, discharge, and velocity. Whereas water quality is usually determined by analyzing samples of collected water in a laboratory or by conducting in-situ testing. Typically, water quality is determined by comparing the data from water samples against water quality guidelines or standards.

Despite dependence on streams, rivers, ponds and lakes for freshwater supply, Malaysian have historically not shown sufficient interest in the protection of her water resources.
Although there are adequate laws and regulations, compliance and enforcement are still lacking. Currently most of Malaysia’s river systems are not monitored by any agencies. Adequate river water quality monitoring would ensure sufficient freshwater supply in the future and initiate emergency procedures should there be unexpected pollution incidents that cause severe damage.

Generally, the purpose of river monitoring is to:
1. Survey streams and water sources to assess its physical condition.
2. Identify areas where water quality degradation exist and investigate its causes and sources.
3. Provide a comprehensive database to analyze trends in water quality.
4. Indicate areas where water quality needs improvement and how this can be achieved.

There are three types of stream monitoring - physical, chemical and biological monitoring.

1. Physical Monitoring (Visual Observations)
The physical characteristics of a stream can provide clues to indicate its health. Healthy streams have lush riparian buffers, clear water and abundant wildlife. Several physical characteristics of water quality are: water clarity, water colour, smell/odour, general land use, description of stream origin & type, riparian vegetation (algae, wetlands), aquatic life forms (fish, prawns), and measurements of in-stream parameters such as width, depth, flow & substrate, drains, erosion and garbage.

2. Chemical Monitoring
Chemical monitoring and testing is one of the most accurate and reliable water quality monitoring methods. Chemical testing is often used to analyze drinking water. It is extremely useful for determining sources of pollution, as well as determining specific pollutants. Common chemical parameters tested are: pH, dissolved oxygen, conductivity, temperature, total suspended solids, turbidity and nutrients (phosphate & nitrate).

3. Biological Monitoring
Biological monitoring of rivers and streams provide remarkable insight into the functional quality of the environment studied. It can reveal important changes in the composition of biological communities that is caused by human activities. Insects and crustaceans that live in a waterway are excellent indicators of water quality because all organisms require specific conditions to live. Based on the sensitivity of the organisms, water quality can be classified into 4 status - excellent, good, fair and poor.

Bio-monitoring is easy to conduct and requires relatively inexpensive equipment. The quality of the water of each part of the river is identified based on the presence of living organisms that live in the water of the surrounding area. Two frequent groups of living organisms used for bio-monitoring are invertebrate and fish. The presence of these tiny organisms is used as an indicator for the quality of the river; whether it’s clean or otherwise. The methods used are fun and simple and it can be done by individuals, families or groups with minimum training. Invertebrate is used to identify short term pollution effects. On the other hand, fish is used to observe pollution effects for a longer period of time. This method is also suitable for anglers and fishing enthusiasts who could play and important role as river watchers.
5. Community Water Quality Monitoring
Managing our biological diversity is all about managing people because the ultimate decision makers for biodiversity are the individuals - you and me. Governments, companies and others have a responsibility to lead and inform the public, but finally it is an individual choice made billions of times a day that counts the most. Today, it is recognised worldwide that strong community participation a key factor in river basin management approach. Participation in the simplest of its meaning is taking part, sharing and acting together. Local community is a major group of stakeholders within a river basin and if mobilized adequately, they could play a key role in the management of rivers especially monitoring activities in the river basin. Community monitoring can stimulate the interest of public and would help induce ownership of river basin especially in their local catchment area.

However in Malaysia, the potential of local communities and special interest group’s involvement in river management is currently not being fully utilized. As such, there is a tremendous need for local communities and authorities to work together to conserve and protect our rivers. In addition, the local community too can play an enormous role as watch dogs to safeguard the environment and create a win-win situation for all parties involved.

Why is community participation important?
1. Most of the time, local community acts as “polluters” and/or “end receivers” either directly or indirectly. They have enormous potential to become “eyes & ears” of the authorities. They can take preventive measures to curb unwanted incidents from happening by informing the authorities.
2. Local communities too have the potential to promote immediate curative measures to rectify unwanted incidents that had happened by informing authorities.
3. Local communities have better knowledge and understanding of the local environment. Therefore they make excellent informers.

Local community can be trained to monitor land use, illegal dumping, water quality testing and become watch dog (RIVER Ranger) of water bodies in their vicinity. However what to monitor will depend on the needs of the data users, the intended use of the data, and the resources of the community monitoring programme. The aims of community water quality monitoring are to develop community participation, partnership, awareness and ownership on issues related to water; and encourage them to take remedial actions. In addition, it can provide links between existing monitoring programmes and community within local river basin (watershed) as well as across the country to enable exchange of information and ideas.

6. Challenges
The biggest challenge for community water quality monitoring programme is to have effective and analytical monitoring of environmental indicators. Effective monitoring schemes are necessary to identify specific pollutants, their sources and occurrences, to develop preventive measure, and to assess the efficacy of corrective actions. Another dilemma in community water quality monitoring is how their results can help or support government agencies effort to protect the environment. Some uses require high-quality data. For example, high-quality data are usually needed to prove compliance with environmental regulations, assess pollution impacts, or make land use planning decisions. In addition, understanding the relationships between water quality conditions and natural landscape, hydrologic processes, and human activities that take place within a river basin are lacking especially in developing countries like Malaysia.
7. Case Study: Community Participation in River Management: Sg Pencala and Kelana Jaya Lakes Rehabilitation Programme.

“Community Participation in River Management”, a project funded by DANIDA was undertaken from Dec 2002 – July 2006 and implemented by Global Environment Centre (GEC) in collaboration with various partners/stakeholders. The Kelana Jaya Lakes Rehabilitation Programme was co-funded by UNDP-GEF Small Grants Programme.

The project was developed to assist in demonstrating community based approach to improve quality of rivers in Malaysia. This is the first river rehabilitation program in Malaysia that focuses on involvement from communities as a component in integrated river basin management plan.

The “Community Participation in River Management” project aims to improve the quality of Malaysian rivers and the status of its biodiversity through awareness campaign and enhancement of community participation in river management. It focused on facilitating the establishment of a two-way communication mechanism between communities and decision makers in developing appropriate solutions and management plans. The project also aimed to increase the understanding of the benefits of managing rivers well and develop ownership towards rivers among the general public, community groups and special interest groups.

The project mobilized community groups along Sg. Pencala to participate in awareness programs and activities related to water quality monitoring, river clean-up and river rehabilitation. Selected communities were trained on the aspects of river hydrology, ecology and biodiversity. In addition the communities were also involved in programs to adopt a sustainable life style such as changing their consumption patterns, reducing and recycling domestic waste, and conserving water and energy. Through the participation of community groups, the monitoring programme documented the presence of a wide range of point and non-point sources pollution along Sg. Pencala.

8. Community River Monitoring Programme

GEC in collaboration with several other NGOs, organized more than 50 training courses on river water quality monitoring and biological monitoring techniques to the following stakeholders: CBOs, schools, local authorities, government agencies, NGOs, private sectors and media. The Project established 13 water quality monitoring sites along 12 km of Sg. Pencala and 5 sampling points for the Kelana Jaya Lakes. Currently, there are 3 CBOs (Friends of Taman Aman and Kelana Jaya Park & the Resident Association of Sec 19) monitoring the water quality of Sg Pencala and Kelana Jaya Lakes.

As part of education program, GEC developed the RIVER Ranger Programme and SMART (Start Managing All Resources Today) Ranger Programme. In the past 1 year, 13 schools within these basins were selected and trained to be RIVER Rangers. The Rangers were trained to conduct water quality monitoring at an interval of 1 month for a period of 6 months and produce a brief report for compilation by GEC to be presented to relevant agencies. Beside water quality studies, Rangers are also required to fill ‘River Health Check Card’ that consists of 10 assessment categories to assess the health of Sg. Pencala and Kelana Jaya Lakes.

Furthermore the local university - Universiti Teknologi Mara - has undertaken a scientific water quality study at an interval of 1 month for a period of 18 months. A total of 15
parameters were analyzed that covers all six Water Quality Index (WQI) parameters, heavy metals, pesticides, hydrocarbon, fertilizer/nutrients and microbes.

Eventually, the water quality monitoring data of the Sg. Pencala and Kelana Jaya Lakes produced by River Rangers, local community and UiTM/GEC will be featured in the website www.sungai pencala.info for public access, as below:

Currently the Sungai Pencala and Kelana Jaya community monitoring programme has been acknowledge and accepted as a model for community programme under the ‘One State One River programme’ by the Drainage & Irrigation Department of Malaysia.

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References
Negotiation Processes in Institutionalising Grassroots Level Water Governance: Case of Self Employed Women’s Association, Gujarat, INDIA

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Abstract
Several grassroots level institutions are currently playing a positive role in water governance in rural India. The Self Employed Women’s Association (SEWA)1 based in Gujarat state of India, a women’s organisation, through its ‘Women, Water and Work’ campaign has proved how through strong grassroots level women led water institutions has turned around water governance in favour of the local communities. The focus of the paper is how through negotiation processes, women’s groups have been able to institutionalise a sustainable water governance system at the village level. Two cases have been selected for detailed discussion, in which gender as an organizing principle has played a crucial role in the process of establishing a sound institution for local water governance.

1. Introduction
People-centred water governance has proved to be solving the water problems in the rural areas of the country, much of the interventions being initiated by the civil society organisations, through mobilisation around water issues. What is increasingly seen is that for any intervention (programme or project) to be successful through people’s institutions, the negotiation processes have played a crucial role in strengthening not only, the institution but also, sustaining the benefits of the programme. Often these negotiation processes initiated by the local people are not visible and ignored and therefore not documented. Currently, however, there is a lot of interest by development professionals and practitioners to take note of the processes for replication of different interventions/best practices in varying contexts. These processes also bring home the point that for any development intervention to be successful, there are no quick fix blue prints as they interface with complex social realities particularly in societies that are divided along caste, class and gender lines.

The paper at hand is divided into four sections. After the introduction, the second section introduces SEWA and its water Campaign. The third section delves into the negotiation processes by women’s groups in two selected districts of Gujarat – Navakheda in Sabarkantha and Thala-Malvan cluster in Surendranagar. The last section draws some lessons from the negotiation processes for a sustainable water governance at the local level.

1 SEWA has won several awards (national and international) for its ‘Women, Water and Work’ Campaign as a best practice.
2. Self Employed Women’s Association and the Water Campaign

The Self Employed Women’s Association (SEWA), a development NGO, established in 1972, is the largest self-employed women’s trade union in the country. It is a membership-based organization (NGO) with a total of around 800,000 members all over the country, of which more that 500,000 are based in the state of Gujarat. Its members are all poor women belonging to the informal sector, of which two-thirds are from the rural areas. SEWA strongly believes that the basis of development and progress is through organization. It works with the two-fold objective of providing full employment to its members and making them self-reliant. SEWA combines four specific strategies – organizing women into groups/collectives, since individual women have no voice; capacity building of women to become owners and managers (not just producers and labourers); encourage capital formation at the household, group and community levels; and increasing social security to enhance women’s well-being and productivity to reduce the impacts of crisis on fragile household economies (SEWA 2003).

SEWA initiated its water campaign in 1995 in which diverse water issues affecting its members are addressed. It is active in 9 districts, mostly in the semi-arid regions of the state, where water is scarce and hardly available for 2-3 months in a year. The objective of the Campaign is to translate ‘optimal and efficient use of water’ into a mass campaign. Women, Water and Work Campaign – also known as the Millennium Campaign is guided by a water vision in which women should have rightful access to sufficient amounts of quality drinking water. The Campaign mobilises and empowers women to identify and address water-related bottlenecks at the village, taluka and state levels. It enables women to control and manage their water sources. This has a direct bearing on women’s livelihoods, incomes and employment opportunities.

The Campaign

The water Campaign is both a movement and a development alternative, spread across 11 districts covering more than 200,000 women in 500 villages of Gujarat (SEWA 2003). It is based on the promise of decentralized water management that captures the specific cultural and environmental contexts where it is currently active. It attempts at meeting needs of women from different socio-economic backgrounds. The organizational structure of the campaign (Figure 1) illustrates a well-coordinated, decentralized approach to water management, involving various stakeholders at three levels of action and interaction – the state, district and the village.

The objectives of the Campaign are to:

- raise women’s and community’s awareness of water-related problems such as availability, quality and its conservation;
- establishment of local water user groups (of mostly women leaders) called ‘pani samitis’ for the maintenance of community water sources;
- capacity building for women through leadership and technical training for them to function as efficient water managers;
- facilitate women’s ownership of water resources, such as registration of household rainwater collection tanks in women’s names and;
- forge links with other organizations, both nationally and internationally to promote gender-responsive water policies.
3. Negotiation Processes
The two cases (Navakheda and Thala-Malvan) have been identified for detailed discussion as they represent a variety of negotiation processes by women’s group with the facilitation of SEWA. These negotiation processes contribute to the development strategy (improved water availability, better livelihoods, health and sanitation and overall well-being) in the quest for
efficient water management. A point to be noted here is that a successful water management intervention may not be always the starting point for its success.

Navakheda
In case of Navakheda, SEWA made an entry by organizing women’s Self Help Groups (SHGs) for micro-credit programmes to address their livelihood needs. Initially vermin-composting activities by the SHGs were promoted. During the course of this activity it was realized by both SEWA and the women members, that regular access to safe drinking water was more important than access to credit. Village women were concerned about instances whereby they had lost work opportunities on account of non-availability of water and ill-health.

Ground water in the region was comparatively higher than other neighbouring districts in the region. Although there were handpumps installed by the government, they were not functioning regularly. A group of women along with SEWA personnel approached the government officials of the State Water Board to find out ways to solve the problem. After a series of discussions they realized that government either did the maintenance work through its own officials or gave out service-contracts for maintenance of these hand-pumps. However, in both the cases the handpumps were mostly in a state of disrepair.

The women’s group came up with the idea of maintaining handpumps themselves. Initially the women members had doubts about their own ability to do so. Moreover, they were not sure whether they would get the support of the village community. Handpump repair work is considered a male domain and women were hesitant to encroach upon this space. However, with the support of SEWA, women members gathered the courage and confidence to undergo technical training for maintenance of water infrastructure. The government officials initially were reluctant to train illiterate or semi-literate women. SEWA convinced the government officials about women’s capability to undertake the task of maintenance and repair of handpumps. Finally the Gujarat Jal Training Institute (GJTI) a government organization agreed to train women in the technical aspects of water infrastructure. After some initial problems and intensive round of training sessions, 4 units of women were ready to initiate the handpump repair work. The government signed a contract with SEWA for maintenance and repair of handpumps in villages in the district. Women were paid a certain amount as wages for their work by the government and part of the expenses such as transporting the tools etc. were borne by SEWA.

In the initial phase of application of their skills for maintenance of handpumps, the village community, especially men were most skeptical about women’s abilities and refused to cooperate with them. Women also received threats that if the handpumps failed to function then they would have to face grave consequences. Despite all odds, women in the Sabarkantha villages did not give up and subsequently the handpumps were all repaired on time and people could access water on a regular basis. Not only were the repairs carried out at the earliest but the women were able to motivate the communities to keep the surroundings of handpumps clean and free from water logging to maintain a clean environment. In addition, women also came up with suggestions to improve the quality of work by modifying tools used for repair which would minimize labour and time. Consequently, SEWA-trained women could not only, save on the cost towards repair but also, provide suggestions to the community to adopt practices for better maintenance of these
handpumps. Today the community wants the women’s group to continue with handpump repair work even though the government has pulled back its service contract in some areas.

The unique feature of the interventions in Navakheda has been making water accessible to a small cluster comprising 17 households belonging to the marginalized section of the village. This section was faced with government apathy and the village community was also indifferent to their problems, but the women’s group with the support of SEWA could meet their water needs. Women bare-foot technicians as they are popularly known, have been able to adopt innovative measures in terms of cost reduction and design of new implements/tools for maintenance of water infrastructure.

In case of Navakheda, the community acceptance of women trained technicians as better alternative to traditional service contractors has threatened the bureaucracy and the politician-contractor nexus. Under political pressure the Water Board was forced to withdraw the service contract in one of the talukas allotted to SEWA. As a result in Dhansura village around 50 technically trained women are idle and there is a possibility that they might lose the skills that they have developed in the course of two years. Further, when the contract is renewed after a time gap, they need to put in more efforts to maintain the handpumps which have been lying in a state of dis-repair for a long time.

**Thala-Malvan**

Thala Malvan is a 19 year old scheme, although its management has been with women members only for the past four years. The scheme involves five villages being served by a group water supply, covering a population of about 8500. The scheme has a tank in Isadra village with a capacity of 450,000 litres. Water is chlorinated once a day before it is released to the rest of the villages. Each village has their own smaller capacity tanks and water is distributed through stand-posts located at strategic points in the village.

SEWA had started its work in the area for the promotion of hygiene and safe practices in procurement and usage of drinking water. The Thala Malvan Scheme was located in the area which was once infested by a major water borne disease. Subsequently, SEWA had approached its members to explore the possibilities of management of the scheme. Initially women resisted taking up the responsibility, due to lack of confidence. There was also a feeling among the villagers, and the officials in the GWSSB, that women, being illiterate and unexposed to any work except unskilled labour and salt work, were incapable of managing the water supply scheme. It took time and great effort on the part of SEWA to give assurance to the people about the project’s feasibility including the economic and technical benefits. Gradually, a few women came forward to participate in the experiment. The village panchayat also nominated a few women to take the lead who they thought were capable of managing the system. The Gujarat Water Sewage and Sanitation Board (GWSSB) provided the women with six-months technical training in mechanical and technical aspects of maintenance of the water supply system. Eventually those women trainees who could meet the standards set by the Board were selected for the final task of operation and maintenance of the system. Finally a contract was signed between GWSSSB and SEWA to hand over the management of this scheme to the women. The contract includes the operation and maintenance of the system. All required repairs at the time of handing over of the scheme were done by GWSSB.
As agreed in the contract, the day-to-day maintenance of the system is the responsibility of the women’s group, although the GWSSB extends help if needed. The cost sharing in the operation and maintenance between SEWA and the women’s group is shared on a 70 - 30 basis. The women’s group bears the cost in the form of labour. While the wear and tear of the system and the replacement of parts such as the taps etc. is the responsibility of SEWA, the water board pays the electricity charges. The expense incurred on the maintenance of the system is recovered from the pre-decided amount as mentioned in the contract with SEWA. At times, there were some problems with finances as the amount received in the contract from the GWSSB was not enough to cover the costs of the project operation and maintenance. Currently, SEWA is faced with the problem of non-renewal of the contract. The scheme is being managed by the GWSSB officials. However, due to poor accountability within the government system, it is poorly maintained as a result of which water shortage for long periods has become a common phenomenon.

The unique feature of the efforts in Thala-Malvan has been the successful management of the piped water supply scheme in all aspects like chlorination, maintaining pressure and flow, repairs and water storage maintenance. Another important feature of this initiative is the emergence of women as local managers of supply systems, who are accountable to the village community. Moreover, women tend to be aware about local realities, needs and conditions which give them more space to negotiate on water issues. Such features are evident in the initiative taken for collection of water charges in the cluster of villages at the local level, although it has met with partial success on account of political and institutional hindrances.

The limitation in Thala-Malvan is that promotion of efficiency through dialogue on inter-village water issues has not materialized. Women’s groups have met with non-cooperation from the affluent sections of the village as their power was being threatened. Just like any other natural resource, water is also a source of power and traditionally access to water has been directly and indirectly controlled by a few. Dependency of marginalized groups on those who control water, was reinforced particularly during the lean months of summer every year. Due to the availability of piped water and RRWHS the dependency has got diluted. To counteract the situation, the affluent people in some of the villages are not agreeable to bear their share of water charges, as a result of which there is a likelihood of the water supply being finally stopped.

Both Navakheda and Thala-Malvan experiences show that access to water and water supply infrastructure is intimately linked with the power balance at the local level. Therefore any efforts to change the existing set-up will have to face opposition from vested interests that have the power to influence the political and administrative set-up governing the water sector.

4. Institutionalising Local Water Governance - Lessons

Both the cases indicate a need based development of an integrated approach for better water management (access of local community to clean safe drinking water for the entire year) that has organically developed from grassroots realities based on women’s lived experiences. With the support of SEWA, women’ groups have been able to take active participation in activities related in water management in the public domain and over the years have gained the support of the local community to a great extent. The cases here clearly depict that women have broken social barriers and by organizing themselves into collectives have been encroach in the male space as water managers. Some of the distinctive features of the Campaign which can be represented as
outcomes of the long negotiation processes by the women’s group are: (a) Formation of strong Pani Samitis or grassroots women’s institutions which forms the backbone of the Campaign; (b) Formation of a Technical Cadre comprising the formally trained women engineers and a grassroots cadre of ‘barefoot technicians’ who have substantially contributed to the maintenance of the piped water supply and the handpumps in rural areas. In the process they were also trained in environmental protection, sanitation and maintenance of water quality for drinking purposes; (c) Women were able to transcend all social barriers in the highly stratified rural society, and have come together regardless of caste, class and ethnicity for a common cause; (d) As a collective women have come to represent a strong political voice and have been able to dialogue with the state on various water problems affecting them.

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Power of Partnerships: Bringing Safe Water to Indonesia

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Abstract
Lack of clean and safe drinking water is a major health and development issue in Indonesia. USAID is working to alleviate this problem, and two recent efforts capture the synergy of the public and private sectors. The Aman Tirta program is a consortium working to support a commercially viable point-of-use water treatment product. The Cinta Air program, a partnership between Coca-Cola Systems Indonesia and USAID/Indonesia, focuses on small water infrastructure and behavior change in a village close to the Coca-Cola plant. These two projects highlight the importance and success of non-traditional arrangements in addressing water issues in Indonesia.

1. Introduction
Safe drinking water is a major development and health challenge for Indonesia and affects a large number of people. More than 48 million people in Indonesia do not have access to “improved” drinking water (e.g., household connection, public standpipe, borehole, etc.) (UNICEF, 2006); only 39% of the urban population and 8% of the rural population have access to piped water which is controlled and ostensibly quality checked (Ministry of Settlement and Regional Infrastructure, 2004). Additionally, more than 100 million Indonesians go without adequate sanitation (UNICEF, 2006).

Even with piped water and other “improved” sources, the water is not necessarily clean (Jones 1993; Dharmapatni and Firman, 1995) due to siltation, proximity to sewage, or inundation from seawater (Dharmapatni and Firman, 1995; Nur et al., 2001). Unsafe drinking water is a major cause of diarrhea in Indonesia (Lenz, 1988), and diarrheal disease, in turn, is the second leading killer of children under 5 in Indonesia (excluding mortality within the first week of life) and accounts for about 19% of child deaths each year (Surkesnas, 2002; Biro Pusat Stastik, 2003). A number of authors have shown that diarrheal disease has been the third leading cause of overall morbidity in Indonesia, and the leading cause of infant mortality (Nazir et al., 1985; Sunoto, 1985; Simanjuntak et al., 1998).

To address water, health, and other issues, USAID and its predecessor agency have been working with the Government and people of Indonesia to meet their needs for over 50 years. USAID/Indonesia has embraced public-private partnerships as a way to mobilize the ideas, efforts and resources of governments, businesses, and civil society in order to stimulate economic growth, develop businesses and workforces, address health and environmental issues, and expand access to education and technology.

Two of USAID’s projects focusing on water in Indonesia have come to fruition through the unique arrangements of public-private partnerships. The Aman Tirta project has supported the marketization of Air RahMat, used to treat drinking water for households. The Cinta Air, or Love Water, project aims to provide clean water supply and water education to residents of Bekasi, West Java, Indonesia.
2. Aman Tirta and AirRahMat

The Aman Tirta (Safe Water System) program is a USAID-funded effort to improve access to safe water through point-of-use water treatment. Aman Tirta has taken a new approach to this task by creating a commercially viable product complemented with a behavior change program.

As described above, safe drinking water remains elusive to much of the Indonesian population. Studies have shown that in some areas, nearly all households boil water, although it is often then re-contaminated (Prihartono, 1994). This re-contamination can occur through improper boiling; mixing with unboiled water; or improper storage (e.g., an unclean ladle or hand is used to obtain water, rather than a spigot) (CDC, 2005; Ainslie, 2007). Aman Tirta’s recent findings showed that up to 96% of source water in one district of Java was contaminated by \textit{E. coli}. When the water was tested after being boiled, 47% of the water was still contaminated by \textit{E. coli} (ACNielsen, 2004; Aman Tirta, 2006). In addition, studies have found that boiling can be economically and environmentally unsustainable (deKonig et al., 1985; Gilman and Skillicorn, 1985). For this reason, inexpensive and simple-to-use point-of-use treatment is vital for public health, particularly for reducing the likelihood of diarrhea in children under 5 years old.

Instead of making a subsidized product that would be available and distributed for the short duration of a project, Aman Tirta seeks to facilitate the production and distribution of a product that will be commercially viable in the Indonesian market, ensuring its sustainability after the program funding has ended. While similar products have been implemented around the developing world, to date these products have been subsidized and not commercially viable. \textit{Air RahMat} differs radically in that it aims to be wholly commercially supported.

In order to create a commercially viable product, a partnership between the public and private sector was vital. There are five main parties supporting \textit{Air RahMat}. The Johns Hopkins University Bloomberg School of Public Health’s Center for Communication Programs is responsible for overall program strategy design, management, and communication and behavior change interventions. CARE is leading the community participation component and enhancing water treatment socialization and adoption and the implementation of the program. PT Tanshia Consumer Products is manufacturing, bottling, and packaging the \textit{Air RahMat} product. PT Dosni Roha, one of Indonesia’s leading distributors or pharmaceutical, health, and personal care products, is distributing Air RahMat across a full range of outlets from variety stores to clinics to kiosks. LOWE Worldwide is handling the developing and implementation of the marketing and positioning of \textit{Air RahMat}. The financial support in its nascent period allows these companies to form relationships and “work out the kinks” while it has a safety net. For example, the bottle was redesigned after the first production run to make it more stable, to improve the visibility of the measuring lines inside the cap, and to create more space on the front of the bottle for type. While this redesign might have been financially impossible for a company on its own, it is possible with the Aman Tirta project and will result in a better and more marketable product. Additionally, the Aman Tirta project is working to build the capacity of PT Tanshia (who will take over whole responsibility for \textit{Air RahMat} in 2009). In this vein, the project works with PT Tanshia on brand management; outreach to NGOs; advocacy with the government; community mobilization; and building a business network so that they will be able to continue the success of \textit{Air RahMat} as a commercial product.
Air RahMat is the Indonesian version of similar products that have been used successfully in more than 25 countries worldwide, and was used generically in Indonesia previously (USAID, 2006a). The name is derived from a combination of four words: Air (water), muRAH (economical), Mudah (easy-to-use), and sehAT (healthy). The product is also certified halal (sanctioned by Islamic law) which increases its appeal to Indonesian consumers.

Air RahMat is a liquid 1.25% sodium hypochlorite solution which, when used properly, can reduce by 40-80% the risk of diarrhea by deactivating the most common microorganisms that cause diarrhea in humans. The 100 mL bottle is enough to treat the average amount of water a household uses in 1 month. It costs Rp 4000 – 5000 (around $0.50), which, at Rp 7 per liter, is cheaper than bottled water (450 Rp/L), refilled water (Rp 175/L), or boiling water (Rp 102/L) (USAID, 2006a). Air RahMat is available through traditional stores such as warung, kiosks, kelontong, apotik (pharmacies) and through non-traditional outlets (community-based organizations, non-government organizations, and community centers). When a 6.3 magnitude earthquake hit Yogyakarta, Central Java, Aman Tirta distributed over 100,000 bottles of Air RahMat through UNICEF, CARE, and other relief organizations (USAID 2006b; Ainslie, 2007). Following the flooding in Aceh province in December 2006, UNICEF distributed Air RahMat to ensure a ready supply of safe drinking water.

The Aman Tirta program debuted Air RahMat to the Indonesian market in Jakarta in December 2005. In February 2006, the product was rolled out to Banten and North Sumatra. By December 2006 the program expanded to other provinces including West Java, Central Java, East Java, Jakarta metropolitan area, and Aceh. Future plans include expanding to all provinces in Java and, ultimately, nationwide (USAID, 2006b; Ainslie R., 2007).

By December 2006, less than a year after being formally launched, more than 1 million bottles have been sold and 950 traditional and 350 non-traditional retailers are carrying Air RahMat.

In addition to facilitating the commercialization of the Air RahMat product, the Aman Tirta program supports its use through education about safe water and health. This education happens through a multimedia campaign promoting Air RahMat, community-level activities, activation activities such as promotions at markets hosted by local radio stations, and community-level demonstrations at posyandu (village health posts). In addition, Aman Tirta focuses on cross-fertilization of other USAID projects working in the water and health sectors to ensure that as many project sites as possible are promoting Air RahMat in their work. The Cinta Air program, described below, incorporates Air RahMat into its programming, as do a number of other USAID-funded health and education programs.
3. Cinta Air (Love Water)

Bekasi is an industrial, peri-urban area outside of Jakarta and is home to 25,000 people as well as the bottling plant of Coca-Cola Systems Indonesia. The rapid population growth of Bekasi has strained the already inadequate water infrastructure. A recent survey of the Kalijaya village of Bekasi revealed that 50% of the households relied on shared or public deep boreholes with a pump for drinking water. The other households relied on unprotected shallow wells or bottled water. Only 15 houses of 1700 in the village have individual toilets; the rest use outdoor toilets which consist of boards for squatting over a river, pond, or irrigation canal, with cloth or plastic sheets as “walls” (Figure 3). Handwashing with soap is a poorly practiced hygiene behavior in the area although an important way to reduce disease transmission (Aulia, 1994; USAID, 2006c).

Figure 3. Open toilet over a river

USAID/Indonesia and Coca-Cola have come together to support the Cinta Air (Love Water) program in Bekasi, West Java (Figure 4). This program is part of the global Community Watershed Partnership Program (CWPP), a strategic alliance between USAID and The Coca-Cola Company (TCCC) that focuses on water for the poor. CWPP enables USAID and TCCC to provide incentive grants to local TCCC business units and bottlers as well as USAID missions to carry out water-related projects in target communities in the developing world. Implemented initially in Bolivia and Mali, Indonesia was selected as the third country in the world to participate in this partnership.

Through the Cinta Air program, USAID has leveraged its support for improvement of water systems in Indonesia. The partnership with Coca-Cola will empower the Kalijaya community to improve their own village wells; learn better health and hygiene practices; and strengthen Coca-Cola Systems Indonesia’s (CCSI) ongoing Go Green Schools program which involves youth in their local environment. Through good communication, strong technical knowledge, and shared goals, USAID/Indonesia and CCSI have built a successful partnership that addresses the vital needs of the community of Kalijaya.

Launched in March 2006, the Cinta Air program is implemented through cooperation by three different programs, all supporting the project team as they address the three prongs of the project—a technical intervention, the multi-media campaign, and the Go Green Schools. The Coca-Cola Foundation Indonesia leads the Go Green Schools and multimedia campaign; USAID’s Environmental Services Program is responsible for the technical water and sanitation intervention and health hygiene advocacy; and USAID’s Aman Tirta promotes the use of Air RahMat.

The objectives of Cinta Air are to:

- Improve public awareness of water conservation practices, including tree planting, to protect and stabilize water resources;
• Improve public health through the promotion of health and hygiene behaviors linked to water and sanitation practices;
• Empower local communities to improve water quality by introducing simple methods and approaches to improve, protect and monitor water quality; and
• Improve stakeholder capacity to understand and commit to long-term, sustainable options for better water supply.

As of January 2007, significant progress has been made towards the objectives in each of the three prongs, all of which complement and strengthen the other. The technical intervention began with a baseline study of local stakeholders to assess their needs and attitudes regarding water usage and storage; sanitation and solid waste facilities; and hand washing and health practices. This study was a main input for a Mini PHAST (Participatory Hygiene and Sanitation Transformation) participatory process whereby the community members themselves identify the needs and problems around water and sanitation. Through a process of community mapping, walks, and discussions with community members, the Cinta Air team learned about the community’s situation regarding water, sanitation, and hygiene, and then worked with the community to identify solutions. The team and the community then developed action plans based on these goals and objectives. They identified 22 existing shallow wells to be improved and protected (Figure 5). The community was required to contribute to the well improvement project (either financially or in-kind with time and labor for cleaning and maintenance), assist in the construction, and organize into user groups to identify maintenance responsibilities. This community involvement in the improvement increases the likelihood that the wells will continue to be properly cleaned and maintained; community pressure will reduce shirking and small user fees will give the safe water a greater value than unsafe water.

In addition to building the small infrastructure to support safe water, the multimedia campaign works to inform community members about the importance of safe water through a number of different outreach events since the beginning of the project. At community meetings, households (primarily mothers) are informed about proper handwashing techniques, household water treatment (including Air RahMat), and other hygiene improvement activities. In addition, outreach specialists from the Cinta Air team work with midwives from the local puskesmas (sub-district health center) to disseminate information on basic health and hygiene to new mothers. The Air RahMat product is also tied into these outreach efforts; the Cinta Air team has identified a local distributor and retailer for as well as a billboard in Kalijaya on which to advertise Air RahMat. The multimedia campaign also held a Breaking the Fast event during Ramadan at the Coca-Cola bottling plant, which was attended by more than 300 people from the surrounding communities. An ustadz (religious teacher) gave a sermon on the importance of water to humankind. By interweaving the
message through health care workers, religious figures, and traditional community meetings, the multimedia campaign reinforces the importance of safe water.

The campaign also has fun events to keep people engaged with health and water topics while enjoying themselves. The Jalan Sehat (Health Walk) celebrated the program’s progress to date and also allowed teams from the village (comprised of more than 440 participants) to compete at different stations that featured water and sanitation trivia along the Health Walk route. The community’s enthusiasm for the event is demonstrated by the creative costumes the teams put together (Figure 6).

At the time of writing, the campaign was also planning on implementing a photography competition, a poster competition, a 10K for Water, a radio talk show, and a school water festival during 2007. Many of these events generally include games, music, and competitions—which invariably attract large crowds.

The Go Green Schools campaign involves students from 4 high schools in education about water, sanitation, and the environment. Cinta Air staff have held activities for students on the topics of solid waste disposal, water quality monitoring, reforestation, composting, and public health. Nearly 80 students at two high schools have committed to support Cinta Air through training of fellow students, composting, awareness-raising, and construction of a greenhouse on school grounds. By involving students, the program helps spread the messages, as students often share their learning with their parents. In addition, high school students are not far away from becoming young leaders—by generating interest in the topics today, Cinta Air hopes to have supportive and educated leadership tomorrow.

The Cinta Air Program will last till August 2007, and in the long term, the Cinta Air Program aims to have the local stakeholders own and sustain the program. Positive responses and feedback have been received by the team from youth and religious leaders, the health agency of Bekasi, the Cleanliness Agency of Bekasi, and two primary school principals. The team will work to transition the continuation of efforts to these groups.

4. Conclusion
Through innovative arrangements and the support of the private sector, USAID/Indonesia has worked to improve Indonesians’ access to and understanding of the importance of safe water. Both Aman Tirta and Cinta Air capture the power of the private sector and the development expertise of the public sector to create lasting change and improvement. These programs should be viewed as successful partnerships that can be repeated elsewhere to affect greater change.

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Governance on Small Towns Water Supply Project in Nepal

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Abstract
The paper is a brief midterm governance assessment of Small Towns Water Supply and Sanitation Sector Project (STWSSSP) being implemented by Government of Nepal. The assessment is made at implementation as well as operational stage at the first phase of the project. The governance of the project at feasibility study & detail design, implementation and operation & management are discussed. Factors instrumental in delays in implementation, cost recovery arrangements in the project after operation and users committee ownership are the key message that the paper intends to disseminate.

1. Introduction
Government of Nepal is implementing the Small Towns Water Supply and Sanitation Sector Project (STWSSSP) in order to improve quality of life of the people living in the project towns by constructing and extending water supply systems, limited drainage and sanitation facilities and providing health and hygiene education program in various small towns of the country. Asian Development Bank has been providing financial assistance to this project and duration of the first phase of the project is 2001-2006. Department of Water Supply and Sewerage (DWSS) is the implementing agency whereas the Ministry of Physical Planning and Works (MPPW) is the executing agency. The project is assisting in implementing a part of the 15-year plan for Small Towns Water Supply and Sanitation Development in the country and about 31 Small Towns are being covered by this project. Further, UN-HABITAT Water for Asian Cities programme in Nepal facilitating to strengthening intuitional and local capacity, gender mainstreaming and support in pro-poor urban water governance in this STWSSSP as well.

Water User and Sanitation Committee (WUSC) is fully involved and jointly responsible for all major decisions related to subproject planning, implementation and long term operation and management (O&M). The project design is also based on the principles of cost recovery, whereby the Town Development Fund (TDF) provides 30 percent of the water supply project cost as loan for a period of 12 years with interest rate of 8 percent. The community contributes an additional 20 percent of the project cost, as 5 percent upfront cash contribution and 15 percent kind. The Government provides the remaining 50 percent as grant to the qualifying community. However, all operation and maintenance cost including loan repayment and any subsequent expansion is the responsibility of the users, which is to be generated through localized incremental tariff system.

The project is nearing its end for the first phase and a number of projects have been completed, several are nearing completion and others are at various stage of implementation. The paper reflects some of the governance issues at the stage on positive outcome as well as hindrances, which have been instrumental in creating some delay – especially during the implementation phase.
2. Feasibility Study and Detailed Design Phase
This is a very crucial phase of the entire project cycle, as it establishes the viability of the proposed project in technical, social, environmental and financial terms. It is at this stage that the consumers get a picture of the scope of the selected alternative, level of investment and tariff level required to pay back the loan amount to TDF. The project modalities are also clearly spelt out to the consumers and their role and responsibility is elucidated.

**Establishment of the scope of the works:** The Scope of Works for the Feasibility Study Phase is fairly comprehensive and deals with the entire gamut of technical, social, environmental and economic / financial issues for each of the identified alternative. It is thus essential to further streamline and curtail the cumbersome feasibility study process and focus on the demands and needs of the users / community.

**Incorporating Design Feedbacks:** The design standards and guidelines provided by the Project Management Office (PMO) of STWSSSP have been modified on a case-to-case basis and from time-to-time. These changes and recommendations should be documented and made available to the engineering firms for proper design and estimating procedures.

**Need and demand assessment:** Proposed projects need to be assessed in terms of their management capacity, need and desire for water supply and sanitation services, increased service level for better quality and reliable services, etc. for the long-term sustainability of implemented projects. It has been often observed that such assessment parameters are “overlooked” leading to less needy town projects getting into the project fold. It is imperative that a very rigorous approach be adopted to establish the need and demand for improved water services in targeted small towns.

**Interaction with the community in determining the service area of the project:** A major bone of contention has been the demarcation of the service area for a town. Service area demarcation often has been done covering political boundaries like an entire municipality or a village development committee (VDC). Typically service area demarcation is done with respect to the feasibility of the source, settlement pattern (clustering), etc. Covering political boundaries like the entire municipality is not necessarily the most cost effective approach. More intensive and transparent interaction with the community is required and the service area should be demarcated as per the technical and financial viability of the water source of the project. This means that not 100 percent of the population within the municipality or VDC needs to be covered by the piped system. There have been several examples where inadequate exercise for determining the scope and service area of the project during feasibility appraisal stage has led to considerable delay in project implementation.

**Streamlining design approach and assumptions:** After the approval of the best sought alternative at the feasibility stage by the community, detailed engineering design of the adopted alternative is undertaken by the engineering consultants. As mentioned earlier, the Project has developed a brief operational manual. However, this operational manual lacks adequate details to ensure similarity and consistency in engineering design carried out by various engineering firms. Some of the critical issues requiring immediate attention to bring about consistency in the design and reporting process are:

- The per capita demand needs to be broadly categorized as domestic, institutional and commercial (schools and offices) and other demands like fire demand etc.
An explicit guideline to accommodate demand of water from temporary and floating population and their growth potential.

A more relevant drinking water quality guidelines need to be developed (at present WHO guideline has been adopted as defacto standard).

Specific guidelines for structural design of civil structures need to be established including seismic considerations to be adopted.

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**Box 1. Lekhnath Town Project, Kaski**

Lekhnath Town was one of the first towns to be selected as a sample town during the project preparation stage in 1999. The acute shortage of water in the town made it an ideal place for the implementation of the Project. However, enhanced scope of the project during the detailed design phase led to unwanted delays and revisions to the project design. After several rounds of discussions and amendments, the scope of the project was reduced to a more manageable scale and the project has finally gone into implementation in late 2005 after a delay of about five years.

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**Incorporating demand responsive principles in detailed design:** One of the basic features of the project is demand responsiveness and incorporating consumers’ wishes and demands. Although the scheme cycle provides ample opportunities for entertaining the demands of the consumers, as it happens with most other development works, the consumers tend to float ideas and requirements even at a very later stage of the engineering design works. This may require changes and additional work for the designer, but should be taken as a challenge and the Project needs to have an inbuilt mechanism to address such “last minute” requests.

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**3. Implementation Phase**

Critical governance issues in the implementation phase is the balancing of community, the contractor, government and the Asian Development Bank.

**Balancing the community’s demands and contract administration:** Being a community based project, there are always certain issues that the community brings up and needs to be considered in the spirit of the Project. However, the Contract with the Contractor limits the degree of flexibility to which the request of the community can be met during construction. The need to introduce variation order and other contractual measures often limits the process. Certain financial resource either through a provisional sum or additional lending from TDF, which can be used by the WUSC directly can go a long way in providing the degree of flexibility and avoiding complex contract administrative procedures. Additionally, consumers of several towns have also been voicing their concern regarding communities’ responsibilities for factors like price escalation awarded to contractors during standard contract administrative procedures. It has been generally felt that considering the nature of the project, a simpler process to address price escalation issue needs to be taken in the contracts.

**Community’s role during implementation:** The Project has prominently placed the role of the community in the forefront. However, this has to be further enhanced considering the high degree of maturity and knowledge demonstrated by the members of the WUSC and general community members in the planning, development and implementation (ongoing in some
cases) of over 20 town projects. Enhancing the community’s role during implementation may require additional capacity building measures.

**Balancing Government financial regulation, ADB guidelines and the Community:** Need to conform to two different regulations – one of the Government of Nepal and the other of ADB – often leads to some confusion and delay in project execution. It would be worthwhile to explore the possibility of having a single regulation for the execution of the town projects. This issue can be further eased by giving greater financial responsibilities to the Town Managers of their respective Town Project Offices (TPOs).

4. Operation and Management Phase

**Community’s responsibility and capacity building:** This phase has not been fully realized yet, though few projects have been completed and their respective WUSCs are operating and managing the new systems. It has been observed that some of the existing WUSCs are quite capable to handle the complexity in operations and management of the systems. Some of the WUSCs have already started providing house connections to households and collecting monthly tariff. It has been observed that some additional training and support is required to make the operating procedures effective and efficient. Such capacity building measures may be, Computerizing the billing and inventory system of the WUSCs, Training on operating and maintaining water quality laboratory and Getting access to services for further improvement or expansion, etc.

**Positives from the Project Cycle:** There are strong positives vibes that have resulted with the ongoing implementation of the Small Town Water Supply and Sanitation Sector Project in various towns in the country. Apprehensions in the early stages of project implementation regarding upfront cash contribution, kind and labour contribution, effective operation and management, tariff setting based on actual operation and maintenance cost including payback of 30 percent loan, etc. have “disappeared” and stakeholders are now convinced that effective operation and management and cost recovery are essential to the success and sustainability of the project, as a whole. Some of the strengths emanating from the project concept and strategy are as follows:

**Community participation:** Participation of community in projects located in urban areas was thought to be very difficult – in fact well nigh impossible. However, after initial hiccups raising five percent cash upfront of the total water supply cost and additional fifteen percent cost in kind has not been a problem. In fact on the average nearly $20 in cash has been contributed by each household within the service area of various towns under implementation. The community and their representatives in the WUSC have been actively participating during contractor selection, contract implementation and running bill payments. This has greatly enhanced the sense of ownership and responsibility.

**Cost recovery:** A unique and probably a pioneering effort in rural and semi-urban water supply and sanitation sector in the region is process of acquiring loan to the tune of 30 percent of the total water supply cost and setting tariff to pay it back in 12 years with an interest of 8 percent per annum. This cost recovery feature of the project is in the process of implementation in some of town projects, which have been completed and handed over to the community (WUSC).
During the feasibility and design phases of Khairenitar Town Project, it was assessed that about 50 percent of total consumers (808) were interested in getting services from the project in the initial phases of project operation. The Project is completed and functioning since last few months. Although the project has not been formally handed over, the WUSC has taken over the operation and management responsibilities. It has provided house connections to 709 customers and is generating about US $ 800 as monthly revenues. Its present monthly expenditure, predominantly staff salaries and regular maintenance cost, is about US $ 350. The monthly revenue shall go up with the installation of meters and levying of incremental tariff in lieu of the present lump sum tariff.

**Local tariff:** As discussed earlier, the water tariff at each town is set to cover the entire operation and maintenance cost including the loan of 30 percent of the water supply cost to TDF. Therefore, the community is responsible to make the technological choice and the level of investment associated with that choice / option. The tariff blocks are set on the incremental block tariff system, where the rate for the initial 8 – 10 cu.m. is kept at a lower rate and gradually increased for higher blocks of water consumption.

**Gender involvement and social inclusion:** A critical and essential feature of the project is the involvement of women and disadvantaged groups in various phases of planning, development and implementation of the town projects. This involvement does not end there and is furthered through the mandatory participation of women in the apex WUSC and ward level sub-committees.

**Enhanced service level:** The basic premise of the STWSSSP has been providing better services to the semi and peri-urban populace, who are often left out in the face of higher investment in the rural and purely urban areas. Therefore, the service level of the Project is higher than the typical rural schemes with higher quantity per capita, quality conforming to WHO Drinking Water Guidelines and better reliability and accessibility.

**5. Conclusion**

The Project experiences have clearly indicated that to enhance and strengthen performances of projects for emerging towns elsewhere, it is imperative to build-in the features of effective governance system such as community participation, cost recovery, localized tariff, increased involvement of women and better service level. Similarly, appraisal process of proposed projects in terms of needs assessment and general feasibility has to be done in a robust manner with special focus on the determination of service area. Further, the design process needs to be streamlined to bring consistency and effectiveness. Introduction of greater flexibility in contract administration and allocating more financial responsibilities to users’ organizations and local project representatives shall go a long way in making project implementation effective. Strengthening and consolidating of such issues in sector project design and implementation shall further the cause of providing sustainable water and sanitation services to small and emerging towns in the sector.
References
The Evolution of Water Rights System in China
- From State to Market

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Abstract
In the past two decades, China has established one complete set of common water right system on the basis of administrative means. However, the equilibrium is being disrupted with the rapid development of market economy in China. The paper makes use of property rights theory to analyze the water trade between Yiwu and Dong Yang City, Zhejiang province, East China to explore evolution of water rights system in China. In the end, the paper summarizes the latest development of waters rights and water market system.

1. Introduction
The water resources in China are not very rich and the average water resources per capita is about 1/4 of the world average. Meanwhile, the spatial allocation is not even. With the rapid economic development, the rise of population and the accelerating pace of urbanization, the disequilibrium between the demand and supply of water resources in China has been worsened. The water resources have become one of the main factors constraining the sustainable economic and social development in China. One of the main solutions is to establish a water-saving society. In order to achieve the objective, it is important to establish one complete set of administrative system of water resources on the basis of water rights and water market theories.

2. The Common Property Rights Arrangement of Water Resources in China
In the planned economy, water was open-access resource in China since the utilization of water resources was mainly constrained by development capability and the utilization cost. There were no competition in water use and the allocation of economic interests. The formal property rights arrangement did not exist at that time. With the deepening market-oriented reform in China, the water use in China has increased dramatically and water resources have become scarce economic resources. Regional disputes on water use have risen rapidly with more fierce competition in the utilization of water resources. The property rights of water resources have become essential because of water scarcity. The Water Law is the key law defining the nature of water management in China and it was implemented on July 1, 1988, in which “The water resources in China belong to the nation” was mentioned. It also included the topics such as the long-term water supply and demand, the macro-allocation system of water resources, the license of water use, the use of water with compensation and the coordination of water disputes. The purpose of the Water Law as revised in 2002 was to undertake the rational development, utilisation, saving and protection of water resources; to prevent and control water disasters; and to conduct the sustainable use of water resources (Shen Dajun, 2004).

In the past two decades, China has established one complete set of common water right system on the basis of administrative means. Although the excludability has been improved, the water
right is still fuzzy. The present institutional arrangement of water rights is the equilibrium of the inefficiency of water use due to the fuzziness of water rights and the cost saving of administrative water allocation. However, the equilibrium is being disrupted with the rapid development of market economy in China.

3. The Water Trade Between Yiwu and Dongyang City
On 24 November, 2000, the municipal governments between Yiwu and Dongyang City signed a contract of partial transfer of water right of Heng Jin Reservoir in Dongyang City. The municipal government of Yiwu City purchased the permanent right of annual water use of 49,999 million cubic meters with RMB 200 million yuan. The water quality in the reservoir reached National Type One Drinking Water Criteria. Yiwu municipal government pays the comprehensive management fee of RMB 0.1 yuan per cubic meter to Dongyang City. The water resources fee would be adjusted according to the average price stipulated in the provincial regulations. The water trade between Dongyang and Yiwu City was completed on equal and voluntary basis and it broke through the barriers among administrative regions and realized the coordination and sharing of regional resources. Besides, the water resources can be utilized fully through transferring the surplus water of Dongyang City in the upper stream to Yiwu City, which has witnessed a rapid economic development in the past two decades. Water scarcity was very serious in Yiwu City. The actual water allocation for agricultural use from Dongyang City to Yiwu City was officially completed on 6th January 2005.

The case was introduced widely both domestically and internationally as a win-win game for both cities because agricultural water in Dongyang was sufficient and the water scarcity in Yiwu city in near future was one of the biggest problems constraining its sustainable development. The event symbolized the emergence of water rights market and marked the beginning of reforming the water rights system in China.

Both Dongyang and Yiwu City are located on the upper and down streams of one river. Theoretically, the water rights of Yiwu River can be regarded as the river basin property rights, which can be shared by the areas along the upper and down streams. However, because Hengjin Reservoir is located in Dongyang City, the use rights and earning rights of water resources in the reservoir are owned by Dongyang City. In other words, the property rights of water resources in Hengjin reservoir belong to the non-exclusive regional property rights. Under the common property rights arrangements on the basis of administrative means, Yiwu City can ask for water drainage from Dongyang City. In fact, Dongyang city supplied the water to Yiwu city free of charge in times of drought many times in the past. However, Yiwu city realized that the periodic water drainage free of charge depending on the upper-level administrative coordination was neither reliable nor lasting. In addition, the polluted river water drainage was mainly for agricultural drainage, but Yiwu city needed to expand its capacity of urban water supply. Therefore, the interregional drainage of high-quality water at Hengjin Reservoir became the best choice. Then, Yiwu municipal government asked for the permission from higher authorities including the Ministry of Water Resources (MWR) to construct the water diversion project from Hengjin Reservoir to Yiwu City.

The greatest advantage of traditional interregional water drainage is that the local government can enjoy the unconditional benefit from the fiscal investment of upper authorities, but the
administrative coordination is usually time-consuming. In particular, it is difficult for relevant parties to reach consensus due to the lack of monetary compensation to the supplier. On the other hand, Zhejiang province where the water trade took place can hardly meet the preconditions for state fiscal investment. The regional water conservancy projects in Zhejiang province have been mainly invested by the local investment instead of the subsidy from the provincial and central government. In the case of Yiwu, the water conservancy projects have mainly been financed and constructed by the local government. The total investment of Ba Dou Reservoir, which was put into use in 1997, reached RMB 180 million yuan and the subsidy from the upper authority only accounted for 10%. The municipal government in Yiwu has the sufficient fiscal income and investment capacity to purchase the water rights. According to the agreement of water trade, the expenditure of water trade amounting to RMB 200 million yuan would be paid off in five instalments with annual instalment of RMB 40 million yuan, which only accounted for 4.5% of total fiscal income in 1999. The total water diversion project cost RMB 700 million yuan with the annual investment of RMB 140 million yuan, which only took up 4.6% of total fixed assets investment in 1999.

The main reason why Yiwu city chose to purchase the water rights instead of asking for water from upper authority was that the returns of buying water exceeded the costs of asking for water from the upper authority. The costs of buying water were the loss of fiscal subsidy, but the returns were the timely solution to the bottleneck restricting the urban development. As for Dongyang City, the administrative allocation of its water resources could scarcely have any gains but make great profits through water trade. The mutual benefits of water trade have led to the inevitable institutional change since the transition from one institution to another meant that the costs of implementing the new institution were less than those of maintaining the old one. Why did the water trade first take place in Zhejiang province? The costs of transferring water rights through administrative means were higher than through market transaction. The special partnership between Dongyang and Yiwu City reduced the transaction costs further, which was one of the important preconditions bringing about the institutional change.

4. The Transitional Path of Water Rights System in China

The water trade between Dongyang and Yiwu City in 2000 broke the administrative monopoly of water allocation in China and it is also the prologue to the reform of water rights system in China.

The water trade between Dongyang and Yiwu City indicates that there is still ample room to introduce water rights and water market system so as to optimise the allocation of water resources in China. With the increasing water shortage, the operating costs of common water rights on the basis of administrative means have become much higher than used to be. With the deepening market reform, it has become more difficult for the higher authority to monitor the local government and the administrative orders can scarcely be carried out effectively. In addition, the government has no capability to deal with the complicated information of assets specificities and the allocation of water rights through administrative means has failed to meet the social demand. The opportunity costs of implementing institutions have risen considerably. Moreover, the cost of identifying and maintaining water rights has been lowered and the returns of establishing the excludability of property rights are rising. The market-oriented reform is also lowering the costs of property rights transactions and the expected earnings of introducing the market mechanism are rising constantly.
The costs of implementing the existing institutions have increased considerably due to the rising internal costs. The excludability costs are being reduced constantly and the earnings of clarifying property rights are on the rise. As a result, the equilibrium of existing institutions has been disrupted. It can be expected that the institutional change of water rights is moving towards the improvement of excludability and clarification of property rights. The precondition of water trade between Dongyang City and Yiwu City was that Yiwu City acknowledged Dong Yang City’s possession of transfer rights of water resources in Hengjin Reservoir. However, many people would wonder how to undertake the transaction without clarifying the property rights. The fuzzy water rights in the most part of China have led to a lot of water disputes and very little cooperation has taken place. The water trade between Dongyang City and Yiwu City has shown that clarifying the property rights will help to nurture the water market. The clarification of property rights includes the identification of the use right, the earnings right, the transfer right and the more obvious identity of owning these rights. However, the clarification of water right must correspond to the social conditions. The fuzzy property rights to some extent are reasonable and can be wholly efficient. Since the cost of establishing the private property rights of water resources is high, the main form of water rights structure will be still the common property rights in the near future, but the internal excludability can be raised constantly. Civil property rights and basin property rights can be divided into regional property rights and collective property rights. The identity of owning water rights can also be diversified, including the governments at various levels, organizations, enterprises, the big consumers of water and even individuals.

The water trade between Dongyang City and Yiwu City exhibited the feature of induced institutional change, but it is not typical in China. As for the whole country, although the total earnings of institutional change are higher than the cost, the induced institutional change can hardly take place because of the disequilibrium of benefits allocation among various interest groups. Thus, the central government still plays an important role in dominating the mandatory institutional change. The MWR will play an important role in making and revising the relevant rules and regulations on water governance.

5. The Latest Development of Water Rights System in China
In recent years, China has been promoting the establishment of water rights system in China. In addition to the water trade between Dongyang and Yiwu City, other typical cases include the water coupon system of rural households at Zhangye, Gansu Province, the large-scale water trade at Ningxi autonomous region and Mongolia autonomous region, located in Northwest China. Recently the development of water rights system has been spread to other parts of China including the clarification of water rights in Song Liao Basin, the trial implementation of water rights in Huolin River, Yongding River, Weihe River, Zhanghe River and Luanhe River in Haihe River valley, Jinjiang River in Fujian province, Fuhe River in Jiangxi province, the Dongjiang River in Guangdong province and the Shiyang River in Gansu province. The water rights and water market system have played an important role in improving the efficiency and effectiveness of utilizing water resources, realizing the optimal allocation and scientific management of water resources and ease the contradiction of water demand and supply.
At present, MWR is trying to establish a set of water saving social management system with the core of total control and quota management. According to the whole nation’s blueprint, the various river basins and regions have carried out the comprehensive planning of water resources respectively, laying a solid foundation for the initial allocation of water rights nationwide. The preparation for water quota system has also made progress. Up to now, twenty-four provinces have issued the quotas of water use. Meanwhile, the planning of water quotas for agricultural irrigation has completed and the quota system for some industries with high consumption of water has been implemented.

China faces many challenges with its water policy as it transforms itself into an industrialised country. However, China needs to strengthen the institutional reforms in water policy further dominated by MWR. Whether China will achieve the improvement of water policy in the near future depends upon the extent to which water policy is made and implemented based on socio-economic and environmental considerations.

Reference
Water Resources Management and Rehabilitation in China

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Abstract
A water resources management plan should be implemented throughout China, which is based on a unified watershed-scale. Water prices should be increased as well as investments in agricultural and industrial water conservation. Save water methods should be applied in the whole regions of water shortage. Increased water use efficiency will ensure that China's water resources will be used in a reasonable, effective and sustainable manner. New technologies and management methods will be required which are underpinned by science. Greater attention must be given to prevention of pollution and other forms of water quality degradation in large river basins.

1. Introduction
Hydrological and environmental changes in China have seriously impeded sustainable development, for four centuries. Hydrological conditions of China's watersheds have long been monitored and studied. Overuse of some water resources has led to soil salinization and desertification. Only in the last few decades has this land degradation become a strikingly apparent, leading to recognition that hydrological factors and environmental sustainability are inextricably linked. Both government agencies and non-governmental organizations (NGOs) have taken or are taking steps to address these issues (Kenneth, 1997). Reasonable countermeasures to protect ecosystems, land and water quality during intense water resource development are proposed, which nonetheless promote social development.

2. Current status
Provincial yearbooks have compiled hydrological data back to the 1950s. Some gauging stations have detailed measurements for over 40 years, while the remainder has at least 25 years data. Groundwater quantity and quality data were taken from China Water Research Bulletins published by Ministry of Water Resources (MWR). Agricultural, industrial, domestic and others water use data was obtained from the National Statistics Bureau (1998a, 1998b, 1989). Data was not available for Macao, Hong Kong and Taiwan. China is divided into five regions, using hydrological, geological, geographical and climatological criteria. These are south east China (SEC), south west China (SWC), north east China (NEC), north west China (NWC) and north central China (NCC) (Feng et al., 1999a). Regions exhibit different water use, development issues and trends, necessitating different rehabilitation measures.

The SEC Region covering 1.23 million km$^2$ or 12.8% of China's total landmass (Table 1). Under the influences of SE monsoons and tropical storms, precipitation varies from 800 mm yr$^{-1}$ in the north to over 1600 mm yr$^{-1}$ in the south, resulting in a climate that ranges from semi-humid to extremely humid. Resources include 905 km$^3$ in surface waters (97.4%) and 25 km$^3$ (2.6%) in net groundwater (Table 1).
The SWC region contains Sichuan, Yunan and Guizhou Provinces, Guangxi and Tibetan Autonomous Regions and Chongqing City. Precipitation varies from 200 to 4490 mm yr$^{-1}$, due to varied landforms and stratified climatic zones across a range of elevations. The Tibetan glacial area accounts for 60% of China's glaciated area. Total net water resources in the region are 1280 km$^3$, of which net groundwater is only 2 km$^3$ (Table 1).

Table 1. Water resources distribution in China in 1990 (MIHWR, 1997, 1998)

<table>
<thead>
<tr>
<th>Region of China</th>
<th>Extent of water resources</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Surface water (10$^9$ m$^3$)</td>
</tr>
<tr>
<td>Southeast (SEC)</td>
<td>905</td>
</tr>
<tr>
<td>Southwest (SWC)</td>
<td>1278</td>
</tr>
<tr>
<td>Northwest (NWC)</td>
<td>210</td>
</tr>
<tr>
<td>Northcentral (NCC)</td>
<td>127</td>
</tr>
<tr>
<td>Northeast (NEC)</td>
<td>128</td>
</tr>
<tr>
<td>All</td>
<td>2648</td>
</tr>
</tbody>
</table>
Table 2. Total area, population, farmland, rain and water resources in China and the World

<table>
<thead>
<tr>
<th>Region</th>
<th>Landmass area (10^6 km^2)</th>
<th>Population (10^9)</th>
<th>Farmland (10^6 km^2)</th>
<th>Rainfall (10^3 km^3)</th>
<th>Volume (10^3 km^3)</th>
<th>Per capita (m^3 person^{-1})</th>
<th>Per area of farmland (m^3 km^{-2})</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>149.5</td>
<td>5.4</td>
<td>13.26</td>
<td>120</td>
<td>46.8</td>
<td>8690</td>
<td>353</td>
</tr>
<tr>
<td>China</td>
<td>9.60*</td>
<td>1.2</td>
<td>0.96</td>
<td>6.19</td>
<td>2.81</td>
<td>2344</td>
<td>293</td>
</tr>
<tr>
<td>Ratio (%)</td>
<td>(6.42)</td>
<td>22.2</td>
<td>1.0</td>
<td>5.2</td>
<td>6.0</td>
<td>27.0</td>
<td>83.2</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Region</th>
<th>Irrigation</th>
<th>Forestry, pastures, fisheries</th>
<th>Agriculture</th>
<th>Rural</th>
<th>Urban</th>
<th>Domestic</th>
<th>Industrial</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southeast</td>
<td>150</td>
<td>7</td>
<td>158</td>
<td>14</td>
<td>11</td>
<td>25</td>
<td>63</td>
<td>245</td>
</tr>
<tr>
<td>Southwest</td>
<td>51</td>
<td>8</td>
<td>59</td>
<td>5</td>
<td>6</td>
<td>10</td>
<td>12</td>
<td>81</td>
</tr>
<tr>
<td>Northwest</td>
<td>46</td>
<td>20</td>
<td>66</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>73</td>
</tr>
<tr>
<td>Northcentral</td>
<td>71</td>
<td>5</td>
<td>77</td>
<td>6</td>
<td>5</td>
<td>10</td>
<td>15</td>
<td>102</td>
</tr>
<tr>
<td>Northeast</td>
<td>36</td>
<td>3</td>
<td>40</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>12</td>
<td>55</td>
</tr>
<tr>
<td>Total</td>
<td>354</td>
<td>43</td>
<td>400</td>
<td>28</td>
<td>27</td>
<td>52</td>
<td>107</td>
<td>557</td>
</tr>
</tbody>
</table>

Table 4. Current water consumption of different users in China.

<table>
<thead>
<tr>
<th>Region</th>
<th>Irrigation quota (m^3 m^{-2})</th>
<th>Irrigation rate (%)</th>
<th>Domestic water quota</th>
<th>Industrial water consumption (m^3/1000 USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Southeast</td>
<td>0.20</td>
<td>76.5</td>
<td>260</td>
<td>110</td>
</tr>
<tr>
<td>Southwest</td>
<td>0.53</td>
<td>47.0</td>
<td>245</td>
<td>85</td>
</tr>
<tr>
<td>Northwest</td>
<td>0.25</td>
<td>50.4</td>
<td>130</td>
<td>65</td>
</tr>
<tr>
<td>Northcentral</td>
<td>0.50</td>
<td>57.0</td>
<td>185</td>
<td>71</td>
</tr>
<tr>
<td>Northeast</td>
<td>0.15</td>
<td>24.3</td>
<td>145</td>
<td>90</td>
</tr>
</tbody>
</table>

The NWC region is made up of Xinjiang and Ninxia Autonomous Regions, as well as the provinces of Qinhai, Gansu, and Shaanxi. It is located at least 600 km from the ocean and is surrounded by tall mountains. Several inland rivers are distributed across the region being the Tarim, Heihe, Shiyong, and Urumqi. Regional water resources amount to 220 km^3, with groundwater being less than 5% (Table 1).

The NEC region's watersheds include those of the Heilongjiang (J), Shuien-Tumen and Liaohe-Yalujiang rivers (A). Under this semi-humid to humid climate, precipitation ranges from 500 to
1000 mm yr\(^{-1}\), under the influence of monsoons and different landforms. Total net water resources are 150 km\(^3\), with 22 km\(^3\) of net groundwater (Table 1).

Total net water resources of the NCC region in the region are 170 km\(^3\) with 43 km\(^3\) (25%) of net groundwater (Table 1).

Precipitation and thawing of alpine glaciers are the primary sources of runoff in China, but such waters are only exploitable when they flow in surface channels or emerge from springs (Yang, 1981). The Yangtze and Zhujiang rivers carry the bulk (48%) of total runoff estimated at 2,700 km\(^3\). Based on measured seepage rates and volumes from farmland channel systems, particularly those in the piedmont plains, as well as a consideration of storm and flood event hydrographs, total net shallow groundwater in China represents about 100 km\(^3\) (Liu et al., 1996). Groundwater resources, excluding those feeding streams, occur mainly in the shallow aquifers of plains regions and total some 100 km\(^3\). While China ranks sixth amongst nations in total water resources, its per capita water resources (2344 m\(^3\) person\(^{-1}\)) are roughly a quarter of the global mean (Table 2).

Use of water in agriculture is the largest sector in terms of water withdrawal, rising four-fold in the last 50 years (Zhao, 2000). Table 3 shows usage in relation to different regions. Different agricultural areas employ water in different ways. As agricultural water use includes irrigation, forestry and grassland use, fishery supplementation, so a wide range of problems has developed as a result of rapid agricultural development.

3. Water issues

3.1 Unequal distribution
China's water resources are unevenly distributed both in terms of area and population. With very high population densities in SE China per capita farmland area is low, roughly 500 m\(^2\) person\(^{-1}\). Catchment areas of the Yangtze River and its southern tributaries account for 80% of China's total runoff, but house only 36% of China's farmlands (Chen and Xia, 1999). Per capita water resources in northern China are one-quarter those in the south, while on an areal basis the north's water resources are a tenth of those in the south (Chen and Xia, 1999). The paucity of water resources in northern China results in more acute conflicts in supply and demand than in the south. Arid and semi-arid lands of the NWC region cover 47% of China, but only benefit from 7% of water resources (Table 1). Humid and semi-humid regions of SE China account for the remainder and enjoy 93% of water resources (Chen and Xia, 1999).

3.2 Serious Water Resource Shortages
Water shortages have restricted China's agricultural, industrial and urban development. About 300 of 600 medium sized cities, of 0.1-1.0 million inhabitants, have experienced water shortages, while 108 of these cities suffer from a serious lack of water (Feng et al., 1999b). The area of drought-prone lands has risen by 50% since the 1950s, reaching 267,000 km\(^2\) in 1990. Only 500 of a potential 640,000 km\(^2\) of potential irrigated area has been developed, of which 100,000 km\(^2\) has poor irrigation facilities. So agricultural production and grain supply is restricted. Additionally, about 7.0 million people and 60.0 million head of livestock must drink highly saline water as no fresh water is available (Feng, 1999).
Water shortages also adversely affect industrial production and living standards. In the late 1980s and 1990s, many electric power plants and factories in large, >1.0 million inhabitants, and medium-sized cities of northern China had to suspend production due to water shortages.

3.3 **Deterioration of aquatic ecosystems**
Regions susceptible to soil erosion have reached 38% of China's landmass. On the Loess plateau, 430 and 276,000 km², or 69% and 44% of total area, are subject to moderate and severe soil erosion, respectively (Feng et al., 1999a). Across half the Loess plateau, soil erosion is greater than 5 Gg km⁻² yr⁻¹, while in some areas it reaches 30.7 Gg km⁻² yr⁻¹. Despite annual investments of $2.4 million (U.S.), reclamation rates are below rates of soil erosion, leading to loss of land productivity.

Due to sediment deposition, lakes along the Yangtze have quickly shrunk dropping by 1500 km² in area and 12 km³ in volume between 1949 and 1983 (Wang et al., 2000). Lake shrinkage has resulted in a 20% decrease in adjustment capacity, a rise in water level of 0.76 m, and a concomitant economic loss of $6.0 billion.

Water pollution is a very serious problem in China. In 1990, 56.0 km³ of sewage drained into lakes and rivers, of which 68% originated from industrial sources and 32% from domestic sources (Feng et al., 1999b). A survey showed that more than 400 of 500 rivers were contaminated to different degrees, and 12 of 15 large cities situated near big rivers had seriously contaminated water supplies.

Polluted water can affect people's standard of living and health indirectly or directly through local diseases outbreaks. Localized endemic illness has increased due to bad water quality: in Bailedou, Qinghai Province with diarrhoeal symptoms have been attributed to water with a high sulphate content.

3.4 **Flood and waterlogging damage**
Seasonal and annual variations in precipitation and stream flow in China are comparatively large. Precipitation within the four months of the flood season may account for 60-80% of annual totals. As floods, water-logging and drought occur frequently, a keen awareness of hydrological extremes guides development and use of water resources in China. Statistical analysis has shown that about 100 of 370 large reservoirs (0.1 km³) have potential dangers, 670 of 2,500 common reservoirs (0.01-0.10 km³) have potential dangers, and 32,000 of the 80,000 small reservoirs (0.001-0.010 km³) also have serious problems. In 1998 he most extensive flood of the 20th century on the Yangtze River damaged a quarter of the cities in southern China, affected 12 cities of 0.1-1.0 million inhabitants, and resulted in losses of $36 billion (Zhao, 2000). In 1994, flooded areas totalled 193,000 km², affecting 223 million people, and resulting in direct economic losses of $2.17 billion (NIHWR, 1997).

3.5 **Acute gap between water demand and supply**
Conflicts between water users along rivers have become more apparent in recent years due to inadequate management legislation, uncoordinated water distribution, uncontrolled development
and water resource wastage in river basin. Such conflicts have the potential to cause land desertification and environmental degradation in the lower reaches of rivers (Feng et al., 2001). In the landlocked watersheds of the NWC region, use of most of the streamflow in middle reaches has resulted in the area of terminal lakes being significantly reduced. The surface area of West Juyan Lake on lower reaches of the Heihe River in Inner Mongolia was 3,000 km$^2$ in the 1960s, but by 1995 only 17 km$^2$ remained. In recent years the lake has dried up in the summer. Some 4,565 km$^2$ of the 38,000 km$^2$ of desertified lands in the Tarim basin are directly attributable to unreasonable water resource exploitation (Zhu and Cheng, 1995).

Different governmental departments have set up factories, each developing water resources for their own economic benefit in an excessive manner. In agricultural production, water consumption is closely related to crop species. Similarly, water requirements for growing cotton (Gossypium hirsutum L.) are 110-112% of precipitation, still 6-17% short of available precipitation in normal precipitation year, but much better than those for wheat (Qu and Ma, 1995). An irrational distribution of crops adversely affects sound allocation of water resources.

3.6 Wastage of water resources

While China suffers from shortages, a large proportion of water resources in China are wasted. Much of the water in reservoirs built between 1960s and 1970s on the plains evaporates. Large irrigation quotas and heavy irrigation are common. Annual irrigation norms across China range from 150 to 530 mm (Table 4). Areas where water conservation techniques applied are few, as some farmers still use traditional but inefficient multi-channel water-diverting methods for irrigation, thus wasting a great deal of water. Poorly constructed channels for water conveyance suffer from severe seepage, mean conveyance efficiency in the NEC and SWC regions ranges from 0.03 to 0.45 (Table 4).

Under flood irrigation conditions with excessive amounts of water, water tables can rise and soils become salinised. Consequently fields must be irrigated in the spring in order to leach salts from the topsoil, thus significantly reducing water use efficiency. In Shandong Province, Hainan, Shiyang River area and over the entire Shiyang River basin water use efficiencies are 24 kg m$^{-3}$, 25 kg m$^{-3}$, 75 kg m$^{-3}$, and 41 kg m$^{-3}$, respectively. The latter case represents wastage of over half the water (Xia and Takeuchi, 1999). In China water use efficiency is very low, and the output water demand index of 0.4-0.7 kg m$^{-3}$ much lower than the worldwide mean of 2.0 kg m$^{-3}$.

Legislation on urban water use is seldom enforced. Furthermore, low water prices result in a great waste of urban water resources. The range of rural domestic water quotas is 65 – 110 l person$^{-1}$ yr$^{-1}$ (Table 4). In some locations where well water is used, water consumption may rise as high as 200 l person$^{-1}$ yr$^{-1}$, resulting in a sizeable waste of water (Qu and Ma, 1995).

4. Rehabilitation measures

Efforts must be made to promote urban, industrial and agricultural water conservation. Sprinkler and drip irrigation are only used on 1.5% of irrigated areas, though water savings relative to traditional irrigation methods could be as high as 50% and 70%, respectively (Qu and Ma,1995). The water wasted under flood irrigation occurs mainly through channel seepage and saturated water evaporation, and results from the lack of coordinated canal systems and poor seepage control techniques. If increasing expenditures on channel upgrading could raise their water conveyance efficiency, 10-15% of the total water used in field irrigation could be saved. An
enhancement of field water conservancy projects, including the levelling of fields and a change from flooding to sprinkler or drip irrigation could save 10-20%, even up to 40%, of total irrigation water use in arid regions and up to 30% of total irrigation water use in humid regions (Cheng, 1996). A rise of water use efficiency from 0.4 to 0.7 would result in water savings of 120-160 km$^3$ yr$^{-1}$.

As the highest water consumption per $1000 of output for the SWC region is over six-times greater than the lowest value for the NCC region, it is clear that a great potential exists for water conservation in the industrial sector (Table 4). The water-reuse ratio is low in the SWC and NWC regions, being 40 and 60% in most cities, but somewhat higher in the NCC and SEC regions. Were all industries to operate at NCC industrial water use and reuse levels, 160 km$^3$ yr$^{-1}$ of water resources could be saved.

A great potential also exists for urban water conservation; however, given low water prices, pressure for water conservation and efficient use of existing water resources are low in most Chinese cities. Water consumption in these cities ranges from 130-260 L person$^{-1}$ yr$^{-1}$ (Table 4). Poor management and maintenance of water conveyance infrastructure can result in serious wastage of water resources. Water leaking from pipes, excessive water usage in some large hotels and gardens, and public fountains can waste large quantities of water. By reducing waste and with wastewater reuse, cities could save 33-50% compared to their current water usage.

Sources can be developed, and more efficiently used through construction of terraced fields supported by local government. In the future, for certain regions, de-salinization of seawater may provide a solution to water shortages (Agnew and Anderson, 1992).

Water resource management at the societal and environmental levels must be improved. Natural ecosystems inevitably vary with time; however, if one only considers economic benefits, ecosystems can be damaged (Jones, 1999). Water pollution in China is serious and linked with economic development. In recent years, the area affected by water pollution has been expanding, resulting in economic losses of roughly $400 billion. Consequently, China must strengthen its water resource management policies, establish water conservation regions, reduce water pollution and continue to raise water use efficiency.

Holistic resource management plans are needed. Inland rivers flowing through different regions require watershed-wide co-ordination. River management draws on expertise in conservation, forestry, industry, agriculture, water quality protection, and urban construction. Each department manages some aspects of the water supply-demand problem, but there is a lack of watershed-wide coordination. Co-ordinating water resource usage, requiring users to observe the water laws and unifying allocation of water resources at the watershed scale should be completed as soon as possible.


References
A Multi-disciplinary Approach to Vulnerability Assessment and Transboundary Water Governance: The Case of the Sesan Basin

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Abstract

Water governance, especially in transboundary contexts, needs to integrate inputs from different disciplines as well as from stakeholders and the public and scientific knowledge from the natural and social sciences needs to be combined with local knowledge and stakeholder needs. There is however often a lack of suitable methods for combining these. Within the EU-financed STRIVER project (www.striver.no) integrated interdisciplinary assessment of four river basins is being conducted; the Sesan (Vietnam-Cambodia), Thunga Bhadra (India), Tejo/Tajo (Spain-Portugal), and Gomma (Norway) Rivers. The project’s focus is on heavily modified rivers in Europe, India, and south-east Asia and this paper describes the approach used in the Sesan Basin, an approach that combines ecological and human vulnerability studies with future scenarios.

1. Introduction

Changes in water governance in different countries and parts of the world can be very dissimilar in character; they do however seem to have one thing in common, that the challenges facing water managers have significantly increased. Water management now has to deal with more issues that affect more people than they did in the past (i.e. water management involves not just hydro-electric power and farmers, but also industrial interests, nature conservationists and ordinary citizens). Water management has increasingly become concerned water-related risks and benefits, and whereas water management has traditionally been considered a predominantly technical field in many countries, the increase in scope, and new demands on water management, now make the political character of the field very clear. These developments from the primarily technical to a combination of technical and political-social spheres has lead to an increased interest in public and stakeholder participation in water management. It has become apparent that there is a need to truly integrate insights and knowledge from the natural and social sciences, as well as local knowledge from stakeholders and the public, in integrated and multi-disciplinary approaches. Participation is of course only one of the challenges for water management, problems arising from the production of scientific information, the communication of that information, legal systems, and institutions are also important (Gooch and Stålnacke 2006). Rapid changes in the driving forces behind water problems have also increased the levels of uncertainty under which policies must be formulated, and have increased the necessity to involve many different groups of actors. While this in turn has lead to an increased awareness of the necessity of including stakeholder and public participation in water management decision-making, as well as in other areas (OECD 2001), it is also important to stress that reliable information must be made available to the public in an understandable form. While we note that local knowledge can also contribute to water management processes, it is vital that public participation is also based on an
understanding of the knowledge provided by the scientific, engineering, and management communities.

Changes in water use, the effects of global warming, and increasing populations mean that water management also needs to focus on different aspects of vulnerability, ecological, economic and social. In order to do so new methodologies need to be developed and ways of involving actors need to be improved. The design and application of a multi-disciplinary approach to vulnerability assessment and transboundary water governance is being conducted as part of the STRIVER Project (www.striver.no). STRIVER conducts an integrated interdisciplinary assessment of four river basins (Sesan (Vietnam-Cambodia), Thunga Bhadra (India), Tejo/Tajo (Spain-Portugal), Gomma (Norway), and through twinning facilitates the exchange of knowledge and experience. The point of departure for STRIVER is the lack of clear methodologies and problems occurring in the implementation of IWRM, as pointed out by both the scientific and management communities. Building upon the development of a multidisciplinary knowledge base assessment in all case studies (policy, social and natural sciences), and the development of a conceptual framework for IWRM, the project seeks to apply IWRM methodologies within the four selected twinned catchments covering six countries in Europe and Asia. The project has received EC funding for three years (2006-2009) under the 6th framework programme (FP6). The multidisciplinary approach described in this paper will be applied in two transboundary river basins, the Sesan and Tejo/Tajo. This paper focuses only on the Sesan basin, and provides a description of the methodology used and the results to date.

2. The Sesan Basin
The Sesan River is one of the largest tributaries of the Mekong River with a drainage area of $17,000 \text{ km}^2$ (11,000 km$^2$ in Vietnam and 6,100 km$^2$ in Cambodia). With its origin in the Central Highlands of Vietnam and the southernmost part of Laos, the river flows through mountainous areas in Vietnam’s Dak Lak, Gia Lai and Kon Tum Provinces before entering Northeast Cambodia, where it moves into relatively lowland areas. In Cambodia, the Sesan winds from east to west through Ratanakiri Province and into Stung Treng Province, where it merges with the Srepok River, another large tributary of the Mekong and then flows east into the Se Kong River just before this river entering the Mekong River close to the Stung Treng Town. Traditionally people have relied on subsistence agriculture and fishing, developing techniques suited for small-scale water utilization. The increase in population and modernisation has created a demand for more intensive utilization of the water resources, such as large-scale hydropower production, large-scale irrigation and increased water supply for urban populations. This has resulted in more discharge of effluents. While small-scale hydro-electric power production is often managed locally, it is the central authorities that drive large scale water projects. Both forms can create problems, but it is often the large-scale production that has created unforeseen negative impacts for local communities which are still embedded in an older subsistence oriented system. The intensified use of water for power production is also at odds with the needs of agricultural irrigation. If Vietnam and Cambodia are to meet the growing demand for hydropower, water for irrigation and urban water supplies as their economies develops, there is a need to modernise the management of the water sector. In both countries reform of the management of the water sector has started, but there is still a long way to go to be able to secure the “rights” of all water user interests, as well as to maintain a healthy aquatic environment.
In both Vietnam and Cambodia, authorities exist at the national, provincial, and district level. The organisation of these authorities is based upon a communist administration system with a strong central-state role. However, due to the large number of research institutions and multilateral and bilateral aid programmes working on the Great Mekong Sub-Region (GMS), the Sesan represents a case with a multitude of actors, both national and international. The national ministries responsible for the management of the Sesan interact in the context of their work on the Mekong and Srepok Rivers and Cambodia and Vietnam are both members of the Mekong River Commission, a co-operative forum for both the utilization and protection of the Mekong River and its tributaries. Also, an *ad hoc* Sesan River Committee has been established, but no permanent basin commission has yet been established.

3. Vulnerability Assessment and Transboundary Water Governance

The analysis of transboundary water governance within the Sesan Basin adopts *vulnerability* as a unifying idea between different disciplines. UNEP have defined vulnerability as ‘the interface between exposure to the physical threats to human well-being and the capacity of people and communities to cope with those threats’ (UNEP GEO3). Vulnerability should therefore be considered a combination of social and bio-physical processes, as human ability to manage physical threats is of vital importance. A region may be faced with significant physical problems, yet because of a good economy, competent management systems, and political will, still be considered less vulnerable than a region with smaller physical problems that does not have these human resources. Four vulnerability assessments are therefore considered in the Sesan Basin: i) bio-physical; ii) socio-legal-economic; and iv) stakeholder-based. The bio-physical based identification of vulnerability involves conducting an analysis of areas considered vulnerable according to certain natural science criteria. Key variables include; land use, land cover and river bank use (irrigation systems, location and type of dams); infrastructure (roads, trains, canals, river navigation); possible future developments; topography, including river bed profiles; water levels and water flows; water level fluctuations; and the location of protection areas. The socio-
economic vulnerability assessment involves an assessment of population of the basin, including ethnic groups; administrative divisions and maps; education levels and training programmes; economy (distribution of wealth and income, employment); literacy; urban-rural divisions; economic policies; ownership patterns; activities of civil society (levels of participation); HEP regulations; environmental flow regulations; drinking water needs and availability; fishing; recreation and tourism. The legal analysis involves an assessment of the gaps within the existing system; identification of any barriers to the implementation; and, through an indicator based evaluation, a measurement of compliance and enforcement. Added to these two we are also conducting stakeholder-based vulnerability assessment that involves an identification of the main areas of concern through stakeholder group discussions (workshops and interviews), creating ‘mind maps’ of these areas of concern, then comparing the maps of concern to those produced in the other two vulnerability assessments. Having conducted the analyses of areas considered vulnerable in terms of natural science, socio-economics, law and policy, and stakeholder perspectives, maps are then constructed in a GIS system. The aim of the maps is to identify basin ‘hot-spots’, i.e., places where there is a high risk (according to natural science criteria), and a low capability (according to the socio-economic, law and policy criteria). The stakeholder perspectives data will then be superimposed to look at similarities and differences. Finally, using the method developed by Gooch and Stålacke (Gooch and Stålacke 2006) scenarios will be developed. These scenarios will take into account the two main perspectives; natural/hydrological risk and socio-economic ability to manage this risk. Working in a 15-year perspective, the scenarios will examine future possible trends and developments in nature/hydrological risk and socio-economic ability to manage risk.

The method thus follows the following schema:

1. An overview of the areas considered vulnerable according to natural science criteria.
2. A similar overview of the areas considered vulnerable from a socio-economic, legal and political point of view, including law.
3. The construction of maps than can be used in GIS systems.
4. The incorporation of both aspects (1 and 2) into a GIS database.
5. The identification of the basin ‘hot-spots’, that is, the places where there is a high risk (according to the natural science criteria) and a low capability to manage those risks (according to the socio-economic and political criteria).
6. The identification of the mains areas of public concern through stakeholder group discussions.
7. The creation of ‘mind maps’ of these areas of concern.
8. The use of the knowledge gained in these processes to construct combined qualitative-quantitative scenarios (Gooch and Stålacke 2006).
4. Vulnerability scenarios

During recent years the use of scenarios for environmental policy-making has attracted considerable attention from both the scientific community and policy-makers (see, for example, Greeuw, Asselt et al. 2000). Many of these applications have however either focussed on larger spatial scales, such as countries (Kahane 1997), or have utilised relatively well-known cases where information, while not comprehensive, has been comparatively readily available (Greeuw, Asselt et al. 2000). In the case of regions, and especially Transboundary water management, scenarios have not yet been so widely used. Scenarios are not precise predictions of the future (Porter 1985) but should be seen as simulation tools, as a technique similar to, but different from, models (Jouvenel 2000). Alcamo (Alcamo 2001) identifies five main elements of scenarios; these are a description of the changes that may take place; of the main factors and driving forces that influence these changes; a definition of the beginning year of the scenario, the base year; the selection of the time frame for the scenarios and the adoption of time steps; and the construction of the storylines, which are narrative descriptions of possible futures. Scenarios, through their simplification of available information and their use of alternative, possible futures, can make the process of challenging uncertainty in water management easier. Utilising past and present trends, scenarios attempt to see which factors might lead to likely futures. A qualitative/quantitative method will be used in the Sesan Basin, where qualitative/explorative scenarios will be used as input into computer-generated models that can best be described as quantitative/explorative in the first stage, and quantitative/normative in a second stage. This combination of storylines and set of model calculations is similar to that used in the ‘World water vision scenarios – the world water situation in 2025’. The European Environment Agency report ‘Scenarios as tools for international environmental assessments’ (Alcamo 2001) also proposes a ‘story-and-simulation’ (SAS)
approach to developing scenarios and a variant of the SAS model will be used in this study.

5. Conclusions
The Sesan Basin study is part of a larger project that facilitates knowledge and experience exchange between river basins in Europe, India and South East Asia. The methodology used in the project aims at facilitating the utilisation of scientific and local knowledge in an integrated manner and the use of physical and human vulnerability studies, combined with qualitative/quantitative scenarios, will allow many different actors to become involved in water governance in the region. A first stakeholder workshop, held in Pleiku in Vietnam in December 2006, has initiated the process and more meetings with stakeholders and water managers are planned for the spring of 2007. The project aims at integrating perspectives from the polity, water managers, stakeholders and the public, and as such is expected to contribute to the development of our knowledge of governance mechanisms and perspectives in the South-East Asian region.

References
Biological Water Quality Assessments and Criteria in Korea

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Abstract
The attainment of sustainable water environment is not enough with only the clean water, but it should sustain healthy and diverse aquatic life. Aquatic life is affected by various factors such as physical habitat conditions, water chemistry, and biological interactions, and thus good condition of both physical and chemical water quality is prerequisite for sustaining healthy organisms. Therefore, biological assessment, along with other physical and chemical assessments, is crucial for evaluating the health of a water body. Biological assessments in Korea were just formalized in the national 10 year master plan (2006-2015), named as “the basic plan for water environment management” with the adoption of narrative biological criteria in the law of water quality and aquatic ecosystem conservation in 2006. These efforts have resulted in a significant change of a paradigm in the management of water environment, and a shift away from a sole reliance on regulatory and administrative activities as the principal measures of success to the inclusion of measures based on environmental results. We expect that integrating biological assessments into existing assessment programs will provide the information critical to protect and restore aquatic ecosystems.

1. Introduction
Water bodies exhibit various physical, chemical, and biological characteristics, but their conditions are expressed as a water quality as a whole. Thus, water quality largely focused on the chemical measurements, and their conditions, resulting in ignoring an ecological concept in the water quality program. Current programs are not protecting rivers or their biological resources because our laws of water conservation and management are being implemented as if crystal clean water running down concrete conduits were the goal. In this conjunction, our policies of conservation and restoration of aquatic systems have been focused on a narrow array of factors, mostly related to chemical pollution. As such, assessments of water quality are being implemented to attain only clear water.

Water resources are not simply the water; however, their value as resources is beyond the water alone. They also depend on biological components (species) and the underlying biological processes that sustain those species. Only clean water is not enough for sustainability of water resources (Karr, 1995), and thus, sustainable aquatic system should support diverse and healthy organisms. Because aquatic biota are affected by not only chemical water quality but also habitats and risks, good water quality based on both physical and chemical aspects is prerequisite for
supporting healthy organisms. Therefore, the true health of aquatic environments is reflected by the biological communities that reside within them (US EPA, 2002).

Since 1980s, some development countries started to understand a sustainability of aquatic environment in conjunction with attaining ecosystem health. Biological assessments have been developed in that context, and now are being implemented (EEA, 1996; US EPA 1999). The concept of ecological integrity (i.e., ecosystem health) has been introduced for the conservation and management of aquatic ecosystems (rivers) in Korea. After the three-year (2004-2006) pioneer research, Korean government is now to formalize an ecosystem health concept in the related regulations. Biological assessment tools are also being developed and tested with a tentative bioassessment program on rivers across the whole country. The purpose of this paper is to introduce current status and development of a biological assessment program in Korea.

2. Conceptual background of bioassessments for water quality
Bioassessment is a primary tool to assess biological condition in a water body, and consist of survey and other direct measurements of aquatic life; algae and aquatic vegetation, macroinvertebrates, fishes, etc. Bioassessment, along with physical and chemical assessments, are critical for evaluating the health of a water body, and in turn, their results are essential to provide the information of disturbed systems to be restored. Aquatic life integrates the cumulative effects of diverse stressors such as excess nutrients, toxic chemicals, increased sediment loadings, and habitat destructions. Therefore, bioassessments allow measuring the aggregate impacts of the stressors, and this, in turn, emphasizes that a conceptual framework of a comprehensive assessment of aquatic environment needs to include ecological integrity (biological health) responding to all existing stressors interrelated (Figure 1).

Figure 1. A framework for using biological assessments and criteria to set aquatic life use (Source: US EPA, 2002).

3. Development of biological assessment tools in Korea
Broad scale preliminary biosurvey should be conducted for the development of bioassessments and biocriteria for a country and in this case regional differences, such as ecoregion, should be fully considered. In Korea, the biocriteria are under development, and remains to complete with more data in spatially broader scale. At the initial stage, however, a narrative biological classification system has been proposed; 4-tired system including categories of excellent (A
class), good (B class), fair (C class), and poor (D class). Indicator species including fishes and macroinvertebrates also were designated to each class. The numeric biocriteria are also under developing, using tiered use of fish, macroinvertebrates and benthic algae. Values of numeric indices were tried to discriminate the indices at 4-tiered classes, as mentioned above. To the selected biological assemblages, various numerical indices were considered in order to get the best candidate for Korean rivers. Values of indices were discriminated at 4 classes, in supportive of the proposed narrative biocriteria.

There exist a quite few number of numeric indices for the assessment of water quality using benthic diatoms (e.g., Descy, 1979; Watanebe et al., 1986; Kelly and Whitton, 1995). All of them followed the format of the saprobic index, first proposed by Zelinka and Marvan (1961), to assess organic pollution of the water. We finalized two indices reflecting organic pollution (Diatom Assemblage Index of Organic Water Pollution: DAipo, Watanabe et al., 1986) as well as nutrient enrichment (Trophic Diatom Index: TDI, Kelly and Whitton, 1995). Parameters consisting of the indices were tried to amend for Korean environment.

A numeric index, named as Korea Saprobic Index (KSI), to evaluate saprobicity of the water body was developed using DIN 38410 (1990), based on the formula of Zelinka and Marvan (1961), and the method of calculating weighting value proposed by Yoon et al. (1992). Our fish multimetric model to evaluate water biological water quality principally followed the multimetric model of IBI (Index of Biological Integrity) invented by Karr (1981). Originally, Karr’s model was consisting of 12 metric. However, we modified the metrics to fit Korean environment, river structure and species, and finally made the model with 8 metrics.

A classification of biocriteria can be varied with management purposes in countries, and the level of class is usually ranged from four to seven. We finalized with 4 class system, form A class to D class (Table 1). When classifying the values of numerical indices of the considered biota into 4 levels, BOD water quality parameter in the same study sites were compared. Several representative indicator species for macroinvertebrates and fishes were included in the classification system, although the standard for the bioindicator remains to be questionable. Thus, the classification according to the indicator species needs to be revised with the accumulated survey data.
Table 1. Biocriteria based on the model values and bioindicators of macroinvertebrates, benthic diatoms along with BOD in Korean Streams

<table>
<thead>
<tr>
<th>Class and narrative description</th>
<th>BM* KSI</th>
<th>Numerical indices</th>
<th>Trophic status</th>
<th>BOD</th>
<th>Indicator species</th>
<th>Macroinvertebrates</th>
<th>Fish</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (Excellent)</td>
<td>0-1.0</td>
<td>0-40</td>
<td>100-85</td>
<td>36-40</td>
<td>Oligotrophic</td>
<td>&lt; 1</td>
<td>Plecoptera temmincki, Rhynchocypris kumgangensis</td>
</tr>
<tr>
<td>B (Good)</td>
<td>1.0-2.4</td>
<td>40-55</td>
<td>85-60</td>
<td>28-34</td>
<td>Oligo-Mesotrophic</td>
<td>1-4</td>
<td>Potamanthidae, Semisulcospira, Coreoleuciscus splendidus, Microphysogobio valuensis</td>
</tr>
<tr>
<td>C (Fair)</td>
<td>2.4-3.6</td>
<td>55-70</td>
<td>60-40</td>
<td>18-24</td>
<td>Meso-Eutrophic</td>
<td>3-8</td>
<td>Radix auricularia, Orthetrum, Zacco platypus, Hamibarbus, labeo</td>
</tr>
<tr>
<td>D (Poor)</td>
<td>3.6-5.0</td>
<td>70-100</td>
<td>40-0</td>
<td>≤ 14</td>
<td>Eu–Hyper trophic</td>
<td>&gt;7</td>
<td>Limnodrilus gotoi, Physa acuta, Carassius auratus, Cyprinus carpio</td>
</tr>
</tbody>
</table>

* BM: Benthic macroinvertebrates

4. Results of biological water quality assessments using tiered use of aquatic life

Using diatom indices, TDI evaluated the water quality of the studied river sites to be worse than DAIpo (Figure 2). With this result it is implied that the studied river appears to be more affected by nutrients than organic matters. Overall, a pattern of variation in biological water quality and agrees with chemical water quality (BOD) with in a broad range. However, both diatom indices showed a considerable variation even within the very similar BOD levels. This result emphasizes that biological water quality evaluated by benthic diatoms is affected various parameters.

The results of KSI using macroinvertebrates at study sites also showed the similar trend of variation to BOD changes with a broad spatial range (Figure 2), as shown in the diatom result. However, the variation of KSI was relative small. A major reason of this variation was evaluated to be habitat destruction. If biological water quality is assessed to be worse than chemical one, there may be possibilities of physical disturbance (e.g., destruction of river bed and siltation) and unknown toxic material. Excepting for some river site with physically disturbed condition, KSI agreed with BOD in most cases, and showed a justification to apply KSI to other sites.
Although chemical conditions, based on BOD values, indicated a good water quality, biological water quality using the biological integrity (IBI) was frequently more deteriorated than expected in the aspect of water chemistry (Figure 2). Those impacted sites were mainly due to habitat simplifications such as sand or silt depositions and channel modifications by various constructions in bank area. These activities usually cause modification of fish habitat providing nursery area and refugee. Accordingly, water quality evaluation using only chemical parameters usually overestimate actual ecosystem health. The same implication also was supported by the results of diatoms and macroinvertebrates.

5. Implementation and perspective of biological assessment program in Korea

Our next step is to establish a national bioassessment monitoring network (> 1000 sites in 5 major river watersheds) for throughout the country. The plan is supposed to be launched in the early 2007. A tentative bioassessment program was named as, “Korea River Monitoring Network for the Evaluation of Ecosystem Health,” and summarized as Table 2.

In Korea, the concept of bioassessment was just formalized in the regulation of water quality management. It provided us with a comprehensive perception of how we deal with water quality, why ecosystem health is important, why we expand the meaning of the pollution and risk, and how we attain the sustainable water resources (Karr, 1995). Because we are at the beginning stage in the development and implementation of biocriteria program, there are still many things to be completed in the program, such as the establishment of bioassessment monitoring network, development of numerical biocriteria, implantation of biocriteria into the broad range of water resource management program. Related with the biocriteria program, the government is trying to integrate an ecological concept into the ecosystem restoration in the amend of the related regulations. Bioassessment is not only the most basic but also an essential process to provide the goal to restore disturbed ecosystems.
Table 2. A tentative biomonitoring program in Korea.

<table>
<thead>
<tr>
<th>Code name</th>
<th>Name of the program</th>
<th>Parameters of assessment</th>
<th>Survey interval</th>
<th>Survey frequency</th>
<th>Geographical coverage</th>
<th>Reporting</th>
</tr>
</thead>
<tbody>
<tr>
<td>KR-Ref</td>
<td>Bioassessment of reference streams</td>
<td>-Chemical water quality -Habitat -Benthic diatoms -Macroinvertebrates -Fish</td>
<td>Every year</td>
<td>Two times (spring, fall)</td>
<td>Started with 50 streams: increasing step by step</td>
<td>-Report -DB</td>
</tr>
<tr>
<td>KR-RH</td>
<td>Bioassessment of streams</td>
<td>-Chemical water quality -Habitat -Benthic diatoms -Macroinvertebrates -Fish</td>
<td>Every year</td>
<td>Two times (spring, fall)</td>
<td>&gt; 1,000 sites: need to be fixed</td>
<td>-Report -DB -Mapping</td>
</tr>
<tr>
<td>KR-R1</td>
<td></td>
<td></td>
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<tr>
<td>KR-R2</td>
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<td>KR-R3</td>
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</tr>
</tbody>
</table>

Note; KR: Korea, Ref: Reference stream, R: River, H: Habitat

References
Development of Biomarker in Surface Water Quality Monitoring  
by Using Culture Fishery  
(Case Study: Saguling Reservoir, West Java, Indonesia)

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Abstract
Saguling reservoir is one of reservoir that located in West Java Province in Indonesia. Originally this reservoir was plan for single purpose to generate the electricity and received water from Citarum River. Water quality in this reservoir is depends on the water quality of Citarum River which have face significant change because of the increased of land use along Citarum River basin and ineffective effluent and stream standard. Parameter that tends to increased is heavy metal especially mercury from industries and agriculture discharge. The studies conduct in Saguling culture fishery using two dominant species of fish Oreochromis niloticus and Cyprianus carpio as biomarker. Mercury concentration in fish was analyzing based on Standard Nasional Indonesia (SNI) 06-264-1991. High concentration of mercury found in Oreochromis niloticus (16.8470 ppb wetweight ) and 12.8943 ppb wetweight for Cyprianus carpio. These results are still below the permissible limit but still high compare to control samples. These sampling point was located in the same area and received water discharge from agriculture and domestic area which have contribution of mercury discharge. Biomarker by culture fisheries can be used as monitoring method to maintain the water quality in Saguling reservoir.

Keywords: Biomarker, Mercury, Saguling, Reservoir, Oreochromis niloticus, Cyprianus carpio

1. Introduction
Saguling reservoir is an artificial lake that located at 6:50 S, 107:25E, 643 m above sea level or 40 km from Bandung City. The surrounding area of Saguling reservoir was hilly, while the river that goes to reservoir has many tributaries. This condition makes the Saguling reservoir different with other reservoir in West Java such as Jatiluhur and Cirata Reservoir. Population that lived surrounding reservoir is dense and predominately by farmer population with extensive agricultural lands. The catchments area of the reservoir or the upper Citarum river faced high population pressure especially from farmer population.

This reservoir also received water from Citarum river basin with 7 sub river basins which are the water quantity and quality depend on the quality of Citarum river Basin. Upper Citarum river receives discharge water from domestic and industrial activities resulting water quality degradation such as the increasing of heavy metals concentration. The rapid change of land
used in Citarum River also effected the quality of Saguling reservoir water. Wangsaatmaja (2004) state that land used for urban area has increased for 49% and 35% for industrial area. Originally this reservoir was planned for single purpose dam to generate the electricity but along the year it re-planned to multi purposes dam such as fisheries, agriculture, tourism and their multiple effects. On the other hand, the people also used for domestic purposes like washing and bathing. Poor management of Saguling reservoir made the water quality became worse.

Water quality monitoring is common methods to maintain Citarum river water and Saguling reservoir water quality by using chemical and physical parameter. Stream and effluent standard were use as an instrument in monitoring river water quality. According to Citarum river water quality monitoring in 2001 only 1.4% of total 146 sampling location fulfill the requirements river water quality standard in Government of West Java Province Decree No.39/2000 (Wangsaatmaja, 2001). These facts demonstrate that monitoring methods by using only chemical and physical parameters was ineffective to monitoring and maintain the reservoir.

Fisheries using cage (net) culture was rapidly increased through the year and it was supported by fishing activities-tourism in the reservoir. There were 5,000 fisheries using cage (net) culture were recorded, this number was still below the limit according to Government of West Java Province Decree No.41/2002 that only 12,000 fisheries (Kompas Newspaper, July 2004). There are two dominant species of fish that were found in fisheries at Saguling reservoir, the first one is *Oreochromis niloticus* (“Ikan Nila”) and *Cyprianus carpio* (“Ikan Mas”). Most of the fresh water fish for West Java consumption was supply by Saguling and Cirata reservoir fisheries (Oktaviatun, 2004). *Oreochromis niloticus* and *Cyprianus carpio* can be used as biomarker as the availability of the fish in Saguling reservoir.

2. Material and Methods

Sampling points selected among fisheries which cultivated *Oreochromis niloticus* and *Cyprianus caprio* with age 3-4 month ($\pm$ 250gr) or ready to harvest. Two samples of fish was taken each fish cage culture and put in the cooler box. In the laboratory, fish was fillet and cut into small pieces, after that the sample was destructed using nitric acid (HNO$_3$) pa and analyzed with Atomic Absorption Spectrophotometry (AAS) specific Hg-analyzer. This method is referred to SNI 06-2464-1991 (Indonesian National Standard) and USEPA 1991-d. The results was calculated and presented in ppb$_{\text{wet weight}}$. Samples of water were also taken during sampling to measured pH and mercury concentration. To compare mercury concentration in fish, samples from control location (unpolluted) area also measured.

Location of sampling points was pointed by GPS (Global Positioning Satellite) and plotted into map of Saguling reservoir and control location. Observation and interviewed was done during sampling especially to find out the data of fish such as fish seed, fish feed and condition surrounding cage culture.

Correlation between mercury levels in fish and water, field condition surrounding the fisheries and potential source of mercury was analysis. The results could be used for an indicator of environment degradation which can be develop the monitoring system in Saguling reservoir and a recommendation for integrated water quality management in Saguling reservoir.
3. Results and Discussion

Location of sampling was shown in Figure 1, point 1,3,4,6,7,9,10,11,12,13 for both fish and water sampling while point 2,5,8, and 14 only for water sampling because fisheries in this point was not available. On the other hand, control point was selected in Subang district, the north of Bandung City. These fisheries received water from upper Cipanagara and Ciasem rivers which was land used dominated by forest and the activities of domestic and agricultural were still low.

![Figure 1. Location of sampling in Saguling reservoir](image)

Concentration of mercury in Oreochromis niloticus and Cyprianus carpio for each sampling point was described in the Table 1. Average concentration for both species was similar although the minimum concentrations for Oreochromis niloticus lower than concentration in Cyprianus carpio. This concentration still below the permissible level for consumption according to FAO Fisheries Circular No.765/825 which is range between 0.1-1 mg/Kg wetweight. Highest concentration of mercury in Cyprianus carpio found in point 6 which value 16.8470 ppb wet weight and for Oreochromis niloticus was found in point 4. These results relatively higher compare to control samples which have average concentration 3.51 ppb wet weight for Cyprianus carpio and 3.62 ppb wet weight for Oreochromis niloticus.

Mercury concentration in water was described in Table 2 which have range between <0.06 – 0.18 ppb and still in permissible limit according to Government Decree No.82/2001 which is 1 ppb for mercury. High concentration were found in point 2, 3, 4 (12 ppb) and 7 (18 ppb) while mercury concentration in control location was <0.06 ppb.
Table 1. Concentration of Mercury in *Oreochromis niloticus* and *Cyprianus carpio* at October 2004

<table>
<thead>
<tr>
<th>Location</th>
<th>Fish (ppb&lt;sub&gt;wet weight&lt;/sub&gt;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Point</td>
<td><em>Cyprianus carpio</em></td>
</tr>
<tr>
<td>1</td>
<td>2.3459</td>
</tr>
<tr>
<td>3</td>
<td>1.1833</td>
</tr>
<tr>
<td>4</td>
<td>3.1478</td>
</tr>
<tr>
<td>6</td>
<td>16.8470</td>
</tr>
<tr>
<td>7</td>
<td>4.4677</td>
</tr>
<tr>
<td>9</td>
<td>na</td>
</tr>
<tr>
<td>10</td>
<td>na</td>
</tr>
<tr>
<td>12</td>
<td>3.5431</td>
</tr>
<tr>
<td>13</td>
<td>na</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td>5.2558</td>
</tr>
<tr>
<td><strong>Maximum</strong></td>
<td>16.8470</td>
</tr>
<tr>
<td><strong>Minimum</strong></td>
<td>1.1833</td>
</tr>
</tbody>
</table>

Table 2. Concentration of Mercury in water each sampling points at October 2004

<table>
<thead>
<tr>
<th>Location</th>
<th>Concentration (ppb)</th>
<th>Location</th>
<th>Concentration (ppb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>&lt;0.06</td>
<td>8</td>
<td>&lt;0.06</td>
</tr>
<tr>
<td>2</td>
<td>0.12</td>
<td>9</td>
<td>0.06</td>
</tr>
<tr>
<td>3</td>
<td>0.12</td>
<td>10</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>4</td>
<td>0.18</td>
<td>11</td>
<td>&lt;0.06</td>
</tr>
<tr>
<td>5</td>
<td>0.06</td>
<td>12</td>
<td>&lt;0.07</td>
</tr>
<tr>
<td>6</td>
<td>0.06</td>
<td>13</td>
<td>0.06</td>
</tr>
<tr>
<td>7</td>
<td>0.12</td>
<td>14</td>
<td>0.06</td>
</tr>
</tbody>
</table>

Saguling map describe that point 4, 6, and 7 was located in the same area which is positioned near the river tributaries and received water discharge from agriculture and domestic activities. According to observation these locations were surrounding by agriculture and domestic area. Mercury can be found in organic form such as phenyl mercury (C<sub>6</sub>H<sub>5</sub>-Hg), methyl mercury (CH<sub>3</sub>-Hg) and alkoxyalkyl mercury or methoxy-ethyl mercury (CH<sub>3</sub>O-CH<sub>2</sub>-CH<sub>2</sub>-Hg<sup>+</sup>). One of mercury source is mercury in organic form which is came from uncontrolled dosage pesticides for agricultural activities (Budiono, 2003). Hadisantosa (2006) also state that Citarum river basin were predominantly used for agricultural activities and using pesticides. On the other hand, these areas also very dense by people who live near the fisheries using floating house. They are doing their daily activities like washing, bathing even they have small chicken husbandry above the cage culture (Figure 2).

The used of soap for washing from the domestic activities influenced the pH which has range 7.3- 8.9. Mercury has characteristic low solubility in the water and depends on the pH of water. The solubility will be higher if the pH low (acid) and the contrary will les soluble in pH high (Lloyd, 1992). According to the sampling pH relative neutral or above pH 7, this condition made the mercury will less soluble in water. The others parameters that measured during the sampling was temperature which has range 27-29°C and Conductivity Level with range 252-685 μmhos/cm.
Mercury concentration in fish food was also analyzed and the results have range between 1-1.5 ppb wetweight. From interview, there were four types of food that were used for almost fisheries. Three of them were produced by factory and the other food was made by the people who take care the fisheries (usually they are not the owner of fisheries) which made by cassava and vegetables. This food may also contribute for the mercury concentration in fish. Mercury uptake can be through both bioaccumulation and biomagnifications process (Soemirat, 2003 and www.ehu.es/europeanclass2003).

Even though mercury concentration in fish still below the permissible limit, but higher compare to control point. In February 2003, mercury concentration in Saguling reservoir reach 0.06 mg/L according to Saguling reservoir management (Oktaviatun, 2004). Although the mercury concentration in water fluctuated, the concentration tends to increased along the year. The change of land used along Ciratum river basin become industries and domestic area influenced mercury concentration in Citarum river and Saguling reservoir. Painting and paper industries have contribution to mercury discharge. The other study also mentions that there are several gold plating industries that using mercury for their process. These gold plating industries is illegal and the activities is not regularly. (Hadisantosa, 2006).

According to the results, common water quality monitoring using chemical and physical parameter still ineffective to monitoring and maintains Citarum river and Saguling reservoir. Biomarker using culture fishery in Saguling reservoir as monitoring system could be used as monitoring methods especially for heavy metal parameters which have characteristic bioconcentration, bioaccumulation and biomagnification. Better management in Saguling reservoir should develop to reach better condition such as people prohibited lived near fisheries using floating house, limitation of fisheries number, and controlling tourism activities. If mercury concentration in water increase rapidly and concentration in fish above the permissible limit, fish from Saguling reservoir must not be consumes but only for monitoring purpose.

Monitoring of water quality in Citarum river and Saguling should be integrated by good cooperation between government, industry, stakeholders and community such as tight implementation of stream and effluent standard, monitoring using culture fish as biomarker, measuring, controlling heavy metal concentration in fish feed for Department of Fisheries.
recommendation and controlling pesticides dosage for Department of Agriculture recommendation.

4. Conclusion
Mercury level in *Oreochromis niloticus* and *Cyprianus carpio* still in permissible limit with concentration maximum 16.8470 ppb$_{wetweight}$ for *Oreochromis niloticus* and 12.8943 ppb$_{wetweight}$ for *Cyprianus carpio* but still higher compare to control samples

Mercury concentration in point 6 and 4 were high, these location received water discharge from river tributaries which is the land used predominantly by agriculture and domestic area.

Saguling water quality influenced by Citarum River quality which effected by industries discharge from paper and painting industries, illegal gold planting industries, uncontrolled pesticides used, and domestic waste.

Biomarker using culture fish in Saguling reservoir as monitoring system could be used as one of monitoring methods for heavy metal parameters especially for mercury which have characteristic bioaccumulation and biomagnification.

5. References
FAO Fisheries Circular No.765/825
Oktaviatun. (2004), Uptake dan depurasi timbal pada ikan nila (*Oreochromis niloticus*) (Lead Uptake and Depuration in *Oreochromis niloticus*). Final Project. Bandung : Institut Teknologi Bandung
(www.ehu.es/europeanclass2003/biological_aspects_of_metal_accu.htm)
Challenges for Implementation of Rain Water Harvesting Project in Arsenic Affected Areas of Bangladesh

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1. Background
Recently Bangladesh is facing severe crisis in supply of safe drinking water due to increasing trend of arsenic contamination in the underground water in different parts of the country. As a result of accelerated installation of shallow handpump tubewells over the past decades, as means of cheaper and convenient "safe" water supply, most people of the country has become heavily dependent on groundwater. Replacing these handpump tubewells, despite severe arsenic contamination, with other options of similar benefits and convenience has become a challenging task for all concerned. The immediate challenge therefore, is to assess various technological options in terms of their technical feasibility, economic viability, social acceptability and environmental sustainability. Rainwater harvesting system, which has been widely used in many parts of the world, possesses a great potential in addressing today's real challenge of acute arsenic poisoning in different parts of the country. It is an option, which has been adopted in many areas of the world where conventional water supply systems are not available or have failed to meet the needs and expectations of the people (Alam, 2006). The rainwater is free from arsenic contamination and the physical, chemical and bacteriological characteristics of harvested rainwater represent a suitable and acceptable means of potable water.

People can construct storage reservoirs so that they can use rainwater during the entire rainy season and about 2-4 months of the dry period. The capacity and the construction materials of the reservoir and its maintenance depend on the socio-economic condition, population, educational background and awareness of the habitants of the area. This study put special emphasis on the construction and maintenance issue of the RWHS and also on the harvested water quality in Charghat and Bagha Upazilas of Rajshahi district.

2. Objectives of the Study
• To assess of the technical requirements and feasibility for efficient rainwater harvesting (e.g., evaluation of cost-effectiveness of tanks of various sizes considering the socio-economic condition of the people of the study area).
• To document of good experience and learning from the study and disseminate those among the sector agencies including the community people.
• To monitor and document construction and performance of the RWHS in terms of users acceptance and user friendliness, water quality, water security and general system management.

3. Study Area
The study area is located in the arsenic affected villages at Bagha and Charghat Upazilas in Rajshahi district in the western part of the country. The average annual rainfall of the project area
is around 1400 mm and the highest rainfall occurs in the month of July, which is around 3000 mm. The villages had been selected considering the concentration of tube-wells contaminated with arsenic and availability of suitable safe water options. A total of 3,290 families were living in the 13 villages namely Miapur, Anupampur, Arazi Sadipur, Chandpur, Talbaria, Kaluhati, Batikamari, Fakirpara, Jotnasti, Kishorpur- Beelpara, Monigram, Habashpur and Bajubagha. The average family size ranged from 4.31 to 5.2. Agriculture is the main occupation of the villagers. About 61.29% of the villagers were related to agriculture and most of the people did not have strong educational background. Most of the villagers live below poverty line and some are hardcore poor living in extreme poverty conditions. In few villages like Kaluhati among 776 people 458 (59.2%) were living always in financial deficit.

4. Methodology of the Evaluation Study
Technical evaluation of the RWHS was done through analysis of design considerations, field observation, and case studies and through interviewing people of Charghat and Bagha Upazila of Rajshahi district on various technical and social aspects of rainwater harvesting as implemented during the study period. Interview was taken of 140 families (caretakers) for evaluating technical aspects of RWHS through base line studies. A few randomly selected water samples were also tested in the laboratory for ascertaining quality of the stored rainwater. Apart from interviewing the caretakers, literature including manuals, progress reports, monitoring reports, mid-term evaluation reports were consulted.

5. Data Collection and Analysis

5.1 Water Supply and Demand
In rain water-harvesting calculation of supply and demand of water is very important. Storage is the difference between actual supply of fresh water and the demand. Different methods can be used to calculate water demand and supply from rainwater. One method is shown below:

Supply:
Average catchment area for rainwater harvesting=20m² (approximately)
Run-off coefficient = 0.8 (assuming for ideal CI roof catchment)
Average yearly rainfall = 1400 mm
Average yearly water supply from rainfall = 20 m² *0.8*1.4 m =22.4 m³

Demand:
Consumption per capita per day, C = 7.5 liters
Number of people per household, n = 6
Monthly water demand = 7.5*6*30 = 1350 liters = 1.35 m³
Yearly demand = 1.35*12 =16.2 m³
Storage volume required for a nuclear family = 22.4-16.2=6.2 m³
Field observation suggests that the average rainwater demand is actually less than 7.5 L/ person/day in most of the families as rainwater is used only for drinking and cooking purposes. Run-off coefficient values vary between 0.3 and 0.9 depending on the material of the catchment area. It takes into consideration losses due to percolation, evaporation, etc.


5.2 Rainwater Storage Reservoir

It was observed from the study that a total 268 RWHS were constructed which were of different capacities ranging from 300 liters, 500 litters, 1.0 m³, 2.0 m³, 2.5 m³, 3.2 m³ and of different materials such as RCC ring, brick, Ferro-cement, plastic tank, Earthen Motka etc. The different types of tanks were FC tiles tank, FC Jar, RCC ring, Brick tank, Chari tank, Plastic motka and plastic tank.

Brick tank of capacity 2500 liter and cost 5000 Tk were in use in large number (Fig.1) among the same capacity’s other tanks because of its reasonable cost, durability and better performance. FC jar, RCC ring and brick tanks of 1000 liter were used at a less frequency (Fig. 2).

A survey had been made among 140 families through interview. It had been observed that FC jar, Brick tank, Earthen motka and plastic tank were being used by 35, 39, 37 and 2 families respectively (Fig.4). It is because of the low cost, availability of the reservoir materials as well as the reservoir capacity and durability of the reservoirs. Another observation was made from the survey that Earthen motka which was widely used (Fig.3) was preferred by mainly the people of low income group (such as agri-labor and day labor), whose monthly income was less than 1500 Tk generally.
The FC tiles tanks of capacity 3200 liter, RCC ring tanks of capacity 2000 liter and plastic tanks have limited use probably because of their relatively higher cost against capacity and for the need of high catchment area. The use of Chari tank was also very negligible for its low performance.

5.3 Quality of Harvested Rainwater

The concentration of As and Fe were monitored in the tubewell and pumps of the villages (data for 12 villages are available). A relationship between As and Fe can be introduced (Fig.5). It had been observed that in almost all cases (with few exceptions) with the increase of the percentage of As contaminated underground water sources the percentage of the Fe contaminated water sources increases.

![Figure 5. Relationship between As and Fe affected underground water sources.](image)

In this study about 1340 water samples of TC and FC were tested. Regarding the test result of TC, out of total samples 894 were bacteria free and 446 were contaminated. On the subject of FC, out of total tested samples 1083 were bacteria free and 254 were contaminated. This could be attributed to some operation and maintenance problems, such as not cleaning the roof catchment and the inlet gutter before rain events, not opening the screw cap to divert the first flush water, and not washing the empty storage tank with bleaching powder. 2419 water samples were tested for pH. pH of 335 samples were found within the acceptable limit (6.5-8.5). About 1035 water samples concerning turbidity was tested and only 50 samples were found unacceptable (greater than 5 NTU). It may be occurred due to the improper collection of water from the catchment i.e. harvesting of rainwater without flushing the first foul water for 10 to 15 minutes. Testing 5 random water samples collected by NGO Forum, it was found that Pb and Zn were within acceptable limit. Iron and Fluoride concentration were below detectable range of measurement, i.e., < 0.05 mg/L (NGO forum, 2000-2003).

6. Operation & Maintenance

It was found that the average cost of O&M in Rainwater harvesting is very negligible, nearly 20 Tk/year. Lack of education and awareness of the caretakers were the major reasons of poor operation and maintenance of the RWHSs. The study had been made among 140 families having different types of reservoirs.

<table>
<thead>
<tr>
<th>Type of reservoir</th>
<th>Good</th>
<th>Medium</th>
<th>Bad</th>
<th>Total no. of reservoir</th>
</tr>
</thead>
<tbody>
<tr>
<td>FC jar</td>
<td>12</td>
<td>14</td>
<td>9</td>
<td>35</td>
</tr>
<tr>
<td>FC tank</td>
<td>5</td>
<td>9</td>
<td>6</td>
<td>20</td>
</tr>
<tr>
<td>Brick tank</td>
<td>23</td>
<td>8</td>
<td>8</td>
<td>39</td>
</tr>
<tr>
<td>RCC ring</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>7</td>
</tr>
<tr>
<td>Earthen motka</td>
<td>6</td>
<td>21</td>
<td>10</td>
<td>37</td>
</tr>
<tr>
<td>Plastic tank</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Table1: Types of caretakers considering quality of O&M of different types of reservoirs
The number of good caretakers of Earthen motka is relatively less (Table 1) because it is mainly used by the people of low income group who have almost no educational background.

7. Conclusion
The action research study clearly identifies rainwater harvesting as a potentially safe, reliable and affordable alternative source of water supply for drinking and cooking for at least 8-10 months of the year. RWHS can be widely used because different types of reservoirs are available and people of different income level can afford it according to their income level. Other important conclusions drawn from evaluations of the research are as follows:

• The supply of rainwater, given the CI roof catchment area available, is much higher than the household demand for drinking and cooking.
• The rainwater can be stored in tanks, jars or pots of different sizes and materials of varying costs to match individual household's need and affordability. Brick tank and Earthen motka are widely used because of its performance and low initial cost and suitable capacity for nuclear family.

References
Adoption and Impact of Zero Tillage technology for Wheat in Rice-Wheat System. Water and Cost saving technology. A case study from Pakistan (Punjab).

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Abstract

One of the major cropping systems of South Asia is rice-wheat grown on 13.5 million hectares on the Indo-Gangetic Plains (IGP). It has a pivotal role in the food security and livelihoods of millions of farmers and workers. Continuously, need is being felt to explore the possibilities of saving critical inputs by adopting alternative resources conservative technologies as zero tillage. Main aim of this paper was to see factors affecting the adoption and impact of zero tillage technology in rice wheat system. Economic analysis of the data presented in this paper shows that zero tillage method for wheat cultivation is the most economical and attractive option for farming community. The high yield grain and less cost of production per hectare was noted on zero tillage farms as compared with conventional farms. In this paper, analytical technique was employed for the adoption of zero tillage technology in Pakistan (Punjab). A binary Logit model was also estimated based on the available data set, with the probability of an adoption of zero tillage technology as a dependent variable and set of other variables as the explanatory variables. It was found that with the increase in farm size per hectare the probability of adoption of zero tillage technology increases. While with the high NPK nutrients cost per hectares and with more tubewell irrigation time required to irrigate one hectare of land the probability of adoption of zero tillage technology reduces. Finally, the adoption of zero tillage technology improves farmer’s profit and eventually contributes in reducing poverty. However, the long-term impacts of this technology on food production, natural resources (land and water) and linkages with poverty alleviation should be further explored.

Key words: Cost saving, Zero tillage, Binary Logit model, Economics

Introduction

The Indo-Gangetic Plains of Pakistan, India, Nepal and Bangladesh are endowed with plentiful natural resources, deep productive soil, sufficient good quality water, climatic conditions that permit multiple-cropping, high population density and relatively good infrastructure. The Green Revolution technologies, beginning 1970s, have remained the cornerstone of South Asian strategy for food security, nutrition, rural development, and poverty alleviation. Slowed growth of productivity in agriculture, and negative impacts of intensive agriculture on environmental quality, suggested for infusion of a complimentary set of new agricultural technologies to boost productivity growth.

In South Asia, the rice-wheat cropping system is found on 13.5 million hectares and is one of the most important cropping patterns for food security in the region. While another 10.0
million hectares are found in China, mostly in the central areas of the Yangtze River Valley. The area of rice-wheat systems in India, Pakistan, Bangladesh and Nepal is 10.0, 2.2, 0.8, and 0.5 million respectively. Rice-Wheat systems represent 32 percent of total rice area and 42 percent on the wheat area in these countries. (Ladha et al., 2000).

In Pakistan, under rice-wheat cropping system, farmers grow rice in Kharif season followed by Wheat in Rabi season. The total area under rice in Pakistan is about 2.2 million ha, out of which 62 percent of rice area is in Punjab alone. Out of total rice area in the country, 50 percent is under fine rice varieties. Punjab, the largest rice-growing province in the country, occupies 78 percent of area under fine varieties. Farmers prefer to grow fine rice in spite of low productivity and longer time period due to its high gross margins. Punjab province grows about 96 percent of total production. (Khan 2002).

The area reported under zero tillage has increased from 50 acres in 1996-97 to 72168 acres in 2000-2001 in Punjab alone. (Bhambhro 2001). There is an increase in the yield with zero-tillage technology over the conventional tillage and the savings made through less fuel consumption and machinery use (Grey et al. 1996). Economically zero tillage is superior over conventional method of sowing because more net returns were recorded on zero tillage farms than that of conventional wheat farms (Nagarajan et al 2002). The main objective of current paper is to see which factors are mostly affecting the adoption of zero tillage technology in rice-wheat system of Pakistan’s Punjab and also to compare and evaluate the cost and crop yield per ha of wheat crops by using conventional and zero tillage technologies.

Materials and Methods

The study was conducted in the Rice-Wheat area of Sheikhupura and Hafizabad districts of Punjab, Pakistan. Three distributaries were selected namely Ghour Dour, Gujjiana and Karak Gill Sub-Minor. Gujjiana and Ghour Dhour distributaries off-take from Upper Gugera Canal of Lower Chenab Canal system (LCC) and come under the Chuharkana irrigation sub-division in district Sheikhupura whereas Karak Gill sub-minor falls in the Gujranwala irrigation sub-division in district Hafizabad.

Total costs, gross margins, crop yield and Benefit-cost analysis were calculated both for zero tillage and conventional methods of sowing. Water use efficiency and fertilizer use efficiency for both zero tillage technology and conventional method of sowing was also calculated.


Results and discussions

Economics

The results as depicted in Table 1a and Table 1b, are quite convincing as far as economic superiority of zero tillage is concerned over conventional method. The yield recorded was significantly higher than conventional method (3409.98 kg/ha as compared to 3122.64 kg/ha). Total cost were Rs.10217/ha in the zero tillage, significantly lower than that of Rs. 12321/ha in traditional /conventional planting system. Gross margins
were Rs. 17146/ha in the zero tillage technology, significantly higher than that of Rs. 13794/ha in conventional method of sowing. Benefit-cost analysis calculated shows that zero tillage method was economically the most feasible (B/C= 1.68) and attractive option as compared to conventional (B/C=1.12) for farming community. Of the bread-up of total cost of production in rupees per hectare, farmers were investing significantly less on land preparation and on irrigation cost per hectare, which is major source of reduced working cost in zero tillage as compared to conventional sowing of wheat.

Table 1(a) Benefit cost analysis of wheat with various techniques.

<table>
<thead>
<tr>
<th>Techniques</th>
<th>Traditional Mean</th>
<th>Zero Tillage Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield in kg per hectare</td>
<td>3122.64</td>
<td>3409.98</td>
</tr>
<tr>
<td>Total cost of production in Rs. Per hectare</td>
<td>12321.17</td>
<td>10216.6</td>
</tr>
<tr>
<td>Gross Margins in Rs. per hectare</td>
<td>13794.02</td>
<td>17145.65</td>
</tr>
<tr>
<td>Benefit cost ratio</td>
<td>1.12</td>
<td>1.68</td>
</tr>
</tbody>
</table>

Table 1(b) Break-up of Total cost of production (Rs/ha)

<table>
<thead>
<tr>
<th>Techniques</th>
<th>Traditional Mean</th>
<th>Zero Tillage Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seed Cost (Rs/ha)</td>
<td>948.64</td>
<td>986.25</td>
</tr>
<tr>
<td>Cost of Ploughings (Rs/ha)</td>
<td>2093.25</td>
<td>756.74</td>
</tr>
<tr>
<td>Cost of Irrigation water (Rs/ha)</td>
<td>1057.37</td>
<td>753.7</td>
</tr>
<tr>
<td>Fertilizer Cost (Rs/ha)</td>
<td>3685.78</td>
<td>4471.09</td>
</tr>
<tr>
<td>Chemical cost (Rs/ha)</td>
<td>389.03</td>
<td>516.44</td>
</tr>
<tr>
<td>Harvesting cost (Rs/ha)</td>
<td>2413.59</td>
<td>2315.04</td>
</tr>
<tr>
<td>Threshing cost (Rs/ha)</td>
<td>1733.51</td>
<td>1174.1</td>
</tr>
</tbody>
</table>

Most importantly water use efficiency kg/m$^3$ for both methods were also recorded. Table 2 shows that water use efficiency obtained on zero tillage farms was much higher as compared to conventional farms. Volume of water for zero tillage was 1828.8 m$^3$/ha significantly lower than that of 2256.9 m$^3$/ha in conventional method. Water use efficiency kg/m$^3$ was noted high 2.29 kg/m$^3$ in zero tillage, which was significantly higher than that of 1.51 kg/m$^3$ in case of traditional/conventional method of sowing.

Table 2 Effect of sowing techniques on water-use efficiency for wheat production.

<table>
<thead>
<tr>
<th>Techniques</th>
<th>Traditional Mean</th>
<th>Zero Tillage Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield in kg per hectare</td>
<td>3122.64</td>
<td>3409.98</td>
</tr>
<tr>
<td>Volume of Water (m$^3$/ha)</td>
<td>2256.97</td>
<td>1828.8</td>
</tr>
<tr>
<td>Water productivity (kg/m$^3$)</td>
<td>1.51</td>
<td>2.29</td>
</tr>
</tbody>
</table>

NPK levels on zero tillage farms and conventional farms are shown in table 3. The efficiency of fertilizer at zero tillage farms was greater because of the facts that these allow uniform distribution of fertilizer, which induce the farmers to use their fewer quantities. In case of zero
tillage, fertilizer is placed close to seed. Fertilizer use efficiency was noted high as compared to conventional method. Higher fertilizer-use efficiency showed that this zero tillage technology is more conducive to optimal use of fertilizer. These results also in lined with the results of Choudhary et al 2000.

Table 3 Effect of sowing techniques on fertilizer-use efficiency for wheat production.

<table>
<thead>
<tr>
<th>Techniques</th>
<th>Traditional Mean</th>
<th>Zero Tillage Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield in kg per hectare</td>
<td>3122.64</td>
<td>3409.98</td>
</tr>
<tr>
<td>NPK kg/ha</td>
<td>171.20</td>
<td>209.40</td>
</tr>
<tr>
<td>Fertilizer use efficiency</td>
<td>18.29</td>
<td>16.28</td>
</tr>
</tbody>
</table>

The results of the logit model are shown in Table 4. All the coefficients of explanatory variables except experience of farmers in years were found significant at 99, 95 and 90 percent of significant level. The results shows that with an increase in land holding of one hectare the probability of adoption of zero tillage technology increases by 0.001. The results are according to the priory expectation because with the increase in landholding, farmers have better choices to experiment with new technologies as compared to resource poor farmers. Similarly according to the perceived benefits of this new technology it should have decreased water consumption in order to be adopted on wider scale. The results support this perception and show that the probability of zero tillage adoption decreases (-0.009) with the increase in irrigation timing (hours/ha) especially tube well irrigation because tube well irrigation has maximum contribution for fulfilling the crop water requirements in the study area. Farmers adopt those technologies, which they perceive as cost effective. Such relationship is depicted by the results of the logit model with respect to cost of fertilizers i.e. the marginal probability (-0.004) of adoption of zero tillage technology decreases with the increase in the cost of fertilizer per hectare. The relationship between cost of chemicals and adoption of zero tillage although is significant but its marginal effect is negligible. Similarly, with increase in number of years of agricultural experience marginal probability of adoption for zero tillage decreases by the coefficient–0.001. The major reason behind this result is that old people are still of the view that indigenous ways of cultivation are superior than the new ones and are following the famous proverb “more you till the soil more would be the crop production”. Dummies for owner-cum-tenant and tenant were included and it was found that if a farmers is owner-cum-tenant or tenant instead of owner, the marginal probabilities of adoption for zero tillage technologies are 0.051 and .025 respectively. Similarly if a farm household is located in the command area of Kakargill and Gujiana distributaries instead of being located in the command area of Ghourdour distributary, the marginal probability of adoption for zero tillage technology is 0.045 and 0.052 respectively. Increased marginal probabilities can be attributed for favorable environment regarding the awareness about the new technology and flexibility and easiness of availability of zero tillage drill in the command areas of the first two distributaries.
Table 4. Regression Results of Logit model

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coeff.</th>
<th>Std.Err.</th>
<th>P-value</th>
<th>Marginal Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>8.882</td>
<td>10.476</td>
<td>0.397</td>
<td>0.031</td>
</tr>
<tr>
<td>Farm size in ha</td>
<td>0.268</td>
<td>0.109</td>
<td>0.014***</td>
<td>-0.001</td>
</tr>
<tr>
<td>Tubewell irrigation time of one ha (hours/ha)</td>
<td>-2.532</td>
<td>1.239</td>
<td>0.041**</td>
<td>-0.009</td>
</tr>
<tr>
<td>Cost of NPK nutrients in Rs/ha</td>
<td>-1.152</td>
<td>0.555</td>
<td>0.038**</td>
<td>-0.004</td>
</tr>
<tr>
<td>Cost of chemicals in Rs/ha</td>
<td>0.013</td>
<td>0.006</td>
<td>0.042**</td>
<td>0.000</td>
</tr>
<tr>
<td>Quantity of FYM (trolleys/ha)</td>
<td>-7.703</td>
<td>4.865</td>
<td>0.113</td>
<td>-0.027</td>
</tr>
<tr>
<td>Abiana charges in Rs/ha</td>
<td>0.071</td>
<td>0.042</td>
<td>0.086*</td>
<td>0.000</td>
</tr>
<tr>
<td>Experience of farmer in years</td>
<td>-0.146</td>
<td>0.100</td>
<td>0.147</td>
<td>-0.001</td>
</tr>
<tr>
<td>Dummy for owner-cum-tenant</td>
<td>14.567</td>
<td>7.343</td>
<td>0.047**</td>
<td>0.051</td>
</tr>
<tr>
<td>Dummy for tenant</td>
<td>7.136</td>
<td>4.054</td>
<td>0.078**</td>
<td>0.025</td>
</tr>
<tr>
<td>Dummy for Kakargill distributary</td>
<td>13.052</td>
<td>6.881</td>
<td>0.058**</td>
<td>0.045</td>
</tr>
<tr>
<td>Dummy for Gujiana distributary</td>
<td>15.023</td>
<td>7.254</td>
<td>0.038**</td>
<td>0.052</td>
</tr>
</tbody>
</table>

Chi square = 55.227  
-2 Log likelihood = 16.876  
Cox and snell R square = .634  
Negelkerke R square = .867  
Df = 11

* Significant at 90 percent confidence level  
** Significant at 95 percent confidence level  
*** Significant at 99 percent confidence level

Conclusions and recommendations

Zero tillage technology contributes in increasing wheat yield and also helps in reducing cost of production. The results show a convincing as far as economic superiority of zero tillage over conventional method of sowing. Zero tillage technology is very conducive in increasing the crop production and net income, its popularity would increase day by day among the farming community and area under such technologies is expected to enhance widely in Pakistan. The suitable policies are needed in order to further facilitate promotion of zero tillage technology by encouraging private sector-public sector cooperation and educating farmers about the use of this technology. The long-term impacts of this technology on food production, natural resources (land and water) and linkages with poverty alleviation should be further explored. The participatory research at farmers’ field could play pivotal role in technology improvements and dissemination.

References


Abstract

Authors are proposing the “Sensor ASIA” to promote sensor network for obtaining real-time high-density environmental data using Sensor Network and GIS technology in Asia. To obtain sensor data at real time from everywhere at low cost is quite important for environmental management, agriculture, disaster management, industries, securities and to support our daily life.

Sensor technology and network technologies, especially mobile network, have been showing its great advancement these days. These technologies make it possible to obtain high-density environmental data both in terms of spatial and temporal. Field Server is a good example of combination of sensor and network. Further, linking the data to GIS is important for searching, visualization, archiving, analysis, and further data exchange.

OpenGIS® SWE (Sensor Web Enablement) specifications will provide standard interface between client and sensor data in GIS. It can even give Web presence to each sensors. SWE-enabled sensors would be discoverable, controllable, and accessible through Web.

We are developing SSG (Sensor Service GRID), basically based on OpenGIS® SWE, to provide, besides standard sensor service, many more high level web-services for end-users, such as sensor plug&play and securities. We envision that off the shelf sensors should be able to be set without highly skilled sensor/network engineers. We would like to promote sensor networks in Asia using SSG and Field Server. We have named this initiative as “Sensor ASIA”.

Introduction

Network technologies, probably represented by internet and mobile phone, have been expanding all of the world. Internet or Mobile phone network is available even country side of developing countries. Connectivity to the Internet has drastically improved. WiFi network can be detected everywhere in the city. Based on these network or internet technologies, so called ubiquitous network environment is being realized so that we can enjoy the advantage of the network everywhere without understanding the technology itself.

The price of sensor is getting inexpensive and smaller in size. Imaging sensors, CO₂ sensors, soil moisture sensors and others, which were expensive before, have been reducing their prices drastically. Some of them can be purchased at only one tenth of the price a decade ago. Even small mobile phone can have GPS and G-sensors.
By combining the network and sensor, we can form sensor networks to obtain real time high-density environmental data. One good example is the Field Server (Fig. 1) developed by NARC (National Agriculture Research Center, Japan). It has several sensors and mesh-network capabilities. Data can be browsed directly as itself is a web-server. The Field Server is currently manufactured by E-LabExperience, in Japan under the license from NARC. HAII (Hydro and Agro Informatics Institute, Thailand) is also producing local version of the Field Server and expanded more than 300 hundreds of the unit over Thailand.

**OpenGIS® Sensor Web Enablement initiative and a deployment example**

Sensor observations can be tagged with related information such as time of observation and location of sensor. The latter tag qualifies sensor observations as GIS data, which is defined as consisting of spatial information. Thus Open Geospatial Consortium - a standards organization that is leading the development of standards for geospatial and location based services - started Sensor Web Enablement Initiative to develop standards to enable the discovery, exchange, processing of sensor observations, as well as tasking sensor systems. Reader should refer to OpenGIS Sensor Web Enablement architecture document and related specifications to get details of following overview.

SWE focuses on:
- Discovery of sensor systems, observations, and observation processes
- Determine sensors' capabilities and quality of observations
- Access sensor parameters that allows software to process sensor observations
- Retrieve observations in standardized encoding
- Tasking sensors
- Subscription to published alert from sensor services

through the establishment of standard encodings for sensor description and sensor observations, and standard web services that actually use these encodings:

- Observation and Measurement (O&M) Schema for encoding sensor observations
- Sensor Model Language (SensorML) for encoding sensor description
- Sensor Observation Service (SOS) for querying sensor observations and sensor description
- Sensor Planning Service (SPS) for planning sensor observations
- Sensor Alert Service (SAS) for publishing and Subscribing to sensor alerts
- Web Notification Service (WNS) for asynchronous messaging between different Sensor Services
SWE provides foundation for operating Web-based sensor networks. Fig. 2 shows a field server which collects environmental data in paddy field and publishes it through SOS. Sensors such as thermocouple, soil moisture sensors, and net radiation sensors are connected to data acquisition devices that communicate with a host computer through local ports such as COM or USB. Observation feeder is a module that is responsible for tagging observations with time and location of sensors, then populate them into an authorized observation database of a sensor services node in public network site. Observation feeder can be deployed at field server side as well as at Sensor services node side. Deploying observation feeder in field server side as the above figure has the benefit that the field server does not need fixed global IP address which is often in the case in mobile Internet connections such as GPRS. For both fixed and mobile sensors, sensor location and observation time are vital sensor parameters. And as mentioned above these parameters qualifies sensors observations as spatial data sets. Sensor observations and descriptions are then exposed to Internet users in form of XML documents that complies with O&M and SensorML schemas respectively. User software can parse and interpret these XML data automatically, thus enabling automated web-based discovery and processing of sensors and their observations without a priori knowledge of the sensor system.

SSG - Sensor Service GRID

However, the important functionalities for application and nominal end-users are sensor plug&play and security. If off-the-shelf sensors can immediately start and send data to archiving system, it will reduce burden for every users. The archived data should be published immediately just by a single click of “Publish”. The data communication should be well secured. No one will be able to listen the data, modify the data or switch the sensor to different one without authorization.

We are currently developing a system to realize these functionalities using SOS as a core technology of sensor observation.
publishing. We have demonstrated a prototype of SSG in January 2007 in Putra University, Malaysia (Fig.3, 4) Several important functionality of SSG are

- Sensor Plu&Play (automatic download of SensorML document)
- Security
- Adaptability for various network environment such as public/private IP, mobile phone, satellite network
- Interface to Google Earth
- Interface to MetBroker [2]

**Sensor ASIA**

Sensor ASIA is an initiative to promote sensor networks in Asia for real-time high density environmental data based on Field Server and SSG. To obtain the data is definitely important for environment management, disaster, agriculture especially food security, and science. The information through Sensor Asia can be combined to food security system. Open information chain from the site of the food production to the end-user is quite important for food security. The idea of the sensor Asia was presented in the 23rd APAN meeting in Manila in January 2007 [3]. Researchers from various countries in Asia-Pacific in the conference have agreed to cooperate and participate to the initiative.

Authors have recently setup a sensor system for a draught research project (by Thai Research Fund, Thammasart University, AIT) in Trakan, Ubonratchani, Thailand (Fig.5). The data is being sent to AIT server real-time every 30 seconds through internet satellite (IP STAR). The data will be served through SOS. Also, the authors are involved in setting up a Field Server node in Khon Kaen, Thailand. The system in the rice field is powered by solar panel. The data is being sent to a primary school nearby then sent to a server in Japan through internet satellite (Fig.6)
Conclusion

Obtaining Real-time high-density environmental data is technically feasible. Expansion of the sensor network through Sensor Asia will contribute to promote various sectors. For example, it is important for developing countries to utilize the sensor data and implement information management system, especially when they try to export their food products. Sensor Asia is aiming at providing inexpensive platform for sensor network and information system.

Acknowledgement

Authors acknowledge Dr. Amnat KHOWANIT, Thai Research Fund, Prof. Takaharu KAMEOKA, Mie University, Prof. Seishi NINOMIYA, Prof. Masayuki HIFRAFUJI, NARO, Dr. Masaru MIZOGUCHI, University of Tokyo for their generous support.

Reference

Preliminary Study on Pollutant Discharge from Domestic Wastewater and Pollutant Load in the River: A Comparative Study between Japan, Thailand and Bangladesh

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Abstract
Flooding control and water pollution abatement have been major problems in the surface water in the Asian countries including Thailand and Bangladesh. We have conducted field surveys and secondary data collection to clarify the relationships between domestic wastewater discharge and pollutant load in the river from October to December in 2006. This paper reports summary data which will be a part of basic data sets for the estimation of pollutant discharge per capita (PDC) and pollutant load per capita flowing into the water body (PLCwb). For the estimation of the pollutant load in the river, river flow fluctuation derived from the tidal level fluctuation was important to be considered in regards to both water quantity and quality, because the river bed in these areas are rather flat.

1. Introduction
In the context of the Millennium development goals (MDGs), decreasing the population without access to safe drinking water and appropriate domestic wastewater treatment facilities was determined as very urgent tasks of the world community. In regards to the efficiency of domestic investment and overseas development assistance (ODA), it is important to consider and discuss on the efforts of stakeholders in the developed countries such as Japan including national and local governments, private companies, citizens, fisheries and researchers. Tsuzuki (e.g. 2006b) proposed pollutant loads per capita flowing into the water body (PLCwb) as an appropriate indicator of the domestic wastewater contribution to the water pollution in the targeted water body.
We have conducted secondary data collection and field survey in regards to pollutant discharge with domestic wastewater and pollutant load in the rivers, lakes and canals in urban and peri-urban area of Bangkok, Thailand, and Dhaka, Bangladesh in October, November and December, 2006. The purpose of this paper is to present a part of the summary of the secondary data and the field survey results, in order to make comparison of the situations of domestic wastewater treatment between Japan, Thailand and Bangladesh. A conceptual proposal for preparation of the comprehensive basin based domestic wastewater strategies with centralized and decentralized domestic wastewater treatment system will be presented in the future opportunity based on these results. A part of this paper was presented in the International symposium on the ‘Restoration and Sustainability of Estuaries and Coastal Lagoons’ in January, 2007, Matsue, Japan.

2. Methods
Secondary information/data collection from documents, papers and web-sites and field surveys were conducted in regards to water quantity and quality in urban and peri-urban area of Dhaka, Bangladesh (Fig. 1), and Bankok, Thailand (Fig. 2). The Sitalakhya River flows west of
Narayanganj District, Bangladesh, and flowing into the Dhaleshuari River, which flows into the Megha River at Bandar. The Narayanganj District is one of the highest population density district in Bangladesh with more than 2,000 person km$^{-2}$ (Alam ed., 2005). The Chao Phraya River and the Tha Chin River flow in the central area of Thailand. Pak Kret District (Amphoe) (area: 89.0 km$^2$, population: 201,399 person in 2004, population density: 2,296.6 person km$^{-2}$) was located at northeast of Notanburi Province (Wikipedia, 2006). Pak Kret Municipality was located in Pak Kret District as one of the twelve communities (Tambon). Total pollutant discharge and PDC in the Pak Kret Municipality was estimated from Sinsupan (2004).

From October to December, 2006, field surveys were conducted in the Sitalakhya River and lakes in Dhaka City, namely, Dhanmondi, Banani and Gulshan Lakes, Bangladesh, and in the Chao Phraya and the Tha Chin Rivers and the Tamru Canal, Thailand. Water quality was measured with a water quality data logger, Compact-CTD (Alec Electronics, Japan), and water quality monitoring kits, Pack Test (Kyoritsu, Japan), and laboratory measurements. Parameters measured with the Compact-CTD were water depth, water temperature, salinity, electricity, EC25 (electricity calibrated at water temperature of 25 ºC), density, sigma-T, chlorophyll-a and turbidity. Parameters measured with the Pack Test were COD$_{Mn}$ and PO$_4$-P.

3. Results and Discussion

Figure 3 shows the water quality measurement results with the Pack Test in the Sitalakhya River and the three lakes, which effectively showed the water quality characteristics in the river and lakes, water quality deterioration near the river side community in the sampling points S2, S3 and S4, and natural purification or dilution in the sampling point S5 were observed. The Dhanmondi Lakes (D1, D2) was in the residential area and used for recreation of the people, however, Banani (B1, B2) and Gulshan Lakes (G1, G2) were in the office and commercial area. The relatively lower concentration of the Dhanmondi Lakes might reflect these characteristics of the lakes. The measurement results with the Compact-CTD in the Sitalakhya River showed vertical homogeneity of the water quality measured in this study (Figure 4).

The Pack Test water quality measurement results showed the characteristics of water quality in the rivers and canals in Thailand also. The simple water quality measurement was considered to be effective methods especially in the field of community participation. Development of more cost-effective water quality measurement methods might be desirable for these developing countries.
Table 1. Pollutant discharge from the Pak Kret Municipality estimated based on the secondary data.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Pollutant discharge kg day⁻¹</th>
<th>PDC kg person⁻¹ day⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOD</td>
<td>11,935</td>
<td>49.2</td>
</tr>
<tr>
<td>TN</td>
<td>3,791</td>
<td>15.6</td>
</tr>
<tr>
<td>TP</td>
<td>1,530</td>
<td>6.30</td>
</tr>
</tbody>
</table>

Source: calculated by the authors based on Sinsupan (2004).

Total pollutant discharge and PDC of the Pak Kret Municipality was estimated as shown in Table 1 based on the MFA results (Sinsupan, 2004). Pollutant load in the Chao Phraya River was estimated with the field survey results of water quality and the flow rate in the secondary data (Table 2). Pollutant load differences between the corresponding monitoring points for Pak Kret Municipality were estimated as 60 – 120 times of the pollutant discharge for BOD and nitrogen. Pollutant discharge and pollutant load estimation should be further investigated. These results would be base data for the calculation of PLCwb in the region. The estimated PDC and PLCwb in the Pak Kret Municipality would be compared to PDC and PLCwb in Japan (Figure 5).
Pollutant discharge has been investigated in Thailand especially with MFA methods (e.g., Sinsupan, 2004). The river water quality including basic parameters including carbon, nitrogen, phosphorus, bacterial pollution, and heavy metals have been monitored periodically by the Pollution Control Department (PCD) (PCD, 2006a). Water pollution control program by the Thai government has been consisted of 1) wastewater treatment and disposal, 2) waste minimization, 3) cleaner production, 4) legal framework, 5) institutional and financial management, 6) monitoring and enforcement, 7) cooperation with related agencies and local communities, and 8) river basin management approach (Simachaya, 2000). Integral water resource management (IWRM) has been studied in Thailand (Lekphet et al., 2004). Environmental education program has been conducted in the drainage area of the Tha Chin River (Thongnopphakun, 2006). Information dissemination has been conducted by PCD by the web-site (PCD, 2006b). The results of this research would assist the environmental education and dissemination in regards to water environment in Thailand.

### Table 2. Pollutant load in the Chao Phraya River calculated with the field survey results and the secondary data of flow rate.

<table>
<thead>
<tr>
<th>Distance from the river mouth</th>
<th>Flow rate</th>
<th>TOC</th>
<th>TN</th>
<th>CODcal</th>
<th>BODcal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>km</td>
<td>m³ s⁻¹</td>
<td>t day⁻¹</td>
<td>t day⁻¹</td>
<td>t day⁻¹</td>
</tr>
<tr>
<td>Wat Potongbon</td>
<td>58</td>
<td>1,082</td>
<td>581</td>
<td>117</td>
<td>1,500</td>
</tr>
<tr>
<td>Wat Tumnuktai</td>
<td>67</td>
<td>955</td>
<td>523</td>
<td>97</td>
<td>1,300</td>
</tr>
<tr>
<td>Pibulsongkram Bridge</td>
<td>80</td>
<td>784</td>
<td>388</td>
<td>78</td>
<td>970</td>
</tr>
</tbody>
</table>

a: Lohani et al. (1980); b: CODcal=2.5*TOC; c: BODcal=0.061*CODcal

**4. Conclusion**

Simple water quality measurement with the Pack Test effectively demonstrated the water quality in the rivers, lakes and canals in Bangladesh and Thailand. Integrated river basin management (IRBM) has been widely advocated among the researchers and governments, and material flux analysis (MFA) has also been studied. The results of this research would assist the water environment improvement in the countries.

**Acknowledgement**

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Pollution Control Department (PCD), Thailand (2006a) Thailand state of the pollution report 2004.
Towards a Sustainable Systems Approach in Governing Water Environment in the Philippines

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Abstract

This paper presents a critical state-of-the-art review of the policy agenda cum theoretical model of governing water environment in the Philippines. Systems approaches on water governance model propose that transparency, accountability and participation of stakeholders or their improvement among water institutions be further strengthened and enhanced to ensure the stability of water governance and policy in the country. There is a need for a transfer of power from national to local water authorities and certainly necessitates the creation of an enabling legal and policy environment that would enhance and support local initiatives, as well as a continuing research agenda on water governance for sustainability.

1. Introduction

The Philippines, although known to have relatively abundant water resources is presently confronted with disturbing sustainable development crisis in the water sector. Ensuring the long term availability of adequate supplies of clean water at a reasonable price is one of the greatest challenges the nation needs to address. Rapid population growth, economic development, urbanization, and industrialization have taken its toll on the water resources of the country resulting in an increased competition for water supply, irrigation, and hydropower. Furthermore, increasing water pollution, degradation of the watersheds, and the inadequate government support to the water sector programs has aggravated the situation. Hence, there is a need for the implementation an integrated, coherent and sustainable integrated water resources management program. Water governance is a central issue to these concepts and entails complex issues and factors. There is a clear need to analyze the impacts of different types of governance of national and regional water resources in a global context (Craswell, 2005). Apart from concerns over energy and oil resources, scientists revealed a global shortage of water would curtail the world's ability to raise food by 2025. A system approach integrates voluminous database, complex issues, and analytical modeling methods such as artificial intelligence, decision analysis, optimization, modeling, etc. to support decision making (Aldeman, 1991). Walker & Zhu (2000) listed four reasons that would justify the development of system approaches decision support system for rural planning and resource management, such as: 1) increase of available information; 2) increase of complex decision making; 3) professionalization of resource management systems; and 4) increase of requirements to demonstrate “due process”. However, such system approaches had been applied mostly on agricultural land use planning options, crop suitability using GIS, crop modeling, and natural resources management (Lansigan, et al., 2000) and being considered just lately in higher education and policy researches.
2. Water Environment Situation
The Philippines is an archipelago consisting of more than 7000 islands and covering a total area of 300,000 km$^2$. The average annual rainfall is estimated at 2373 mm/year. There are 421 rivers in the country. There are also 59 natural lakes and more than 100,000 ha of freshwater swamps. The groundwater resources are estimated at 180 km$^3$. The total internal water resources would therefore amount to 479 km$^3$/year. A survey of surface water storage potential has identified sites for 438 major dams and 423 smaller dams. The total water withdrawal was estimated on the basis of the water rights issued by the National Water Resources Board (NWRB) to 55,422 million m$^3$ in 1995, of which 88% is for agricultural purposes. The water situation in the Philippines may be best described as an abundant scarcity. There is so much water, but it is scarce for most Filipinos. Moreover, scarcity has become so widespread that it seems happening most everywhere in the country. Irrigation service areas have dropped nationwide due to urbanization and drought (Malayang, 2003).

3. Policy Agenda for Water Governance
Outputs of the policy forum on water resource management in May 2002, revealed three major themes. This include: (1) there is an alarming water crises; (2) the water crisis, which is caused by a conjuncture of natural and anthropogenic events and rooted on destructive land-use practices, is aggravated by a flawed governance system characterized by a soft state (wherein laws are formulated in imprecise terms); and (3) while there is a need to strengthen national laws in order to address the water crisis, the need to empower local government units (LGUs) and communities is clearly recognized (PIDS, 2002). Major key problems in water governance were: (a) the failure to implement the laws and the presence of corruption—the problem of a soft state; and (b) the absence of mechanisms to operationalize an ecosystems approach and a market-based valuation technique in water resource governance. At present, the following laws provide the legal framework for water governance in the country: the 1987 Constitution which mandates that all water resources belong to the State; Presidential Decree (PD) 1067 in 1976 or The Water Code of the Philippines; Republic Act (RA) 8041 in 1995 or The Water Crisis Act; and the Executive Order (EO) 364 in 1996, which created the Presidential Task Force on Water Resources Development and Management. In this regard, it may be argued that it is necessary to establish a science-based governance mechanism and support the institutionalization and statutory recognition in any form of both a watershed approach and a market-based valuation system in water resource governance. However, legislating for a watershed or market-based approach will only be effective if it is supported by capacity-building programs inasmuch as the issues involved here are of technical rather than of legal nature. Water management inevitably involves a two-tiered system of governance-national and local. The central government still holds significant powers in water resources management. In some instances, other sectors such as non-governmental organizations (NGOs) also influence water policy and management schemes. However, failure in water governance is eminent due to: (1) failure to implement the laws – ‘soft state’ of governance system; (2) the absence of institutional mechanisms to operationalize integrated watershed approach; (3) the lack of appreciation of water as an economic good; and (4) the lack of mechanisms that will integrate water and watershed plans and programs of various agencies (PIDS, 2002). And, just lately, the Clean Water Act was enacted in 2004, with Implementing Rules and Regulations issued in May 2005. Provisions of the Clean Water Act will soon open commercial opportunities among various stakeholders.
4. A Conceptual Model of Water Governance

Water governance is viewed broadly as the collection of social controls on human conduct relating to water (Malayang, 2003). The controls constitute the deliberate intentions of a body politic to shape the state and conditions of water resources and its availability and services to humans and to other beings. They are articulated by the decisions and actions of water institutions which are either formal like state agencies or LGUs or non-formal regulatory arrangements like customs and tradition. In this view, water governance encompasses the set of purposive human decisions to bring about actions that are intended to maintain, or alter (if they are unacceptable, e.g., if polluted), the physical and social components of water resources. These are the decisions and actions that determine how water resources are able to produce energy, information and materials for acceptable human ends.

The model (Fig. 1) as expounded by Malayang (2003) is constructed from the following observations on how decisions and actions on water environment are made in the Philippines:

1. There is a multiplicity of institutions – organizations and regulations – governing water and its uses in the country; (Malayang, 1999; Magallona & Malayang, 2001 as cited by Malayang, 2003);
2. The authority and jurisdiction of water institutions differ in terms of a hierarchy of their coverage. Some are national while others are regional (or sub-national) and local. Others are global which have acquired legal authority in the Philippines through treaty ratification; they, too, affect water decisions and actions in the country;
3. The mandates of the institutions differ. Some are statutory (prescribed by law, and others are customary (or are creations of tradition or of local social arrangements, e.g., irrigation associations); and
4. Water institutions differ as well in terms of the societal sectors that they occupy; i.e., some are state agencies, while others are community or civil society groups (i.e., non-state organizations like irrigation associations, farmers’ associations, consumer groups, NGOs and peoples’ organizations (POs), private business groups (PBGs) and research and academic institutions (RAIs). Some of the latter might have legal personality ascribed to it by the state such as farmers’ associations given water rights under agriculture and fishery, or NGOs and POs given official capacities in the national planning process like through the Philippine Council for Sustainable Development (PCSD). Thus, the decisions and actions on water resources in the Philippines are in fact a product of the interplay of multiple institutions operating in different hierarchies of authority, and in different societal sectors of decision-making and action taking. It is multi-level and multi-sectoral. And because the concerns on water may cover a number of issues over its uses and features, it is multi-thematic as well (i.e., it covers a range of technical, social, economic, and political concerns on water). The three – hierarchy, sectors, and themes – define a “governance space” where water decisions or actions occur, or which can be located at any given time (Fig. 1).
5. Concluding Remarks

Transparency, accountability, and participation are the keys to strengthening water governance in the Philippines (PIDS 2002). The water governance model suggests that water policy, management, and governance in the Philippines will likely become more effective and efficient if they were to be the product of multi-sectoral participation in shaping the decisions and actions on a wide array of water concerns. Participation is to be anchored on public transparency and accountability to engender higher levels of legitimacy, public trust and credibility of water institutions, and thus of water governance itself. Those who own and manage water definitely have power over those who are deprived of this resource. But if governments fail to redistribute wealth and power by protecting local communities and vital water resources from the invasion of greedy corporations, who can the people rely upon but them. Stronger democratic movements at different levels that will demand and successfully obtain greater accountability from both governments and private corporations are therefore needed. And at the end of the day, when so many people are dying from lack of access to safe drinking water and sanitation, the struggle for water has to be transformed into a struggle for a fundamental human right and for being an economic good. Paradigm shift of research agenda is needed on water resource indicators, quality, productivity, as well as blue, green water and environmental flows; virtual water and associated nutrient flows, risk assessment on the water systems discourse to integrate natural science and social science into system approaches for a sustainable science on water environment (Craswell, 2005).
References


Watershed Management and Implementation of Total Pollution Load Management System (TPLMS) for Water in Korea

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Abstract
Korea launched new national water quality improvement initiatives implementing watershed management and total pollution load management system (TPLMS). This paper summarizes these changes of water pollution management policy in Korea and implementation of TPLMS with discussion of the difficulties encountered in implementation. These Korean experiences can provide benchmarking references for the other Asian countries.

1. Water Pollution Management Policy in Korea
Water management policy in Korea mainly focused on the water resource development to support the increased water demands until 1980s. Management focus was shifted to water quality control and major investments were made to construct public owned treatment facilities since late 1980s. However, improvements of water qualities particularly in major reservoirs were not so satisfactory because of the limitation of end-of-pipe approaches, difficulties in pollution source control, resident’s resistance on tighter regulations, and upstream- downstream conflicts on environmental regulations.

Korean government launched new national water quality improvement initiatives so called ‘Comprehensive Water Management Measures for the Four Major River Basins (hereafter Comprehensive Water Management Plan, CWMP)’ to effectively deal with such problems. Implementation of the CWMP is legally supported by the 'Acts Relating to Water Resources Management and Community Support for the Four Major River Basins (hereafter, 'Special Acts'). New watershed-based management schemes those have been introduced and evolved in the establishment and implementation processes of the CWMP are briefly summarized in following table.
Table 1. The Changes of Water Quality Management Schemes

<table>
<thead>
<tr>
<th>Conventional Policy By Water Quality Preservation Act</th>
<th>Watershed-based Policy By Special Acts</th>
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<tbody>
<tr>
<td>Special Measure Zone</td>
<td>Riparian Buffer Zone</td>
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<tr>
<td>Water Quality Criteria &amp; Effluent Standard</td>
<td>Land Purchase System</td>
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<tr>
<td>Emission Charge</td>
<td>Total Pollution Load Management System</td>
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<td>Support for Water Source Protection Area</td>
<td>Water Use Charge, TPL Excess Charge</td>
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<td>Financial Supports for Water Source Area</td>
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<td></td>
<td>Support for Civilian Water Quality Monitoring Activities</td>
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<td></td>
<td>River Basin Management Committee</td>
</tr>
</tbody>
</table>

2. Establishment of Watershed Management System in Korea

In the course of reforming the government's water quality policy for the five years, Korean government was challenged by severe resistance by the community people, self-governing bodies and civilian groups in the upper and downstream regions. As a result, the government established its planned watershed management system, following a number of difficult processes, such as convincing the residents of its need for such a system through more than 420 public hearings, explanatory meetings and panels.

The process of taking the special measures for four major rivers, which commenced in 1998, is significant in terms of the history of Korean environmental policy. Such measures are not just an administrative program by which some projects are developed and thereby investment is made as set forth by related laws, but involves a task to establish the "watershed management system" based on thorough analysis of its previous measures for water quality management. That is, the special measures for four major rivers are related to a reform program reflecting the conception of the nation's 21st century water management policy, as well as a blueprint for passing the Special Act on four major rivers.

Specially, in the course of establishing such measures, the government daringly abandoned its previous bureaucratically administrative practices which have been controlled by the central government, and had heart-to-heart discussions and debates with the residents in watershed regions. Based on the agreements with such community people, the government successfully established the watershed management system for four major rivers. This is deemed to be a victory achieved as a result of its hard efforts made for the five years (1998–2002) in order to accomplish its objective, the ‘transformation into a watershed management system’. The following is the key contents adopted in taking the special measures for four major rivers.
• The measures are based on the discussions and agreements between the residents in the upper and downstream regions. The residents in the upper stream regions are not allowed to develop water or land resources unlimitedly without considering the situation of the residents in the downstream regions, whereas the residents in the downstream regions should not require overly heavy restrictions be placed upon the upper stream regions because of their own environmental needs. The primary principle was that reaching a compromise should be based on the agreements between the parties involved.

• By grafting the 'user pay principle' on the measures, the government introduced the water-use charge system. This enabled the residents in each watershed region to secure their own funds required for watershed management, helping resolve the equity problem occurring between the restricted zones and the non-restricted zones.

• Introduced the buffer zone system and the total pollution load management system which become an effective measures for watershed management. This ensured a systematic basis for undertaking scientific and reasonable watershed management measures.

• Founded the ‘basin management committee’ as a decision-making body, and the ‘watershed environment office’ as an executive body for watershed management. This ensured effectiveness in the government's policy-making process and the strength of its executive system.

• The measures four major rivers created a community culture built based on enhanced community participation in debates, discussions and agreements with the government from the beginning stage - an underlying element of watershed management. That is, such measures helped form a frame for the ‘co-prosperity of upper and down stream regions’ through such reasonable debates, discussions and agreements between the members of each watershed - self-governing bodies, community people and civilian groups.

3. Implementation of Total Pollution Load Management System (TPLMS)

Total Pollution Load Management System (TPLMS) has been introduced for efficient regional environmental management coping with the limitations of present water quality management policies. TPLMS for Water involves determining the target water quality standard for each block of the water systems, computing the maximum allowable load, and regulating or controlling the amount of pollutants discharged from the region within the maximum permissible load. This system is expected to help achieve a balance of preservation and development of a region by permitting regional development necessary solely within the extent in which the target level of water quality is attainable. It is just introduced and in the stage of implementation in four main watersheds in Korea.

Korea's total pollution load management system discriminates Han River basin from the other three river basins. In the case of the Han River basin, regional governments may implement the TPLM voluntary bases, whereas for the other three river basins (Nakdong River, Geum River and Yeongsan River) should a regional government fail to meet its target water quality level, the implementation of TPLM is compulsory.
4. Difficulties Encountered and Settlement of TPLM in Korea

4.1 Institutional Issues

_Lack of incentive under voluntary implementation scheme_. In case of Han River basin, TPLM implemented with voluntary scheme confronting residents’ objection due to overlapped regulations such as Source Water Protection Zone, Special Management Region and Natural Environmental Preservation Area. Although voluntary scheme is the ideal policy in case of...
successful implementation, it can encounter the implementation barriers as follow. The incentive system for inducing voluntary TPLM is not enough to induce TPLM directly. Therefore, the Ministry of Environment (ME) motivated local government with indirect pressure such as restriction on sewage treatment facility permission, EIA and so on. Local governments tend to be forced to implement voluntary TPLM.

Also, as local governments, city and municipal authorities, take charge of implementation plan of TPLM, it can be hard to consider comprehensive measure to improve water quality of whole watershed area. For instance, if a municipality located in upper stream doesn’t plan TPLM implementation, TPLM implementation plan of the down stream municipality might not be effective. In order to effective implementation of TPLM, it needs comprehensive plan reflecting on whole watershed areas.

The aim and approach to TPLM of local government differ from that of ME. Local governments intend to implement TPLM for developing their area more within legal basis, on the other hand ME pursue comprehensive watershed management for actual water quality improvement. Therefore, there are conflicts of interest in setting of target water quality for TPLM and it’s implementation between ME and regional government as well as between regions, and these can induce the difficulties in TPLM implementation.

Lack of capacity prevents local government from implementing TPLM actively. Local government officers are likely to delay the implementation of TPLM by temporal impediment of plan or setback of permission. This is not only because they are deficient in experiences also because TPLM is directly connected with their local development. Also, Regional difference in institutional and financial capacity of regional government can result in differences in implementation, and undesirable side effects in some region.

Differences in regional implementation conditions. Differences of environmental management condition in each region including socio-economic factors affect the performance and effect of TPLMS implementation. Uniform implementation of TPLMS disregarding difference in regional pollution reduction cost can result in social cost-inefficiency and regional inequity. Also, there is the lack of data and information for those affecting factors and conditions in each region as well as the behavioral and strategic changes in pollution management of regional polluters under TPLMS. Establishment of systematic approach for efficient pollution reduction in the region (cost-benefit analysis of each reduction methods, establishing optimal mix of pollution management methods, etc) as well as capacity building of local government are required.

4.2 Technical Issues
Besides institutional problems, there are technical issues such as estimating total pollution load, determining target water quality standard and allocating pollution load quotas.

First, TPLM requires accurate information on pollutant source and pollutant load in order to estimate management object, BOD. However, there are short of precise information on pollutant load and source and it can cause uncertainty. It is not easy to build up the confidential data such as water-purifier tanks, underground water and unreported pollution discharge facilities. Most of all estimating non-point source is the hardest part to estimate pollution load. Current measure to
estimate non-point source is deficient in that it does not reflect characteristic of storm water.

Second difficulty is to targeting water quality standards. Lack of frequent monitoring, insufficient number of monitoring points and large change of flow can be the fundamental limitation to determine target water quality standards. Current monitoring information has limitations for using as data for TPLM.

Allocating pollution load quotas is the problem to be solved. Due to lack of institutional scheme, pollution load cannot be allocated into individual pollutant charging facilities. It is allocated only large-scaled pollution charging facilities rather than all of the small and medium sized facilities. Moreover, considering whole watershed, and allocation pollutant load can cause the conflict among local authorities. Even though allocation pollutant load has legal basis based on three Major River Special law including regulation and sanction measures, it is needed to be more realistic in the process of planning TPLM.

5. Implications of Korean Experiences to Asian Countries
Based on Korean experiences, the following can provide the implication to environmental management in order to achieve integrated and effective management of watersheds.

5.1 Effective Problem Solving by Adapting Watershed Management System
Since the watersheds mirror natural water flows, they provide a most reasonable foundation in managing water resources. Up to the present point, the Korean government's programs regarding the improvement of water quality have been focused on point-pollution sources or some particular waters including downstream regions or marshes. Such an approach may turn out to be successful in resolving some particular problems, but it is not effective in resolving the chronic problems which cause deterioration of water quality. The watershed management method can provide more accurate data & information necessary to find many stressors impacting the water resources, and such an information will help make decisions in taking measures necessary to conserve and restore given resources. Thus, the integrated watershed management system will ensure effective resolution of the water resource problem by taking all of such stressors into consideration to achieve reasonable allocation of water resources.

TPLM for water is based on a basin or watershed management system. In many Asian countries a watershed management system is not adopted yet. For effective environmental management, the transition to a watershed management system is necessary. The U.S. and the EU, like many other Asian countries, are characterized by the fact that administrative borders do not coincide with river basins, so considerable attention was paid to shared water resources issues. There is a strong need for integrated and sustainable water resources management to be implemented on the river basin scale, the natural unit of hydrology. These countries have created highly effective and resilient institutions for integrated river basin management.

5.2 Promotion of the Residents' Participation
The watershed management system can enhance the residents' awareness and support effectively. Once individual residents become concerned about their own watershed, they will not only participate in the government's conservation and restoration programs for such a watershed, but also become interested in the government's priorities and decisions regarding important matters.
As such, the watershed management system helps build such a participatory community, reduce complications, and induce the agreements between related parties necessary in taking measures required to accomplish the nation's environmental goals. This will further enhance the potential for the success of the government's environmental programs.

5.3 Active Development of Deregulated Environmental Management Plan
In addition to the conventional EM system, including land restrictions and installation of basic environmental facilities, implementing TPLM should be accompanied by the active development of a deregulated EM plan—such as environmentally friendly living patterns and environmentally friendly management of farmhouses and stables. A special focus should be on the emerging problem of non-point sources of water pollution. All sectors need to focus on minimizing the impact of non-point sources, beginning with the planning stage in developing water quality management programs and including developing training programs, establishing aquatic buffers and better site design, implementing erosion and sediment control projects, and installing BMP (Best Management Practices) facilities to reduce non-point sources.

5.4 Solving possible difficulties of TPLM implementation
As the experience in the United States, Japan, and Korea has shown, implementing TPLM can encounter both institutional and technical challenges. For example, local governments lack incentives to implement TPLM. Since TPLM is directly connected with regional development, some conflicts of interest can arise. In Korea, local governments tended to focus on complying with the legal regulations of implementing TPLM, while the central government pursued comprehensive watershed management for actual water quality improvement. It is important to establish schemes to induce the active participation of local governments. Another institutional challenge is the lack of local government capacity for TPLM implementation. Providing education programs for local government officials and workshops for public awareness can help solve this problem. In terms of technical issues, the lack of precise information on pollutant loads and sources can cause uncertainty. A TPLM committee for watershed management in each watershed can help resolve these conflicts and technical problems.

Capacity building for implementation of TPLMS and reduction of administrative cost are also important. Information provision for cost-effect pollution reduction, support of expertise for selection and implementation of optimal pollution reduction strategies, and provision of regional capacity building program are recommendable.

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http://tmdl.nier.go.kr/
Abstract

Due to the government failures in conserving the environment in the past, the question of whether they could still play important roles in protecting the critical watersheds is a challenge. This paper presents a case study in the Philippines where city government played an important role in developing financing scheme to rehabilitate their denuded watershed through water levy. Its key actors and its roles are identified and described. A sample of a pilot utilization of the proceeds for watershed protection is presented. Lessons learned from the case study gives future perspective for the government to play major role in the watershed protection.

1. Introduction

In the Philippines, the general public is aware of the problems on reduced water availability, severe shortages, or deteriorating water quality and uncertain future water supplies (Bautista, 2005). The watershed degradation poses threat to the country’s economy, affecting livelihoods of the many rural households for their farming and forestry activities.

Watershed functions are considered to be the first environmental service functions that has been recognized for payments due to immediate relevance for the people (van Noordwijk, 2005). It is no doubt that markets for forest watershed services whilst not well documented are now widely used to improve forest management, reforestation and forest protection (Landell-Mills and Porras, 2002). This paper presents the city government initiative thru water ordinance to secure financing the watershed rehabilitation. This focuses the main actors and its roles in the development and financing the rehabilitation activities.

2. Study Site

The Baticulan watershed is located within the boundary of San Carlos City at the northeastern side of Negros Island in the Philippines. It lies between the towns of Palampas and Rizal, covering a total of 428 hectares. Part of the main Mandalagan Watershed, it is one of the six main water sources that supplies for both domestic and agricultural use in and around the city.

Historically, the whole of Negros Island was naturally covered with rainforest, however due to massive logging during the 1950s and 60s, and continuous shifting cultivation, its original natural vegetation coverage has reached below five percent. Currently, the watershed is mostly farmed using shifting cultivation. Ten percent of the whole area is public land while the rest is privately owned. Both past and current land use practices have resulted in serious soil erosion, flooding particularly during the rainy seasons and degradation of agricultural land.
In spite of these conditions, San Carlos City is still a booming city with more than 120,000 inhabitants. Its strategic location in the region makes it an appropriate industrial and infrastructure development zone. Because of its growing population, domestic and industrial water demands are high. Inhabitants are concerned that water supply will be a scarce resource in the future. To meet the economic growth of the city, the City government developed a scheme to rehabilitate the denuded watershed.

3. Water Levy – Government Initiative
The widespread degradation in the upland has urged the City Government of San Carlos to incorporate in the City Ordinance No.37 Series of 2004 “An ordinance regulating the operation of the City Waterworks of the City of San Carlos, Negros Occidental and creating the Watershed Development and Protection Fund, and for other related purposes.” It is a special levy for environmental fee of P 0.75 on every cubic meter of water billed. The proceeds will go to a special account known as the “Watershed Development and Environmental Protection Fund” which supports the implementation of the Master Development Plan (MDP) of the City. The concept of this fund is that inherent with the use of water are the negative externalities incurred in the production and consumption of water. The price of water should include the cost of externalities to address the negative impacts on the environment. It is estimated that the budget allocation per year for the project is approximately 1.2 million pesos. After a year, the ordinance took effect.

Other features of the Ordinance include the provision of drilling or construction of artesian well and deep well for domestic use as well as spring.

4. Key Actors
The actors of a given landscape are the persons who have direct influence to the conditions in a certain landscape (van Noordwijk, 2005). It is really important to identify the key actors for possible replication in sites where similar conditions apply. There were four (4) major actors in the development of water levy till the implementation of rehabilitation and protection activities (Table 1). These actors have their specific roles and functions and success would rely on them.

5. The Implementation
The local water consumers (include the households, local industrial firms, and small-scale farmers) are paying 0.75 pesos per cubic meter of water used. Then, the City waterworks department (CWD) automatically deducts the environmental fee and placed into the special account. Section 3 of the ordinance specify the disbursement of environmental fee that funds accrued in the Watershed Development and Environmental Fund can only be disbursed in conformity with the Implementing Rules and Regulations governing the said funds to be
submitted by the City Waterworks Department and approved by the Sanggunian.

Under the Memorandum of Understanding (MOU) between the City Government of San Carlos and the San Carlos Development Board, Inc (SCDBI), the SCDBI has the responsibility to leverage the said funds for watershed rehabilitation. Among the other obligations of the SCBDI are - to develop a detailed comprehensive plan on identified watersheds within the City; to negotiate with the stakeholders and establish a legal framework that will be mutually beneficial; and to provide a multi-year watershed rehabilitation and conservation plan as well as its responsibility of realization of the plans.

Table 1. Actors and roles or functions in the ES transfer of rewards in Baticulan Watershed.

<table>
<thead>
<tr>
<th>Actors</th>
<th>Roles</th>
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<tbody>
<tr>
<td>Upland communities</td>
<td>- Tenants of the private lands around the Baticulan Watershed; most of them are migrants from neighboring provinces. Cultivating the land through planting root crops and bananas.</td>
</tr>
<tr>
<td>Private land owners</td>
<td>- Own around 90% of the whole watershed. Allow their tenants to oversee and/or cultivate their respective lands. Most of the landowners are living in the downstream of the watersheds.</td>
</tr>
</tbody>
</table>
| City Government or Local Government Units (LGUs) | - Government body whose activities are towards the welfare of the local people and the policy and decision makers in the area.  
- Initiated the policy framework (Ordinance) that will allow financing the watershed rehabilitation through water levy. |
| San Carlos Development Board Inc. (SCDBI) | - A multi-sector-represented non-stock, non-profit, and non-government business organization that was given the task to utilize the special fund for watershed protection activities. |
| Households, domestic water users, private individuals | - Water users who pays environmental fee (0.75 pesos/cubic meter of water bill) for clean / regular water used for hygiene, drinking, domestic activities and recreation. |

The SCBDI currently prepares development plans that establish protection forest, and vegetable and mango orchards on the degraded private lots. Because of the upland people living in the watershed areas, additional activities include community organizing, landuse mapping and zoning. Their target is to have at least 40% reforestation.

The upland farmers in the watershed are the laborers in the watershed rehabilitation activities. For a period of three (3) years, they are hired by the landowner to plant and maintain trees. Depending on the negotiation, the landowner will set a portion of his land to be cultivated by the upland farmer for his own cash crops. Because of this, the SCBDI provides assistance to landowners to prepare an agroforestry management plan, where upland farmers could continues to apply agricultural cropping systems.
Box 2. The Pilot Test

Recently, the SCBDI accomplished the reforestation of the watershed of one lot owner (Figure 1). The lot, which has a total area of 3.81 ha, was divided into 4 management units. Each unit has its own respective development plans depending on the area, slope, soil type and existing structures and vegetation. There are at 3 management types implemented in the said site including protection forest, production forest and belt areas where strips of fruit trees are planted. As of 2005, a total of 7,014 seedlings of indigenous and fast growing species where planted. During the reforestation activity, the upland communities were given the priority to work as laborers.

To better utilize the fund generated from the water levy, through the leadership of the City Government, a Rapid Hydrological Assessment (RHA) training of the local agencies was conducted. It was participated by different stakeholders of the watershed. With this, the stakeholders would better understand the characteristic of their own watershed.

With the City Government and SCBDI, the Genesys Foundation, a local non-government organization in the area, nominated the Baticulan Watershed to be a learning site of the Rewarding Upland Poor for Environmental Services programme (RUPES). In 2005, it was granted and become a learning site for the institutional study on enabling conditions for payment for environmental services (PES).
6. Lessons learned and Challenges:
The following are the lessons learned from the case study presented:

- The initiative shown by the government attracted other players in this case the SCBDI and the Genesys Foundation to come in and do their part. Basically, the government could not do everything alone, but with its initiative especially when the one taking the lead has the mandate to protect the environment then others will take part. The leadership and openness of the government could be seen as political investment for this case.

- The upland people living in the watershed have no rights to the land since they are tenants. This situation could be traced back during the Spanish colonialization in the country. The landlord-tenants relationship is prevalently operating till today. They are poor in terms of human capital such as no political voice and no employment available. Because of this, the role of the government is seen significant.

- Financing schemes to rehabilitate the denuded watersheds like water levy are crafted to address critical threats on the scarce resources. The government used their authority and position to develop new financing not previously availed for conservation.

This financing scheme is now being replicated in some other parts of the country. It is imperative to identify the different actors and its roles for future studies. In this case study, the government initiative has an important role in the development of financing scheme for the rehabilitation of the watershed. This is just one of the approaches on watershed protection and is at an infantile stage. The questions such as “are all the water consumers/users properly consulted and well informed? Is there a monitoring body in place to make sure the funds are wisely used? Is watershed rehabilitation the best solution to address water scarcity?” are yet to be answered.

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Low-Cost Innovative Solutions for Treating Public Market Wastewater in the Philippines: Deploying Hybrid Anaerobic/Aerobic Cocopeat Filtration Systems

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Abstract
Public markets in the Philippines and around Asia pose significant challenges for wastewater treatment due to the relatively high strength of the discharges and variability of flows. The Muntinlupa Public Market, located in Muntinlupa City in the southern part of Metro Manila, is one of the largest public markets in the metropolitan area with 1,448 stalls and 24 hours a day operation. With support from the U.S. Agency for International Development for planning and design, the city constructed a treatment facility which began operating in February 2006. The wastewater treatment system is an innovative combination of anaerobic and aerobic treatment coupled with filtration using cocopeat media to meet local discharge standards. It also includes a water recycling system that will allow re-use of the treated effluent for flushing toilets, watering plants and street cleaning. This technology is being applied elsewhere in the Philippines and is suitable for other locations in the region.

1. Market Wastewater
Wastewater from public markets is generated from distinct sources and activities. These include:

- Meat, poultry, fish preparation and sales
- Fruit and vegetable (produce) sales
- Prepared food stalls
- Public restrooms

When combined into a common outfall, the resulting wastewater mixture typically contains high levels of organic material, suspended solids, fats, oils and grease. It commonly contains two to three times the organic matter and solids typically found in residential wastewater, classifying market sources as “high strength.”

To effectively manage high-strength wastewater, treatment infrastructure must be designed and sized not only to address hydraulic loading in terms of volume (cubic meters per day), but also organic loading, which is expressed in terms of kilograms of BOD (Biochemical Oxygen Demand) per day, and solids loading, which is expressed in terms of Total Suspended Solids (TSS). Additionally, appropriate pre-treatment devices are required to remove fats, oils and grease from prepared food stalls, and the high percentage of solids associated with butchering and produce preparation and sales activities. Such devices typically include septic tanks, grease interceptors, grit chambers and bar screens.
2. Design Considerations

When the Muntinlupa Public Market Wastewater Treatment Facility was designed, the market had 1,448 stalls with approximately 4,800 active vendors and workers and an average of 4,500 daily customers. The average wastewater output was a flow of 210 cubic meters of sewage per day with a BOD of approximately 600 milligrams per liter (mg/L). Suspended solids and fats, oil and grease were also quite high. The discharge outfall flowed to the Alabang River which drains into Laguna Lake, an important fishery and future water supply for Metro Manila. The discharge limit into Laguna Lake was 50 mg/L BOD.

3. Site Specific Challenges

Developing an effective wastewater management strategy for the Muntinlupa Public Market required careful consideration and planning to overcome several site-specific constraints:

- Limited available space for wastewater treatment infrastructure. The identified site for the wastewater system was limited to 160 square meters and was used as a parking lot and delivery area.
- Relative elevation of the outfall in relation to the area designated for treatment
- Unconsolidated and unstable fill material containing garbage in the treatment area along with seasonally saturated soils

Perhaps the most innovative aspect of the Muntinlupa Public Market wastewater system is that the treatment facility is located entirely underneath the area designated for parking and deliveries. The ability to contain the wastewater system underneath the parking lot was the driving factor in selecting the treatment technology. In order to accomplish this, the main reactor tank was designed by a structural engineer to withstand the heavy loads from cars and delivery trucks that utilize the parking area. The resulting tank lid is a slab of concrete and steel 15 centimeters thick.

Developing the sewer system was also a challenge as the relatively low elevation of the outlet required that wastewater be pumped up to the inlet of the treatment system. This required the installation of a pump tank with trash screening and duplexing pumps. While raw wastewater pumping systems are common in sewage treatment, this component added significantly to capital expenditures and operation and maintenance (O&M) costs that were not anticipated during the initial project planning for the system.

Finally, installing the site-built tankage in an area of unconsolidated fill and trash was a challenge in both excavation and worker safety. Pouring concrete for the main tank required that the soils underlying the tank be compacted and stabilized prior to construction. Additionally, these unstable soil conditions resulted in the need for shoring to protect workers during the initial installation activities for the tank.

4. Technology Selection

The Muntinlupa Public Market Wastewater Treatment Facility use a combination of technologies including an anaerobic baffled reactor (ABR), sequencing batch reactor (SBR) and cocopeat filtration system to treat the wastewater to discharge standards. This combination of technologies was chosen for the following reasons:

- ABR technology is an effective and low-cost method of reducing BOD and TSS from high-strength wastewater.
• The ABR tank could be built onsite with a structural top cover designed to support the weight of delivery trucks that frequent the parking area.
• The SBR technology is a proven low-cost method of oxygenating anaerobic effluent to reduce BOD and the odors typically associated with anaerobic treatment.
• Cocopeat is a locally available waste byproduct that has shown potential as a biological filtration medium for wastewater effluent.

Other technologies effective in treating high-strength wastewater were considered for use in this project but were rejected for the following reasons:

1. Sewage lagoons – require a relatively large land area that was not available at this site.
2. Constructed wetlands – also requires a large land area and additional pre-treatment devices.
3. Activated sludge - high installation and O&M costs and could not be effectively installed below the parking area.
4. Trickling Filter – high installation and O&M costs and could not be effectively installed below the parking area.

The table below summarizes the technologies considered, approximate cost, anticipated O&M expenses and land area requirements:

<table>
<thead>
<tr>
<th>Technology</th>
<th>Capital Cost</th>
<th>O&amp;M/Month</th>
<th>Land Requirements</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABR/SBR Hybrid</td>
<td>$140,000</td>
<td>$500</td>
<td>150 sq. meters</td>
<td>Selected</td>
</tr>
<tr>
<td>Lagoon</td>
<td>$80,000</td>
<td>$175</td>
<td>2000 sq. meters</td>
<td>Space constraint</td>
</tr>
<tr>
<td>Constructed Wetlands</td>
<td>$120,000</td>
<td>$175</td>
<td>1500 sq. meters</td>
<td>Space constraint</td>
</tr>
<tr>
<td>Activated Sludge</td>
<td>$200,000</td>
<td>$700</td>
<td>150 sq. meters</td>
<td>Cost and couldn’t keep parking lot</td>
</tr>
<tr>
<td>Trickling Filter</td>
<td>$200,000</td>
<td>$700</td>
<td>150 sq. meters</td>
<td>Cost and couldn’t keep parking lot</td>
</tr>
</tbody>
</table>

5. The Hybrid System: How it Functions
There were several discrete components to the Muntinlupa Public Market wastewater system. They are described below:

Sewer Collection System - Wastewater from the market’s wet section (meat, fish, produce) is collected and screened, then combined with flows from the public toilets and prepared food stalls in a gravity sewer that flows to a pump tank where two alternating pumps (duplexing) are installed. The screenings are placed in covered receptacles and removed as solid waste weekly.

Anaerobic Baffled Reactor – The screened wastewater enters the ABR tank through the inlet structure, which directs the flow to the bottom of the first compartment. Due to the nature of wastewater under anaerobic conditions, a granulated sludge blanket is formed. As the wastewater flows up through the sludge blanket, the solids are trapped in the granulated sludge blanket where anaerobic bacteria consume the organics as food. The result is that a
partially clarified effluent flows up over the baffle to the next compartment where the same action is performed. In each subsequent compartment, the effluent is clarified further until the final compartment in which the anaerobic effluent is relatively free of suspended solids and the BOD level is greatly reduced. Because raw wastewater is delivered to the ABR under pressure, low volume pumps were required so the overflow rate did not exceed the settling rate of the sludge blanket.

Profile and plan views of the Anaerobic Baffled Reactor system

**Sequencing Batch Reactor** – Connected to the ABR is an aeration chamber with coarse bubble diffusers designed to impart dissolved oxygen to the effluent prior to discharge. The SBR is controlled by a process logic controller (PLC) that first aerates, then settles the wastewater under quiescent conditions, and finally discharges the supernatant to the media filtration system. The discharge structure is at a preset level and connected to a lamella clarifier, which is a settling tank with inclined plates to further reduce suspended solids. Due to funding constraints, only one blower is used to deliver atmospheric oxygen under pressure through the network of diffusers placed at the bottom of the aeration tank. Ideally, two blowers would be used and controlled by an alternating control panel equipped with an alarm that indicates if there is a malfunction.

To reduce foul odors, the aeration chamber is equipped with a simple venting system composed of a 4 inch PVC pipe with an exhaust fan, also controlled by the PLC, which extends to the roof level of a nearby building. There is a plan to use an activated carbon vent stack cover should the need for enhanced odor control ever arise.

**Cocopeat Media Filtration** – Cocopeat is a waste product of the coconut producing industry. It is obtained by shredding the coconut shell and removing the coir fibers. The remaining cocopeat is dried and then layered in a lined box with an effluent distribution piping network on top. Effluent is pumped from the aeration chamber through the piping network and distributed to the cocopeat through small holes drilled into the pipe. The pressure system is controlled by a timer that sends intermittent doses of effluent through the pipe. As the effluent flows through the cocopeat media, the downward flow draws atmospheric oxygen into the pore spaces in the media. This naturally aerated media filtration system provides a highly treated and polished effluent suitable for reuse.
**6. Effluent Reuse**

Effluent from the Muntinlupa Public Market is disinfected so that it will be suitable for reuse and recycling for the public toilets, floor washing and dust control. To accomplish disinfection, effluent passes through a chlorination chamber where a liquid chlorine solution is mixed with the treated effluent to impart a chlorine residual to the wastewater. Chlorinated effluent is then pumped to a storage pressure tank where it receives the appropriate chlorine contact time to ensure full disinfection and is available for reuse on a demand basis.

**7. Financing**

The full cost to construct the wastewater system was 6.8 million pesos (approximately US$136,000). During the first year of operations, O&M costs for operations staff, electricity, repair parts and consumables were approximately 27,000 pesos per month ($540). The reuse of the treated effluent resulted in a savings of 15,000 pesos per month ($300) in electricity costs because less water needed to be pumped from underground. This partially offset the O&M costs. To recoup the capital costs of the system, the City has implemented a full cost recovery plan in which stall owners are charged a user fee of 5 pesos ($0.10) per day per stall. This will cover the O&M costs and result in full cost recovery in approximately 3 years. The user fee has been collected since June 2006 and there have been no complaints, presumably because the market is well run and the project has been thoroughly discussed with the market vendor association.

**8. Social Marketing Campaigns**

Awareness of sanitation and wastewater treatment issues is very low throughout the Philippines and must be elevated to build support for pilot projects and willingness to pay required user’s fees. Social marketing uses commercial marketing and advertising techniques to get people’s attention, communicate a set of discreet, easily understood messages and encourage them to take a specific action or change a behavior, such as urging people to have their septic tanks desludged. In Muntinlupa the city and the LINAW team developed a campaign plan with target audiences and messages and then developed a mascot, fliers, posters, newspaper ads and a video...
about the market treatment facility that was aired on a local cable TV station. They launched the campaign at a large shopping mall with an exhibit and event that featured a live mascot and back up dancers who put on a show and then handed out fliers. Meetings were also held with the market vendors’ association to discuss the project with them, answer their questions and get their support. The vendors welcomed the project because they take pride in the numerous awards the market has received, including Most Outstanding Healthy Market in the National Capital Region for 2003-2004 and Huwarang Palengke sa 2004 (best market award).

9. Lessons Learned
Since the commissioning of the treatment system on February 24, 2006, there have been several lessons learned. These include:

1. The constraints with the site at the Muntinlupa Public Market, while considerable, are not atypical of public markets in the Philippines and elsewhere in Asia, especially those located in densely populated city centers. As word of the success of the Muntinlupa project spreads, several other Philippine cities are replicating it for their markets and two resorts have already built similar systems based on the design. Many are experiencing similar constraints including very limited land area, unstable or seasonally saturated soils, and the need for raw wastewater pumping. Considering these factors during the initial stages of project development is advisable.
2. It is possible for local government units to develop wastewater treatment systems using their own resources to meet stringent effluent discharge standards.
3. Full cost recovery of public investments in wastewater treatment infrastructure is an achievable goal when low-cost, low-maintenance systems are used.
4. Public participation. A key factor to the success of the project is believed to be the significant effort in public participation driven by an intensive social marketing campaign. This effort, lead by the LINAW project, included a multimedia outreach effort to increase awareness of wastewater issues and demand for treatment facilities and increase willingness to pay user fees.

10. Conclusion
The Muntinlupa Public Market wastewater project is a functioning model of low-cost, low-maintenance treatment technologies that are combined to provide sustainable wastewater treatment for high-strength flows. Using a combination of public outreach to drive the demand, and full cost recovery mechanisms to pay for the system, this approach brings the technology within the reach of many communities within the Philippines and throughout the region.

Acknowledgements
This work was completed with support from the United States Agency for International Development (USAID) Local Initiatives for Afforable Wastewater Treatment (LINAW) and Environmental Cooperation-Asia (ECO-Asia) projects. Under these projects, USAID encourages use of a low-cost, low-maintenance approach to wastewater treatment by helping its partner cities develop pilot projects that demonstrate appropriate and sustainable technologies. LINAW has been working with Muntinlupa City since 2004 and has provided technical assistance to help design a wastewater treatment facility for its public market and to oversee the construction.
The Sanitation Facilities Improvement Based on Social and Cultural Consideration in Kelurahan Batununggal, Bandung City, Indonesia

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Abstract
The increasing number of population in big cities in Indonesia especially in Bandung City that mostly caused by urbanization has brought a demand to provide many kinds of facilities for their citizen which already influence the increasing land use demand. Unfortunately, the increasing of facilities demand is not supported by land provision and it causes a further land conversion. The impact from land conversion can be viewed from the growth of slum settlements area in several occupancy locations such as in along side of Cikapundung River. Based on data of West Java Environmental Protection Agency in 2003, 141,264 Ha from 183,105 Ha of total area in Kelurahan Batununggal in Cikapundung Area is used for settlement area. The growth of slum settlements area is triggered by poverty and as a consequences from not fulfilled many kinds of basically needs such as the availability of shelter, clean water, health sanitation systems has stimulated people especially poor people to establish buildings alongside of Cikapundung River. Based on that, the growth of slum settlements area has brought a negative impact toward its surrounding environment. Moreover with social and cultural behavior from their community which dispose their wastewater and solid waste directly into Cikapundung River as consequences from a limited of sanitation systems in that area and it causing high water pollution in Cikapundung River. Because of that, in order to improve the water environment and quality of life of the local community, West Java Environmental Protection Agency together with the local community build a Community-Based Sewerage System with Tangki AG.

Keywords: Conversion Land, Slum Settlements Area, Social and Cultural Behavior, Tangki AG

1. Introduction
The number of population in Bandung City has been increasing since 1960 and it is showed from the data which from 986,880 people in 1959 becomes 1,028,245 people in 1960. Nowadays, the increasing number of population is increased about 4,8% per year and mostly caused by urbanization. The impact from urbanization causes the high number of unemployment in Bandung City because most people who do urbanization are not educated and do not have any skills to work. To survive, they work at informal sectors such as being a beggar, labor, street singer, maid etc. Because of the low income, they cannot afford to have and rent a house and to fulfill their basically
needs like a shelter, they establish buildings in many occupancy locations such as alongside river and alongside rain trail which in further becomes a slum settlement area. Since than, the growth of slum settlements area has becomes a main problem in Bandung City.

The slum settlements area is defined as a settlement which has a high density people (more than 500 people per Ha) with lower income and lack of infrastructures such as clean water, health sanitation systems, other social infrastructures such as school, house of worship, clinic etc. Furthermore with that condition has influenced to the environment like an environmental degradation and it is triggered by social and cultural behavior from their resident. The correlation between environmental physic condition and social and culture in Bandung City especially in Cikapundung Area can be viewed from the conceptual frame in Picture 1.

The Increasing of Population Number in Bandung City

The Increasing of Facilities Demand Which Impact to the Increasing of Land Use Demand

Conversion of Land Use

The Growth of Slum settlements Area in Alongside of Cikapundung River With The Social and Cultural Behavior from Local Community Which Still Has Lack of Environmental Awareness

The Increasing of Water Pollution in Cikapundung River

The Effort from Government to Improve Water Quality in Cikapundung River By Using Tangki AG With Involving Local Community Participation in Tangki AG Development Process

The Decreasing of Water Pollution Index in Cikapundung River

Picture 1. Conceptual Frame

2. Social and cultural consideration

One of the other occupancy locations that people used as a settlement area in Bandung City is Cikapundung River as one of Citarum tributary rivers. Cikapundung River has potency and function as a municipal flushing and natural drainage, raw material for drinking water, electrical powerplant and also as tourism object. Cikapundung River with the length is 28 km which 15,50 km of the river passes accross Bandung city, partially (10,57 km) passes densely-populated settlement area which occupied by 1.058 buildings and 71.875 people. Because of that, Cikapundung River has much kind of problems especially in environmental aspect and it is happened because of unbalanced between carrying capacities and the number of population. The description about the location and settlements area in alongside of Cikapundung River can be viewed in Picture 2 and 3.
Based on data of West Java Environmental Protection Agency in 2003 it is known that from 183.105 Ha of total area in Kelurahan Batununggal is settled by 12.109 people so that in every hectare has 66 people which settled in that area. Furthermore, with the density and limited of land has stimulated the growth of slum settlements area in alongside of Cikapundung River. The condition already showed that community which lived in alongside of Cikapundung River has a limitation to improve their quality of life because of lack many kind facilities especially sanitation facilities system. Moreover, mostly people who lived in that area are poor people with lower income and it is represented by their social and cultural behavior. The social norms which tend easier to break and poverty culture that can be seen from skeptic and aphetic behavior but in other hand that social and cultural behavior has already created a unique and different social cohesion than other community, especially in community level organization, house holding and sense of public domain which very close such as in providing clean water, garbage storage, people’s cooperation when the flood occurred, etc. The description about slum settlements area in Cikapundung River can be viewed in Picture 4.

The disparity between the population number and environmental carrying capacities and also social and cultural characteristic from the local community in Cikapundung Area has brought many kinds of problems such as: a) Many kind of existing buildings made a difficulty to arrange
the area in alongside river, b) The behavior from local community especially in disposing their wastewater and solid waste directly into the river, c) Mostly with the building density and land limited made a difficult to build a septic tank in every house.

Based on West Java Environmental Protection Agency in 2003, it is known that the total number of domestic wastewater which is disposed to Cikapundung River is about 2,496,802.30 litres/day and it is estimated that the number will increase continuously. The estimation of domestic wastewater flow rate can be viewed in picture 5.

![Domestic Wastewater Flow Rate Estimation In Cikapundung Area](image)

Picture 5. Domestic Wastewater Flow Rate In Cikapundung Area

The high amount of wastewater has caused high water pollution in Cikapundung River such as bad odor, diseases like cholera, diarrhea, etc, sewerage clogging and flooding and is caused by behavior from local community itself, which still dispose their domestic wastewater and solid waste directly into Cikapundung River. Thus, regarding to the social and culture condition from local community which still has lack of environmental awareness and limitation to improve their quality of life, West Java Environmental Protection Agency together with the local community has a cooperation to improve water quality in Cikapundung River by using Tangki AG.

3. Cooperation mechanism

Based on social and culture characteristic in slum settlements area which has an unique and different social cohesion, the cooperation mechanism done by West Java Environmental Protection Agency is implemented by involving participation from local community as a way to build an environmental awareness, such as: a) To socialize environmental friendly living way, b) To change bad habit from community which usually dispose their wastewater and solid waste into collecting it, with supported by the availability of good sanitation (like septic tank), c) To maintain existing drainage to create a clean and health environment.
Furthermore, the involvement of local community in Tangki AG development process is purposed to build sense of belonging among local community toward wastewater treatment plant that will be built. The local community is involved from planning, organizing and controlling until actuating process, such as: a) Holding public meeting which involving local community and organization to discuss a development process, b) Holding communal work to build tank and ponds, c) Installing the central pipe to wastewater treatment plant (Tangki AG). The cooperation mechanism process until it is established can be viewed in Picture 6, 7 and 8.

![Picture 6. Cooperation Mechanism Activity with Local Community](image)

Tangki AG consist of a network of collecting pipes laid beneath footpaths or below existing drains running along walkways through the communities. Treatment plants are constructed from concrete, plastered brick tanks and chambers. Some of those facilities are covered with light sheet metal shutters. The function of Tangki AG is to collect and treat wastewater from households and then disposing it to the river so that it will help to reduce the water pollution which derived from households.

Finally, the Tangki AG development process has already given a significant contribution to improve water quality and surrounding environment in Cikapundung River. The existing condition can be viewed from the decreasing of BOD and COD as described in Picture 9.
4. Conclusion
The conversion of land use as a consequence from disparity between facility demand and land provision has already brought many kinds of problems in cities, especially in Bandung City. One of the manifestation of that problems is the growth of slum settlements area in alongside of Cikapundung River. Furthermore, with the density of building and social culture characteristics from the people which still has a lack of environmental awareness has caused a high amount of water pollution in Cikapundung River. Because of that, West Java Environmental Protection Agency together with local community build a Community-Based Sewerage System with Tangki AG. The cooperation mechanism is done by involving the local community in all processes which are started from planning, organizing and controlling until actuating. Moreover, with the unique and different social cohesion of people like their close relationship each other made the process becomes successfully and it can be viewed from the decreasing of water pollution index in Cikapundung River.

References
Separating Drainage as the Alternative Small Municipality Water Treatment

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Abstract
Recently, almost the drainage system in Indonesia was use the mixing drainage, rain water and waste water drainage. The drainage system will directly connect to the river as the main drain. This condition will be affected to decreasing of the river water quality. The other way, while the flushing was not occurred by the rain water, the waste water, especially from the municipality, will be stagnant at the drainage channel, that will caused some odor and healthy problem in municipality area.

The research was conduct to maintain the waste water from the municipality by using the separated drainage system. Small new neighborhood was used as the pilot scale of the municipality as the application of the method. Method of the waste water screening by using the activated carbon or zeolith sand was used to removing the odor and the turbidity of the waste water.

The result was shown that the separated drainage was effective to reduce the waste water to directly flowing to the river, and the simple screening waste water was effective to use as the first treatment of the waste water in the small municipality to removing the odor and decreasing the turbidity of waste water.

Keywords: Separating drainage, waste water treatment, pilot scale

1. Introduction
The waste water from the municipality was the one problem that must be solved in Indonesia. Most of the municipality area in Indonesia has not the permanent waste water treatment. Waste water from the household was directly flowing into the drainage channel system. Usually, the main drainage of the drainage channel system will be flowing to the river as the main drain, and as the result of the untreated waste water that flowed, will be decreased the river water quality, where in the some chase, that river water was used as the raw water for the drinking water in the downstream area.

The drainage system in many areas in Indonesia was the mixing system, where the rain water and the waste water were flowed into the same drainage channel. Waste water will be diluted and flushed into the main drainage by using the volume of the rain water. The volume of waste water was usually only 1 – 2 % of the rain water volume. Problem was occurred when in the dry season, where there was not enough rain water available to flushing the waste water. Waste will be stagnant in the drainage channel. In the sloping area the problem was not high enough; other else
in the flat area, the problem was occurred. The stagnant waste water in several day will be caused the bad odor and the color will be change to be dark color with some flog that occurred at that waste water. This condition will be caused the decreasing of the health and esthetic level in the municipality. Usually, this condition occurred in the middle of the dry season and the waste water will be flushed after the rain came.

This condition was aggravated, where in the many municipalities in Indonesia have no waste water purification plant. That constrain were support with the unavailability of the budget and area to build the treatment. As the developing country, the municipality has a big population and the density of the population was very high. It was very difficult to finding the open area to construct the complex waste water treatment. While the government role, in this chases municipality government, was very few to support budget and effort to maintain such kind of this problem. It was very common to saw such as condition in many places. It was very important to find the method of the waster water treatment that fulfilling the conditions of the municipality. This method must be achieve the small, simple, inexpensive, and have sufficient easy maintenance.

2. Methodology
The research was conducted to achieve the solution of the small, simple, and inexpensive method that can be implemented at the municipality area. This research was conducted in Malang Municipality, East Java, Indonesia. This municipality was the one of the faster growing municipality in East Java. As the one of the higher education center in Indonesia, every year this municipality receiving more than 10,000 new students as the resident beside the 786,699 actual population of the municipality (until June 2006) that has 1.1% population increasing in every years (Malang Municipality Database, 2006) and the population density was 8,377 people in kilometer square area (Malang City in Figure, 2005). This research was the pilot scale of the waste water purification plant that implemented at the new neighborhood.

2.1 Separating Drainage
It was very common in the Indonesia municipality drainage design that using the drainage channel as the rain water drainage and the waste water drainage in one function. The drainage channel was designated to receive the rain water with 2 or 5 years return period and the waste water from the household that occupied the area. The design criteria of the drainage were shown that the waste water from the household was 75 – 80% from the water consumption of the household member in one day. Where, the water consumption for the municipality was approximately 150 litters per person per day.

There were two different drainage channels comes out from the household, one for the rain water and the other one for the waste water from the bathroom, kitchen and the other room of the household. While the rain water was flowed into the drainage system, the waste water from the household will be flowed into the pipe to the collecting storage that collect the waste water from the other household. But this pipe only receiving the waste water that not came from the toilet, the black soil will be separating from this waste water treatment. Waste water will be flowing by gravity to collecting storage. This pipe was design by the hydraulic uniform flow that prevents the back water that will occur at the pipe before entering the collecting storage. The pipe design was considered to the amount of waste and the time when the waste water will flow into this pipe.
This storage was placed underground, below the neighborhoods road to prevent the decreasing of the land use in the neighborhood area. This storage will be connected with the simple waste water treatment, that will treat the waste to reducing the odor and decreasing the turbidity before the waste water was flushing into the drainage system. The collecting storage dimension designed to store the waste in the half amount of the entire waste water. The assumption that used was the time of the waste water outflow occurred only in the peak time, in the morning and in the evening, where the water consumption using was very high for supplying the household member. Based on this assumption, storage dimension that available for this neighborhood was approximately 4 m$^3$.

### 2.2 Simple Waste Treatment

The waste treatment was placed to treat the waste water from the household before the waste water entering to the drainage system. This purpose of this waste water treatment was to reducing the odor and decreasing the turbidity in the waste water. Basically, the purpose of this waste water treatment, to remove the odor and reducing the turbidity, was very low. But as the early step to promoting the reducing of pollutant burden of the river as the main drainage system, this step must be obviously conducted. Main purpose of this research was introducing the simple system that can used widely in the municipality and can be placed at the small neighborhood that without using the wide area, easy to maintain and not expensive in the budget to construct.

This waste water treatment plant was consisting with the five small storages that allow the waste water flowing by gravity force trough the spillway that placed at the side of the storage. Waste water will be flowing to the lower storage after the upper storage was filled with the waste water. The storage was placed as the cascade storage. This section was allowing the waste water to settling the sediment that containing in the waste water into the bottom of the storage. The hydraulic retention time of these 4 storages was supporting the purification process of the waste water. The using of the 4 storages was formulated from the scale modeling of the waste water that showed that the effective number of the storage to reduce the odor and the turbidity was 4 storages. At the end of that cascade storage the active carbon or the zeolith in the sandy form screen was placed. This section was act as the slow sand filtration for screening the waste water. The use of the active carbon or zeolith sand was purposed to reducing the odor, and removing the sediment that still contain at the waste water. The use of this material was based at the scale modeling research that shown the material that suitable to reducing the odor and the turbidity. Pump must be installed in the end of this treatment plant in order to flow the treated waster the drainage channel if the drainage channel level was higher that the lowest storage after the screening process has conducted.
3. Result and Discussion

The research area was the new neighborhood in Malang Municipality that consisting by 15 household with the width of the area was 3,000 m$^2$. (Dini, 2006). The consideration that the research conducted at the very small pilot project was the organization of the municipality. The lowest organization in Indonesia municipality was “RT” that in assumption it was very easy to conduct the regulation of the separating drainage and communal waste water treatment in the small area that were regulated in one of authority. The rain water was calculating with the 5 years return period for the research area using the conventional Rational method. The waste water that produce from the household was calculated by using assumption that in every household was occupied by average 5 people. In the other hand that neighborhood was occupied by 75 people. The amount of the rain water that resulted from the Rational method calculation was 0.03 m$^3$/s while the amount of was 0.0001 m$^3$/s. The result shown that the amount of waste water was not has many influences to the municipality drainage design. In the other hand, the reducing amount of the waste water from the channel design has no influence to the standard of the municipality drainage system.

The combination between the cascade storage as the beginning process of the treatment and the active carbon or zeolith slow sand filtration at the end of process was resulting the suitable condition for water that will flowing into the drainage system according the scale modeling research. Result shown that the turbidity was decreasing from 45 Nephelometric Tubidity Unit (NTU) becomes 5 NTU, where the water quality standard for the drinking water for the turbidity was lower than 7 NTU. (Aulia, 2006; Robert, 2006). The odor of the waste water was removing and the taste of the water was become no taste. Physically property standard for the water was fulfilled before flowing to drainage system. The chemical property standard was not covered in this research, according to the aim of this research that the one purpose of this research was fulfill the removing the odor and for the esthetic standard.
As the developing country, Indonesia has facing the water environmental where about 56.16% of the household was disposed their waste water directly into the river or by flowing into the drainage channel system. This evidence was support that almost the entire river in Indonesia was indicated that the water quality not meet the water criteria class 1 (drinking water raw based on Regulation 82/2001). This condition can be decreased by decreasing the burden of the pollutant from the source of that pollution, the household. Separating the waste water from the rain water that flowing into the drainage channel system will decreasing the burden of the pollutant that will flow into to the drainage system.

The separating drainage was widely and the common system that used in the developed country. Opposite with that in Indonesia, especially in the small municipality at the remote area, the mixing drainage system was the choice of the planner. The mixing drainage was the cheapest and the fastest way to drain the exceeded water from the area. But in the other side this system was neglected the side effect that caused by mixtures the waste water and the rain water into the environmental decreasing level. The new idea of the separating drainage must be promoting widely as the solution to prevent the decreasing of the environmental level.

This research was the simple sample that can be conducted in the small neighborhood, where the separating drainage that used can be effectively implemented to prevent the decreasing of the environmental level. This system can widely used in the other small neighborhood in the municipal that organized by the lowest level of the government authorization. This system will be easily implementing because the management to maintain the system was no so complicated. The government role must be conducted, such as enacted the regulation, controlling the design criteria, etc, to promoting the using of this system widely.

As the solving problem to solve the waste water treatment, the simple cascade storage tank with the carbon active or zeolith slow sand filtration was the one of treatment plant that can be implemented. This simple plant can be removing the odor and decreasing the turbidity that containing in the waste water. Although the purpose of this waste water treatment was very low, as the simple waste water treatment solution in Indonesia, this system was suitable as the first stage to promote the water environmental awareness of municipality in Indonesia. Because the treated parameter was only for mainly fulfill for the esthetic criteria, the other parameter of the effluent standard that occurred must be observed more detail to achieve the standard of the treated water even though the treated water was only flowed into the drainage system.

The advantage of this system was could implement in the small neighborhood, that not needing the wide area to conduct the system and can be manage by the local people as the member of the neighborhood. The construction of the system was simple and not need the complicated maintenance. This system was not changing the drainage system design that was used widely in Indonesia recently, and the main consideration was that the system was inexpensive in budget. The disadvantage was the parameter that treated in this system was very limited according to the standard of the treated waste water.
4. Conclusions
As the first stage of the research, the implemented of the system was more carefully observed to obtain the more perfect result to promoting the water environmental awareness in the municipality. The following research must be conducted to achieve the standard of the treated waste water, and the effectiveness of the system must be compared with the other waster water treatment in the small municipality.

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Sustainable Improvement for Sanitation in Households

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Abstract
A trial improvement of sustainable sanitation in the household are carried out on Miyakojima, Japan. Groundwater of this island, only source for the tap water, has been deteriorated by nitrates deriving mainly from agricultural activities and household wastes. To reduce the nitrates loaded from households, the Bio-toilet and constructed wetland are used. Reductions of load from household to groundwater are estimated fairly much.

1. Introduction
About 31 million people on the countryside in Japan have no or badly functioning wastewater treatment. Furthermore, from the view-point of sustainable future, two more problems will be focused as follows:
1) Need for reduction of nutrient to conserve water environment from eutrophication.
2) Need for reduction of materials to conserve the groundwater quality in order to keep drinking water safe.

Sustainable improvement for sanitation in households is proposed in this paper.

The system is located in the household upstream of conventional waste water treatment systems. The sustainable improvement will change the route of nutrient (phosphorus and nitrogen) to original one (Organic Loop). The sustainable improvement will conserve the water environment at low cost in both construction and maintenance.

2. A trial of sustainable improvement for sanitation in Miyakojima

2.1 NO₃⁻-N concentration in groundwater of Miyakojima
Miyakojima belonging to Okinawa prefecture, one of the most southern islands in Japan, is located in the mesh of 24-25°N and 124-125°E, having an area of 159km² and 48,000 populations. The average air temperature is 23.4°C and the annual rainfall is about 2,000mm. The island has a very flat and low topography and the elevation at the highest point is only 115m a.s.l. Nitrate concentration (NO₃⁻-N) in groundwater of this island has been recorded since the end of 1980s.

Nitrate is known to have two kinds of risk, health and environment. The health risk may occur particularly in infants under six months of age by drinking bottle-fed milk that is unsanitary and...
Nitrate is well known as a material causing eutrophication in water regimes as well as phosphorus. In the south-west islands of Japan, a very big concern is the influences of groundwater eutrophicated by nitrate to the ecosystem in coral reef as it is fundamentally organized and formed under a low level in sea water nutrient. The coral reef ecosystem is very important not only for tourism also for coastal fisheries in these areas.

The source of nitrate was investigated by Y. Nakanishi and estimated as follows. In 1998, 960 tons of nitrogen was annually loaded to groundwater of this island. About 35.6% was derived from cultivation, 31.4% from animal husbandry, and 16.4% from domestic wastewater.

Enactment of the two municipal ordinances has been carried out in Miyakojima. One is the ordinance on conservation of Miyakojima Groundwater. Another is ordinance on source protection of drinking water supply on Miyakojima. Under these ordinances various programs have been in practice to keep the quantity and quality of the groundwater. The concentration of NO$_3^-$ has been reduced gradually since 1990.

### 2.2 Composition of the trial at Nakama’s house

Three people live at Nakama’s house at the trial. Wastewater composed of black water and grey water is guided to a septic tank and infiltrate to base rock through the bottom of the septic tank. The septic tank has the size of approximately 1.5m×1.5m×1.0m. At the trial of the sustainable improvement, urine and feces are treated both using bio-toilet. Grey water from kitchen, bath room and others are first stored at the septic tank, and then pumped up to a constructed wetland. As Mrs. Nakama proposed to use the wastewater from the constructed wetland, garden products beside the reservoir were added to this trial. Wastewaters from the reservoir are infiltrated to the base rock through a soil.

![Figure 1-1: Nitrate-nitrogen concentration in groundwater of Miyakojima.](image1)

![Figure 1-2: Estimation for annual amount of nitrogen loaded to groundwater in Miyakojima.](image2)
3. Bio-Toilet
Bio-Toilet is a kind of dry toilet, invented by M. Kinoshita about 30 years ago. Urine and faeces from toilet are lead to bio-reactor which contains sawdust. Urine is once stored in small pore spaces of sawdust, then evaporates by rotating with sawdust and lose its water content.

4. The constructed wetland
4.1 The constructed wetland at Nakama’s house
The constructed wetland is used for grey water treatment. A limestone called Ryuukyuu Sekkai is used as filter material which has high porosity in the particle. The constructed wetland has the size of 2.0m×2.0m×0.6m (depth). The filter particles are first submerged 2hours by the wastewater from the septic tank, then the water are drained. The filter particles are exposed to air 22hours a day for the decomposition of organic carbon(BOD). In reservoirs, wastewaters from the constructed wetland are stored few days.
4.2 Result of the trial improvement

Measurements of water qualities were carried out 6 month after the completion of wetland. Data were changing as days passed, the average water quality are shows as Fig.5. Fig.5 shows the results of the measurement of the influent, the effluent of the constructed wetland, and the treated grey water in the infiltration basin. In the infiltration basin, COD is around 20 mg/l, T-N is 10 mg/l, and T-P is 0.6 mg/l. more purified in the treated water reservoir. This means that the treated water reservoir takes an important role in N&P removal.

Figure 5. Changes of the COD, the T-N, the T-P in the influent (closed circles), those in the effluent (closed triangle), and those in the infiltration basin (closed square) in the constructed wetland.Ⓐ, Ⓑ and Ⓒ are correspond to the point shown Fig.4.
5. Total rate of reduction to the underground

Table 1. The estimated yields of C, N, P at households

<table>
<thead>
<tr>
<th></th>
<th>Urine &amp; Feces</th>
<th>GreyWater</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>[g/human/day]</td>
<td>[g/human/day]</td>
<td>[g/human/day]</td>
</tr>
<tr>
<td>BOD</td>
<td>19</td>
<td>39</td>
<td>58</td>
</tr>
<tr>
<td>T-N</td>
<td>8</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>T-P</td>
<td>0.9</td>
<td>0.3</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Table 2. The reduction of the loads at each devices

<table>
<thead>
<tr>
<th></th>
<th>A [mg/l]</th>
<th>The rate of reduction in concentration at the Wetland</th>
<th>B [mg/l]</th>
<th>The rate of reduction in concentration at the Reservoirs</th>
<th>C [mg/l]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>①</td>
<td>② = ①−③</td>
<td>③</td>
<td>④ = ③−⑤</td>
<td>⑤</td>
</tr>
<tr>
<td>BOD</td>
<td>80</td>
<td>70</td>
<td>10</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>T-N</td>
<td>15</td>
<td>5</td>
<td>10</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>T-P</td>
<td>1</td>
<td>0.5</td>
<td>0.5</td>
<td>0.45</td>
<td>0.05</td>
</tr>
</tbody>
</table>

From the average data of water quality at point A, B, C, the rate of reduction in concentration are calculated as Table 2. The total reduction rates from the household to the groundwater are about 80-90% after constructed wetland and over 95% after the reservoirs shown Table 3. As for the nitrogen, the rate of reduction is 72% at Bio-toilet, 10% at constructed wetland, 14% at Reservoirs and 96% in total. Removal of nitrogen at the reservoirs is fairly much. If inhabitants of household like reservoirs in the sustainability improvement, they will also enjoy plants and the spectacle in their garden.

Table 3. The rate of reduction after Constructed Wetland and after Reservoirs.

<table>
<thead>
<tr>
<th></th>
<th>Yield at household ( , )*</th>
<th>Bio-toilet + After Constructed Wetland</th>
<th>Bio-Toilet + After Constructed Wetland + Reservoirs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Urine&amp; Feces</td>
<td>Influent</td>
<td>Effluent</td>
</tr>
<tr>
<td>BOD</td>
<td>58 (39,19)</td>
<td>19</td>
<td>39</td>
</tr>
<tr>
<td>T-N</td>
<td>11 (8,3)</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>T-P</td>
<td>1.2(0.9,0.3)</td>
<td>0.9</td>
<td>0.3</td>
</tr>
</tbody>
</table>

*(Urine & Feces, Grey Water)

Acknowledgements

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The Existing Urban Environmental Sanitation System in Hanoi and Problems Related

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Abstract

Urbanization is a very popular phenomenon in developing countries, and Vietnam is not an exception. In Vietnam, the rapid urbanization and flow of immigrants to urban areas in two biggest cities, Hanoi and Ho Chi Minh City (HCMC), are indeed the main challenge of the infrastructure development. In these cities, the rapid urban population and economic development are accompanied with increased resource consumption and environmental degradation due to inadequate sanitation services. This paper will discuss the existing urban environmental sanitation in Hanoi, its legal framework, and the main environmental problems caused.

Key words: Developing countries; environmental pollution; groundwater exploitation; Hanoi; urban environmental sanitation system

1. Introduction

Recently published data show that world-wide 2.4 billion people do not have access to improved sanitation (UN, 2004). This global sanitation-related crisis has been recognized, and UN has put forward a Millennium Development Goal to halve the number of people without access to adequate sanitation by 2015 (UN, 2003). In order to achieve this goal, improving the already existing sanitation systems to meet the increasing demand is a must for municipalities. This paper analyzes the existing urban environmental sanitation system in Hanoi, the capital city of Vietnam. In particularly, the system’s infrastructure, the related legal framework, and main environmental problems caused will be discussed. The analysis is conducted with the main objective to present to relevant professionals the picture of the current urban sanitation system in Hanoi in a hope that the information will facilitate the decision making process for finding appropriate solution. It is noted that the environmental sanitation as hereby defined includes water supply, disposal of wastewater and excreta, and municipal solid waste management.

2. Brief description of the study area

Hanoi, the capital city of Vietnam, has a long history of about 1,000 years. The city’s urban infrastructure also has a long history and major drainage system in the main streets was built by the French during the colonization period from 1874 - 1954. When Vietnam implemented its “open-door” policy in early 1990s, the city has witnessed rapid economic development and population growth. The city’s population has increased about 30% during the period from 1995 – 2003, from 2.4 million people to about 3 millions people. The number of urban districts has
increased from 5 to 7 plusing 5 sub-urban districts with a total area of nearly 1,000 km² (Hanoi PC, 2003).

Like many other cities in developing countries, rapid urbanization, increasing immigration from rural areas, industrialisation, and economic growth have put a strong pressure on the urban infrastructure in general and environmental sanitation in particular. The urban population growth and economic development are accompanied by increased resource consumption and environmental degradation. In the last decade, the environmental pollution has become worsen because the urban environmental sanitation infrastructure is inadequate to provide the basic necessary services, like sanitary management and disposal of human waste and wastewater. This has led to severely polluted receiving water bodies in the cities (Hanoi SADCO, 1997).

3. Institutional framework related to environmental sanitation in Hanoi

In Hanoi, the urban solid waste (SW) is managed by Hanoi Urban Environment Company (URENCO), a public non-profit utility belongs to Hanoi city people’s committee (Hanoi PC). Mandate of URENCO is to collect, transport and disposal of SW generated in urban districts of Hanoi. The collection and management of solid waste generated in peri-urban districts is responsibility of local authority, the people’s committee at district and ward levels.

As regard to wastewater, the Hanoi Sewerage and Drainage Company (SADCO), a public utility under Hanoi PC, is responsible for treatment and disposal of both domestic and industrial wastewater. SADCO is responsible for the provision, operation and maintenance of the sewerage and drainage network in the core urban area of Hanoi. Hanoi SADCO manages the primary and secondary network (ditches, channels, city’s sewers and rivers, as well as other sewerage and drainage facilities).

Water supply is implemented by Hanoi water work authority, also operating under Hanoi PC. In summary, the mandates of the different public utilities providing urban sanitation services are regulated and financed by Hanoi PC.

A recent study on legal and institutional framework related to environmental sanitation of Hanoi city has shown that the environmental law enforcement is relatively weak (Bucher, 2005). At state level, the National Assembly has ratified environmental protection law in 1993. However, when down to city and provincial levels, the environmental law enforcement is weak due to a lack of human capacity, a strong institutional framework, and commitment from people as well. Financial capital for environmental law enforcement is also a concern of relevant organizations. Hanoi People’s Committee issues its own regulations following central decrees and laws, but if no expenses are made in their enforcement, those regulations are not implemented correctly and adequately. This has resulted in institutional and legal weaknesses, main obstacles to the development of a well-managed urban sanitation system.

4. Solid waste management

It is estimated that in 2005, the total amount of SW generated in Hanoi is of about 900,000 tonnes. Hanoi URENCO is responsible for SW generated in urban districts, in peri-urban districts the SW management is implemented by environmental department of the districts’ people committee. Approximately, 80% of total generated urban SW is collected and disposed of into landfill by
URENCO. The remaining 20 % is either improperly disposed of into open landfills or illegally thrown to the city’s rivers and lakes. The SW is not on-site classified, and only a small portion of the organic SW is classified and used for compost production in a composting plant placed under management of Hanoi URENCO. A study on nutrient budget for Hanoi city has shown that only about 10 % of N and P contained in SW is recycled (Cau, 2003).

Collection and disposal of industrial waste is entirely responsibility of industries. However, the industries usually commission Hanoi URENCO to collect and disposal of their waste in waste collection service contracts.

5. Wastewater pollution
In Hanoi, receiving water bodies are severely polluted by discharges of untreated wastewater, in which industrial wastewater is main the pollution source, although Vietnam has ratified water resource law in 1999 strictly prohibiting the discharge of hazardous wastes, untreated wastewater or treated wastewater that does not meet the permissible standards into any water receiving bodies. The reason is that the law has not been effectively implemented due to the lack of guiding circulars and enforcement measures.

In 2003, it is estimated that every day the total amount of industrial wastewater discharged is 263,000 m$^3$, and only 6.2 % of this amount is treated before being discharged into water receiving bodies in the city. In addition to industrial wastewater, a large amount of hospital wastewater is also discharged untreated to receiving water bodies. It is estimated that about 7,000 m$^3$/day of hospital wastewater is discharged into the receiving water bodies, and only 30 % of this amount is treated before being discharged (Hanoi DOSTE, 2003).

The water quality monitoring data in the four main rivers and lakes in Hanoi have clearly shown that the water quality of rivers, lakes and ponds in Hanoi is worsening due to the discharge of untreated industrial wastewater, which contains toxic substances, inorganic substances and high organic content. Averagely, concentrations of BOD, COD, heavy metals and coliform in To Lich, Lu, Set and Nhue rivers are 3 – 4 times higher than standards (Hanoi DOSTE 2003).

6. Sewerage and drainage system
Hanoi SADCO is responsible for wastewater drainage at city and district levels of Hanoi. Down to ward and commune level, the wastewater drainage management is placed under management of ward people committee. The sewerage and drainage system of Hanoi is a combined one, which means that both industrial and domestic wastewater, storm water and street cleaning water are served by on drainage system. The sewerage and drainage system is working under the automatic-flowing mechanism (due to the difference of hydraulic pressure between two points of the sewerage system) (Hanoi DOSTE, 2003). Overview of the drainage system is shown in figure 1.
Total length of the central sewerage and drainage system, which is placed under maintenance and management of SADCO, is of about 318 km, approximately of the 60% of total transport road. It is estimated that the total coverage of the drainage system just accounts for 40% of city’s total area. Total length of local drainage in small alleys under management of ward people committee is of about 190 km. The ratio of sewer length per capita in Hanoi city is about 0.3 m/person, which is much less than average ratio in other developing countries, 2 m/person. The ratio is still much less for small sewers in alleys and living areas (the tertiary network as indicated in Fig. 1) where total length of sewers is of about 190 km, equal to 29% of 641 km of total length of the roads (with width > 2 m). Among those, only 72 km or 11% is under SADCO’s enterprises. The rest part of the network is under management of local authorities such as ward/commune PCs (SADCO, 2003).

Most of the existing sewerage and drainage channels in Hanoi have a small size, low hydraulic slope, inappropriate structure, and the amount of sludge and sediment that settled in the system is relatively high. In addition, due to the fact that Hanoi’s topography is relatively flat, the soil foundation is the range of between 2.5 – 10 m, decreased from northeast to southwest, which is not good for the automatic flowing sewerage system. Therefore, the wastewater receiving and transporting capacity of the existing sewerage and drainage system is still far under the demand. During rainy season, flooding happens quiet often.

Another problem of the drainage system in Hanoi is that some parts of the system, especially the ones located on central districts of Ba Dinh and Hoan Kiem, which were built during French colonization period, before 1945s, are now not working properly. Wastewater leakage and ground water pollution are occurring. This problem coupled with flooding during rainy season has caused the environmental pollution worsen.
7. Groundwater exploitation
The centralized and large scale exploitation model is implemented and managed by Hanoi Water Work Authority. Currently, there are 9 wells and some water distribution stations with the total exploitation capacity in between 400,000 – 450,000 m$^3$/day. The decentralized and small scale exploitation is implemented and managed by factories and households. According to a statistic, there are currently about 299 wells being exploited and used by factories. The exploitation capacity of these wells is in between 60,000 and 100,000 m$^3$/day. The total number of wells that being exploited and used by the people is of about 100,000 with a total exploitation capacity of about 100,000 m$^3$/day (Hanoi DOSTE 2003).

Totally, the amount of ground water that is currently exploited in Hanoi is in between 600,000 and 650,000 m$^3$/day. This groundwater withdrawal rate is nearly the same with the recharge rate of approximately 700,000 m$^3$/day (Nga, 2005).

8. Discussion
From the above-mentioned discussions, it is concluded the following key issues related to water and nutrient management of Hanoi’s urban sanitation system:

- Excessive groundwater abstraction
- Serious surface water pollution due to inadequate treatment of wastewater
- Coverage of sewerage and drainage system is inadequate to provide sanitary disposal of wastewater
- Nutrients recycling is not well done

References
Application of Photosynthetic Bacteria Treatment System for Recovery of Organic Carbon from Noodle Processing Wastewater

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Abstract
This paper presents a case study on application of photosynthetic bacteria wastewater treatment system to recover organic carbon in wastewater in the form of photosynthetic bacterial cells. In noodle production process, the wastewater was mainly produced during rice soaking and rinsing processes containing starch as its main constituent. For carbon recovery purpose, wastewater was applied to laboratory photosynthetic wastewater treatment system where carbon could be transformed into protein in purple non-sulfur or purple sulfur bacterial cells. The system has shown to be effective for the treatment of starch wastewater and cultivation of photosynthetic bacteria when operated at hydraulic retention time of 6 and 10 days.

1. Introduction
The application of photosynthetic bacteria to wastewater treatment is one of the attractive methods since the microorganisms are widely available in nature and capable of removing organic substances even under high organic load (Hiraishi et al., 1989) especially in sunlight intensive area like tropical countries. The treatment will require minimum additional energy apart from natural sunlight and the treatment cost can be substantially reduced. They are applicable to organic compounds (Madigan et al., 2000) and wastewater from various industries (Noparatnaraporn et al., 1986). By introducing this system, it might be possible to develop a high-efficiency treatment process without odorous gas production. The proposed system (Figure 1) consists of two ponds connected in series. In the first pond, it is expected that acidogenic bacteria consume organic matter in wastewater and photosynthetic bacteria grow with their metabolite. Then the following aerobic fishpond is expected to have a high fish yield. Moreover the by-product of the treatment, the photosynthetic bacteria cells, has high nutrition such as protein and vitamin (Kobayashi and Tchan, 1973; Getha et al., 1998; Banjaree et al., 2000) which is a good alternative for fish feed.
2. Wastewater from noodle production
Typical production of rice noodle includes broken rice and water as two main raw materials for production of unfermented rice noodles. It involves washing and soaking of rice, pasting the rice and making the starch slurry. For thick noodle processing, the slurry is then used in sheeting prior to cooking and drying step. For thin noodle processing, the sheeted slurry is cooked and dried in an oven before cutting process. The processing of vermicelli noodle is slightly different from thick and thin noodle. The starch slurry is passed through a filter press, yielding semi-dry starch solids. The starch solids are steamed before being extruded to form vermicelli noodles. The production of rice noodles produces wastes at various stage, i.e. raw material preparation, production, packaging and process line cleaning. Among these, wastewater is mainly produced during rice soaking/rinsing and cleaning of pasting tank. It contains starch as main constituents with high BOD and suspended solids.

3. Experimental system
Laboratory scale reactors (3-L working volume) simulating photosynthetic bacteria ponds were used (Figure 2). The reactor was illuminated for 12 hours per day by two 60 W incandescent lamps from both side. The bioreactor was operated as single pass complete mixed reactor by providing magnetic stirrer mixing. During the experiments, intermittent aeration was supplied to prevent permanent drop in oxidation-reduction potential (ORP). Feeding of wastewater and withdraw of reactor effluent was done once a day. Enriched photosynthetic bacteria (wild strains) were used as seeding in the photo-bioreactor. The organic loading to the system was varied between 0.16 and 0.35 kgCOD/m³.d respectively. Microbial population in the system was studied by determining bacterio-chlorophyll-a (Bchl.a) for photosynthetic bacteria and chlorophyll-a for microalgae. Purple non-sulfur bacteria (PnSB) were also quantified by fluorescent in-situ hybridization (FISH) technique. The populations of sulfate reducing bacteria (SRB) and purple sulfur bacteria (PSB) were quantified by conventional plate count methods. Crude protein content of sludge withdrawn from the photo-bioreactor was also analyzed.
4. Organic carbon conversion in the system
The photo-bioreactors were operated either with or without infrared transmitting filter. The main purpose of filter installation is to prevent the growth of microalgae in the system. It was found that high COD removal rate of more than 90% was achieved under the organic loading rate of 0.1 to 0.3 kg/m$^3$.d. High COD removal was obtained when the HRT in the system was operated between 3 and 10 days even though occasional fluctuations on the removal efficiency were observed at low HRT case. The removal of organic substance is mainly accomplished by PnSB which utilized organic substrates in the presence of light from wastewater as photosynthetic electron donor and carbon sources. In addition, sulfate reduction can also help eliminating some fraction of organic substances. The treatment performance in the photo-bioreactor with and without infrared transmitting filter was comparable to each other.
The reduction of HRT did not only increase organic substance but also raised sulfur compound loading to the system. As a result, they produce sulfide which is inhibitory compound for PnSB. Sulfite concentration in effluent was kept below 20 mg/l while sulfate concentrations in effluent was increasing. This was mainly due to the oxidation of incoming sodium metabisulfite which has been used for bleaching and antioxidant purposes. Nevertheless, sulfate concentration was found gradually declined towards the end of the operation due to the development of sulfate reduction in the system.

Figure 4 shows the variation of ORP in a feeding cycle. In photo-bioreactor without infrared transmitting filter, ORP increased much higher than those in photo-bioreactor with infrared transmitting filter after feeding because oxygen was produced from the photosynthesis of microalgae in the presence of light. Higher organic loading and the use of infrared transmitting filter could control the ORP mostly in the negative range. Microanaerobic condition is preferable to the growth of PnSB as compared to microalgae but too low ORP might also promote the SRB activities.

5. Bacteria community in the system
Photosynthetic bacterium cultivated from natural mixed culture consists of at least two species of PnSB; Rps. palustis and Rba. blasticus. There was a decreasing trend of Bchl.a and PnSB in the system. The growth of SRB was found significant in the latter stage. The opposite trend of PnSB and SRB suggested that there was a competitive relationship among them. The growth of PSB associated with SRB was also observed at high organic loading rate as PSB could utilize sulfide produced from SRB activities for their growth. Chl.a was found abundant in the photo-bioreactor without infrared transmitting filter since visible wavelength could be easily absorbed by microalgae during photosynthesis. The use of infrared transmitting filter was found effective for suppression of microalgae growth.

6. Single cell protein (SCP) production
Crude protein content in the sludge obtained from the photo-bioreactor with infrared transmitting filter at all HRT was found more than 50% (Table 1), sufficiently high to be utilized as SCP. Sludge from the system with infrared transmitting filter had higher protein content than that
without infrared transmitting filter as the photosynthetic bacteria cell contain higher protein than microalgae.

Table 1. Production of SCP from photosynthetic bacteria at different HRT.

<table>
<thead>
<tr>
<th>Run</th>
<th>HRT (d)</th>
<th>Light</th>
<th>Organic-N (mg/l)</th>
<th>Crude protein (mg/l)</th>
<th>SS (mg/l)</th>
<th>Crude protein content (g/g-dry weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-1</td>
<td>10</td>
<td>with filter</td>
<td>38</td>
<td>234</td>
<td>437</td>
<td>0.54</td>
</tr>
<tr>
<td>A-2</td>
<td>w/o filter</td>
<td></td>
<td>33</td>
<td>208</td>
<td>529</td>
<td>0.39</td>
</tr>
<tr>
<td>B-1</td>
<td>6</td>
<td>with filter</td>
<td>46</td>
<td>287</td>
<td>430</td>
<td>0.67</td>
</tr>
<tr>
<td>B-2</td>
<td>w/o filter</td>
<td></td>
<td>52</td>
<td>326</td>
<td>541</td>
<td>0.60</td>
</tr>
<tr>
<td>C-1</td>
<td>3</td>
<td>with filter</td>
<td>35</td>
<td>181</td>
<td>343</td>
<td>0.53</td>
</tr>
<tr>
<td>C-2</td>
<td>w/o filter</td>
<td></td>
<td>41</td>
<td>254</td>
<td>458</td>
<td>0.55</td>
</tr>
</tbody>
</table>

7. Conclusions
High organic removal of more than 90% was achieved in photosynthetic bacteria treatment system operated at HRT of 6 and 10 days. Infrared transmitting filter was effective in suppressing the growth of microalgae and allow purple non-sulfur to grow. Two species of purple non-sulfur bacteria were identified, i.e. Rps. Palustis and Rba. Blasticus. The growth of purple sulfur bacteria associated with sulfate reducing bacteria was observed. The sludge withdrawn from the system contained high protein content of more than 50% which to be utilized as single cell protein.

8. References
Organisers: Ministry of the Environment, Japan
The Secretariat of Water Environment Partnership in Asia (WEPA)

Co-organisers: Institute for Global Environmental Strategies (IGES)
Asian Institute of Technology (AIT)