Integrated Water Resources Development and Management in a River Basin Context: the Brantas River Basin's Experience

Abstract

This paper describes a synthesis of Integrated Water Resources Management (IWRM) by taking into account Brantas River Basin in East Java, one of the densely province in Indonesia. The Brantas River in East Java has a watershed of 11.800 km^2 and stretches 320-km from its spring at Mount Arjuna to the point where it branches into two rivers, Surabaya River and Porong River, that both ends into the Madura Strait. Jasa Tirta I Public Corporation was assigned by the Government to conduct water resources management, including dealings in water, utilization, conservation, and rehabilitation of water infrastructures. Baseline of the whole process of integrated water resources management in the Brantas River Basin is water resources corporatization, where beneficiaries are involved in funding the operational activities in water resources management, under the responsibility of Jasa Tirta I Public Corporation as operator, in the role sharing scheme applied there to.

I. Introduction

The Brantas River Basin, East Java has experienced integrated water resources development that resulted into diverse water resources infrastructures for flood control, power generation, irrigation, and bulk water supply, etc.

Upon completion of most of the water resources infrastructures, Jasa Tirta I Public Corporation was assigned as a corporate body by the Government to conduct water resources management. In order to sustain the development results, Jasa Tirta I applies a corporatized approach to water resources management – one of the earliest in modern time of Indonesia. This corporatized approach embraces an integrated water management system.

A. Physical Features of the Brantas Basin

Brantas River has a watershed of about 11,800-square km and stretches 320-km from its spring at Mount Arjuno to the point where it branches into two rivers, Surabaya River and Porong River – that both ends into the Madura Strait. Brantas flows clockwise with Mount Arjuno and Kelud as its center. Along the main flow there are many tributaries; the important among others are: Lahor, Konto, Ngrowo and Widas River.

Average precipitation in the basin is about 2.000 mm/year, and available surface water is approximately 12 billion m^3/year, but less than 25% of this amount is controllable – annual manageable water availability is about 3 billion m^3.

Population in the basin is quite dense, closing to 14.7 million people in the year 2000. This counts for 42% of East Java population. As well as the population, the Regional Gross Domestic Product (RGDP) for the basin is quite high, valuing approximately Rp 98.8 trillion in 2000, that is 58% of the RGDP for East Java. This prosperity is supported among others by the water availability related to the infrastructures in the basin.

Table 1 Physical features and present social figures of the Brantas Basin

Main river course: **Brantas**		Length 320 km
Administrative location: Province of East Java		110º30' and 112º55' eastern longitude, 7º31' dan 8º15' southern latitude
Passing through 14 regencies and municipalities		
A.	**Main Tributaries and Basins**	
	▪ Lesti	625 km^2
	▪ Konto	687 km^2
	▪ Widas	1,539 km^2
	▪ Brantas	6,718 km^2
	▪ Ngrowo	1,600 km^2
	▪ Surabaya	631 km^2
	Sum	11,800 km^2
B.	**Main Reservoirs**	
	(Sengguruh, Sutami, Lahor, Wlingi, Lodoyo, Selorejo, Bening and Wonorejo)	
	▪ Gross Storage (initial/present)	647 / 405 million m^3
	▪ Effective Storage (initial/present)	479 / 343 million m^3
C.	**Surface Water Availability**	
	▪ Precipitation average in the basin	2,000 mm/year
	▪ Surface runoff coefficient	0.50
	▪ Surface water availability	12 billion m^3
D.	**Surface Water Utilization**	
	▪ Irrigation water	2,400 million m^3
	▪ Domestic-residential supply	158 million m^3
	▪ Industry bulk water	131 million m^3
	▪ Maintenance flow	204 million m^3
	▪ Fisheries	41 million m^3
	Sum	2.934 million m^3
E.	**Social-Economy Condition (2000)**	
	▪ East Java population	34.8 million
	▪ Brantas River Basin population	14.7 million
	▪ Ratio of population for Brantas River Basin to East Java	42%
	▪ Milled rice production in the basin	2.99 million ton
	▪ Regional Gross Domestic Products (RGDP) East Java	169.8 trillion Rp
	▪ RGDP of Brantas River Basin	98.8 trillion Rp
	▪ Ratio of RGDP for the Brantas River Basin to East Java	58%

B. Historical Perspective on Water Resources Development in the Basin

Brantas River was known in the past as Kadiri River, originating from the spring in Sumberbrantas Village, in the highlands of the Mount Arjuno and Mount Anjasmoro complex. The river has been subject to various natural powers, like the erratic eruptions of Mount Kelud that has been recorded as far as in 1000 AD changing the river morphology with its debris. Like most tropical basins with volcanic activities within, the basin is fertile and has nurtured various agricultural activities in the past until present.

Before modern development actions took place, the Brantas River branches into a few rivers before it reaches Mojokerto. The first branch was flowing northwards namely Kedungsoro River, followed by the second and the third, both of which flowed northwards as well namely Gedek and Mlirip Rivers, then unified again forming Surabaya River flowing north-eastwards. Reaching Wonokromo, Surabaya River turned northwards and was named Mas River.

The fertile area and the availability of abundant water supply caused the downstream area developed rapidly, this phenomenon gradually spread to the upstream area of the river basin. On the other hand, development in the upstream area shall give impact to the downstream area, vice versa. Clearly, due to the wider agriculture land in the upstream area, water supply in Brantas Lower Reach kept on deteriorating and finally brought about serious problem.

Approaching the end of 19th century, Surabaya River began to have difficulties on keeping the channel well maintained for navigation during the dry season. Brantas Delta irrigation area with its sugarcane factories also faced water supply difficulties. Not less than 16 sugarcane factories had been established in the delta since middle of 19th century.

At that time, the function of river was for navigation, irrigation, and flood control. Due to the above difficulties and the development of the land traffic, the water traffic was eliminated and other aspects, such as providing electrical power, replaced the function of river. By the middle of 19th century, many irrigation canals in the downstream area are tapping water directly from Brantas, Surabaya, and Porong Rivers and it was done partially for the sake of individual and group interest. This situation poses further management problem, until gradually, the small irrigation canals were integrated into a large irrigation system: the Brantas Delta Irrigation. The dikes were also unified as a continuous system from the upstream part of the river, to the estuary. In line with the current development, coordination in implementing activities was then required.

The prominent things directing to works under coordination included water supply and water services as well as flood prevention for the monoculture system that later became the commercial agricultural enterprise.

Up to the of colonization period, Brantas River was still the most developed. Many water resources infrastructures were constructed during this period. Some of the significant works included the effort to secure Surabaya from flood, development of irrigation areas (Brantas Delta, Wonokromo, Molek, Kedungkandang, Warujayeng, Kertosono and Turi Tunggorono), river improvement and securing Brantas Lower Reach from flooding, development of other irrigation areas within Brantas tributaries, and water resources improvement in South Tulungagung plain.

II. Comprehensive Water Resources Development

A. Integrated Water Resources Development Concept

As result of its defeat in the Second World War, the Dutch colonial government surrendered under the Japanese invasion in 1942. Most of Indonesia, especially Java was then briefly governed by the Japanese colonial rule, that ends abruptly in 1945, whereas Indonesia proclaim its independence.

As part of the war reparation, the Japanese was assigned to construct various civil structures in Java, Borneo, and Sumatra. In the Brantas River Basin, the Japanese Government completed in 1961 a tunnel to drain the Ngrowo River Basin, a tributary of Brantas that

always inundates the Tulungagung area. By completion of this tunnel, the Ngrowo Basin could be converted into a fertile land. Success of this drainage system put highlights to the importance of developing a complete river basin wide development scheme.

As final result of the river basin wide study, it was concluded that water resources development in the Brantas River Basin must be conducted on a basin wide perspective and works out on creating an overall water resources infrastructure system that is integrated each to another. The Ministry of Public Works suggested then to Japanese Government to conduct an river basin-wide study in order to settle a water resources development plan.

This concept was not far from the initial concept of integrated basin development that was stipulated by the United States of America for the Tennessee Valley development. Only to the Brantas River Basin, it was enhanced in form of creating development master plan in a step-wise manner.

B. Brantas Basin Development Master Plans

Comprehensive water resources development is carried out based on “One River, One Plan” principle. This comprehensive plan commences in 1961 and is based on a series of master plans that involves stage-wise planning in accordance to the national development requirements.

The integrated water resources development strategy is prepared as follows:

1. Master plan as development guide. In order to achieve sustainable development, the master plan will serve as guide for development planning of each related institution. Coordination with related agencies is the way to obtain agreement on intersectoral matters.
2. Immediate development objective rank is flood control. The Brantas River Basin has been severely hurt by flooding. Flood control and erosion control is the considered as urgent problem in the basin. The first master plan emphasizes on flood control.
3. Stage wise planning in accordance with development requirements.
4. Continuous review on the master plans. In order update the plans to ever changing social and economic condition, the master plan are reviewed once around 10 years

As result of this strategy, the comprehensive water resources development plan establishes four master plans in sequence. Details of them are as follows:

- **Master Plan I** was prepared in 1961, emphasizes on flood control by developing dams at the upper reaches and river improvements to increase flood relief capacity.
- **Master Plan II** was prepared in 1973 after most objectives of the first master plan was achieved. This master plan was founded in accordance to the government policy on food sustainability, by emphasizing on irrigation development.
- **Master Plan III** was prepared in 1985 after irrigation schemes were developed in the basin and as result of the irrigation development, agricultural intensification was made possible. The third master plan emphasizes on water supply for domestic and industrial

uses, as more urban area is evident in the basin.

- **Master Plan IV** was prepared in 1998, to emphasize on effective water resources conservation and management.

C. Development Results

Development in the basin resulted into 8 (eight) reservoirs (Sengguruh, Sutami, Lahor, Wlingi, Lodoyo, Selorejo, Bening and Wonorejo), four river-improvement-schemes, four barrages, and three rubber dams. Total investment in water resources infrastructure is priced Rp 7.38 billion based on the year 2000 price level (equivalent to US$ 738 million, whereas 1 US$ equals Rp 10,000).

Table 2 Water Resources Infrastructures in the Brantas River Basin

No	Structure		River	Purpose
A	**Large Dams**			
1	Selorejo Dam	(1970)	Konto	Water supply for irrigation, hydro power generation, flood control, recreation
2	Sutami Dam	(1972)	Brantas	Water supply for domestic, irrigation, industry, hydro power generation, flood control, recreation
3	Lahor Dam	(1975)	Lahor	Water supply for domestic, irrigation, industry, flood control
4	Wlingi Dam	(1978)	Brantas	Afterbay of Sutami Hydro power, water diversion for irrigation, hydro power generation, flood control, recreation
5	Bening Dam	(1984)	Widas	Water supply for irrigation, hydro power generation, flood control, recreation
6	Sengguruh Dam	(1988)	Lesti	Sediment control to Sutami reservoir, hydro power generation
7	Wonorejo Dam	(2000)	Bodeng Song	Water supply for domestic, hydro power generation, flood control
B	**Barrages**			
1	New Lengkong	(1974)	Porong	Water diversion for irrigation, domestic, and industry
2	Gunungsari	(1981)	Surabaya	Water diversion for irrigation
3	Jagir (rehabilitation)	(1981)	Wonokromo	Water diversion for domestic
4	Lodoyo	(1983)	Brantas	Afterbay of Wlingi hydro power, hydro power generation
5	Tulungagung Gate	(1986)	Ngrowo/Parit Agung Canal	Water regulation for domestic, hydro power, and flood control
6	Wonokromo	(1990)	Mas	Flood control
7	Mrican	(1992)	Brantas	Water diversion for irrigation
C	**Rubber dams**			
1	Gubeng	(1990)	Mas	Water diversion for domestic
2	Jatimlerek	(1993)	Brantas	Water diversion for irrigation
3	Menturus	(1993)	Brantas	Water diversion for irrigation

Although it is difficult to quantify real benefit of this development scheme, it could be seen that various sectors in the basin enjoys benefit from the infrastructures. Comparison of situation prior to the development (1960) and as recent as before Jasa Tirta I Public Corporation is assigned to manage the infrastructures (1990) could be seen in **Table 3**.

Table 3 Comparisons of the Pre and Post Development Era

Items	Unit	1960[1]	1990
Flood control	Inundated areas	60.000 ha	None
Irrigation	Cropping intensity	0,8 / year	1,8 / year
Hydropower	Million kWh/year	170	910
Raw water for domestic	Million m^3/year	73	125
Raw water for Industries	Million m^3/year	50	115

Evidently, about 60.000 ha of area are secured from annual inundation as flood control in the mainstream is established with a designated capability to control 50-years return period flood. Hydroelectric power generation in the basin also increases from a small amount of 170 kWh that is generated by two hydroelectric generation units from the Dutch-period, to a lump amount of 910 million kWh annually that is generated by eight units. Also, related to that, development of water resources infrastructures has secured water supply for irrigation, domestic and industrial purposes. As seen, the agricultural cropping intensity in the basin has increased twice since the 1960's.

III. Institutional Evolution of Water Resources Management

A. Post-Construction Problems in the Brantas River Basin

After construction period, it is necessary to maintain function of the completed infrastructures in order to ensure maximum benefit to achieve the designated technical life span and to achieve sustainable development. Adequate operation and maintenance activities are necessary to be conducted by a permanent institution, with professional staff and adequate budget. However, after most of the water resources infrastructures in the Brantas River Basin were completed, some specific problems were encountered:

After the construction period, it is necessary to maintain the function of the water resources infrastructures to ensure optimum benefit at their planned lifetime. Adequate operation and maintenance (O&M) activities are necessary to be performed, however, these activities encountered specific problems as follows:

1) Institution

   Until 1990, the Brantas River basin has no permanent institution that could perform O&M activities in a conceptual and sustainable manner. Brantas River Basin Development Project (BRBDP) is a temporal institution whose duty is only to carry out the construction and not the O&M.

[1] This column was computed based on information prior to the basin development as cited in the first Master Plan (1960). Mendalan and Siman HEPP solely provide hydropower generation; raw water for domestic purposes is based on abstraction of Ngagel I and II water purification plant in Surabaya; raw water for industries is obtained from abstracted water by sugar cane factories – dominant industry in the basin at that present moment.

2) Funding

BRBDP who had then to carry out the O&M, encountered problems in obtaining fund for these activities due to the limited National Government Budget.

3) Water Resources Degradation

Lack of O&M budget resulted in degradation of the water resources infrastructures, and less coordination among related agencies complicated the water resources management. This scheme posed risk of water resources degradation, which in the long run shall harm economic development of the basin. Whereas water degradation is evident, sustainable resources are at risk.

B. Corporatization of Water Resources in the Brantas Basin

1. Objective of the Corporatization Process

Since the establishment of Jasa Tirta I, water resources service in the Brantas River Basin is corporatized. Objectives of the corporatization process are as follows:

- To develop and sustain a river management system that conserves the river as an integrated part of the ecosystem, whilst preserving its economic potentials and function for the people's welfare.
- Improve river basin management performance in a useful manner.
- Improve public and private participation in water resources management in order to reduce the National and Regional Development Fund.
- Develop a harmonious and motivate working environment to sustain prime-class-service for public demand through competent management of water resources infrastructure for stakeholders' satisfaction.

2. Main Tasks and Scope of Activities of the Corporate Body

The proper form of institution to apply corporation concept in river basin management is a state-owned company in form of "public corporation". This preference is made based on consideration that beside economic objectives of the management, water has also social functions. Thus, it is evident that water resources cannot be managed fully commercial (privatized). Thus, Jasa Tirta I is a public corporation.

To achieve the objectives, the assigned corporate body deals with technical, financial and management issues. Main tasks are credited as follows:

a. Performing operation and maintenance activities of water resources infrastructures;
b. Dealings in water and water resources;
c. Management of river basin, including water resources conservation, development and utilization;
d. Rehabilitation of water resources infrastructures according to capability of the corporate body.

Scope of activities undertaken by the Jasa Tirta I is related to: (1) watershed management; (2) water quantity management; (3) water quality management; (4) flood control management; (5) river environment management; (6) water resources infrastructures management; and (7) research and development.

3. Financial Sources

Financial source for undertaking of the main tasks in water resources management, are secured from the beneficiaries participation. Beneficiaries gradually bear the operational cost of the assigned corporate body. Basically, beneficiaries render their participation in the following sources:

a. Beneficiaries pay for water services, rendered in form of water fee and tax;
b. Polluters are obliged to pay pollution fee and tax;
c. Government finances social services like flood control, water quality control, and water resources conservation.

C. Corporatization Achievement

As a professional institution, Jasa Tirta I Public Corporation is responsible to develop a proper management system and technology application for basic and advanced water resources management in the Brantas River Basin. Purpose of the corporation covers technical aspects, financial aspect, and management aspect.

1. Technical Aspect

For development purposes of water resources infrastructures, flood control, pollution control and other environmental aspects, comprehensive master plans have been developed in sequence. These master plans were completed in coordination with related inter-sectoral agencies on mutual agreement.

In implementing the stipulated activities, as designated in the master plan, the responsible corporation carries out coordination especially with the related agencies**.** Water allocation – as an example – is carried out through coordination with the governmental agencies, Jasa Tirta I Public Corporation as managing institution, main stakeholders, representatives of sectoral users, non-governmental organizations, and experts, at the provincial and basin level.

As result of this coordination, a specific reservoir operation pattern for the Brantas River Basin is prepared by Jasa Tirta I Public Corporation and agreed by all parties. Implementation of this pattern will be carried out by the corporation (that is responsible for maintaining the reservoirs), related irrigation agency, and other main stakeholders. This mechanism is used to solve inter-sectoral water allocation and appraise a fair and transparent result.

For other aspects, like river environment management and water quality management, the same procedure is used. The governmental agencies, main stakeholders, representatives, and experts are consulted and proactively involved in the implementation process.

It is expected that in the near future, a coordination body is established – as a committee to solve the coordination problem among the various sectors involved in water resources management. This committee is expected to be established both at the national, regional and basin level, whereas management institutions like Jasa Tirta I in the Brantas River Basin, as residing member to implement the committee's decisions.

2. Financial Aspect

The Corporation, step-wisely apply the principle of "full cost recovery". Beneficiaries like the state electricity company (in Indonesian: *Perusahaan Listrik Negara*, abbreviated as PLN), domestic water supply companies (*Perusahaan Daerah Air Minum* abbreviated as PDAM) and industries, contribute financially for the water resources and infrastructure management.

Tariff of the rendered water service fee is decided mutually, based on agreement among the stakeholders. The service is conducted also on a contract basis that provides security for both parties. In the future, it is expected that the Basin Water Resources Management Committee will act as consultation forum for having an agreement on the tariff for each water user.

3. Management Aspect

As a state-owned company, the managing corporate body is subject to various management audit and control. Management performance of the corporation is judged based on either financial criteria's as well as good-corporate performance or best common practice in managing a company.

During the last 10 years, the corporation is positioning itself better, in form of a consolidated water resources management system that is supported by regional legislation for the operational basis of the management. The corporation also implements a quality assurance system that ensures good performance of the management body. ISO 9001:2000 had been applied since 1997 as commitment of Jasa Tirta I to achieve stakeholders' satisfaction through continuous improvement of the system and responsive actions on stakeholders' complaints.

IV. Assessment on Relevant Challenges and Issues in the Future

The following challenges and issues are identified as the most likely to have significant impacts on future water management in the Brantas Basin.

A. Challenges

The following challenges were identified as the most likely to have significant impact on future water management in Brantas. These are formulated in consideration that it is not in particular order that reflects the threat but more of a simultaneous ramification of the challenge.

1. ***Economic growth*** shall affect shifting demands between and within agriculture and industrial sectors, which in turn leads into differences in water use efficiency and supply-delivery requirements. Economic growth is most responsible for water pollution, especially effluent discharge and on the long run, more complex and intricate aspect of balancing the water demand in its proper quantity and quality. A strong economy can allow for greater flexibility in the water management framework by providing opportunities to put economic instrument in use for better environment control. Although, recent crisis in Southeast Asia has not proven that the opposite economic situation improve water resources management; the crisis decreases economic growth but not water misuse.

2. ***Social shifts***, in form of population growth and urbanization affects directly water use. Population growth increases pressure on all environmental resources, including water. As shown in the population growth rate in the Brantas River Basin, which is estimated as far 2%, water pressure could double-fold water-stress. Urbanization on the other hand increases pressure on supply and sanitation. Closed enclaves of densely populated areas are subject to environment degradation and as well water resources destruction. It is necessary to take into account the importance of public participation in the sense of conserving natural resources.

3. ***Environment degradation*** affects water supply in terms of quantity (overexploitation) and quality (pollution). Environment degradation impact transcends into water resources through links of economic performance, public health, social stability, and welfare sustainability. This impede the importance of public awareness; how to alter consumptive behaviors and increase participation in conservation. Political will to conserve should be accompanied by regulation drafting and legal procedures, to ensure its implementation.

4. ***Shifts of paradigms*** are one of the impacts in the Southeast Asia post crisis condition economic advent. Social economic development has given path to shifts of paradigms on water resources. Water that has always been regarded as a social good has transformed into an economic good with social function. This has also affects the Government role, which shifts from being a provider towards enabler, from a centralized towards a more decentralized approach, from a single purpose towards multi sector approach, from a less towards broader public-private-participation.

B. Issues

River basin management consists of development, utilization, and conservation as well control of water resources. It could be defined as an effort to realize utilization of water resources to satisfy all demands in an efficient, effective and fair manner, by taking in consideration conservation and control on water and its resources.

This management concept is summarized in the maxim of One River, One Plan, and One Integrated Management that cover activities of watershed management; water quantity management; water quality management; flood control management; river environment management and water resources infrastructure management.

Key issues identified in this context are as follows:

1. Technical

a. ***Watershed degradation*** has become an important constrain, since erosion (related to land use and spatial management) and natural forces (volcanic debris) enhances sedimentation that shortens economic life of major dams in the basin and natural base flow degradation during dry spells.

Key issues:

- Optimal soil stability and productivity
- Sustainable and optimal forest resources management in accordance with their natural, social and economic functions
- Sustainable and environmentally considered land use

b. ***Limited water availability*** in the Brantas River Basin, where only 25% of the potential 12-billion m^3 renewable water is available for consumption. Increase in water demand and constraints in supply lies behind limited availability, impeding an out-of-balance condition that poses conflict of interest between users.

Key Issues:

- Water demand and supply management
- Protect and conserve ground water to meet demand

c. ***Water quality degradation*** occurs in the Brantas River Basin—where pollution from domestic and industrial sources has load the river and creates a span with the designated standards. Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Dissolved Oxygen (DO), and other water quality parameters are continuously monitored.

Key Issue:

- Water quality meets its assigned standards and designated use

d. ***Flood hazard*** is occurring even the first Brantas River Basin Master Plan (1961) has mitigate this threat from the dense-populated basin. This hazard occurs back due to slack urban drainage facilities, degradation of recharge areas as well as sedimentation in major multi-purpose dams that has the responsibility to store water during wet seasons.

Key Issue:

- Optimally control the impacts of flooding and mitigate its hazard

e. ***Threatened river environment*** is an accumulation of riverbed degradation and management in river corridor use; has converged with water quality degradation that threats the ecosystem, bio-diversity, and human welfare as well.

Key Issues:

- Stable and diverse riverbanks function in accordance with prevailing rules and regulations
- Preserve river functions, water resources infrastructures and river based ecology

f. ***Water resources infrastructure degradation*** due to lack of proper operation and maintenance could hazard water resources management in the river basin.

Key Issue:

- Improving operation and maintenance activities by support of professional management and financial contribution from water stakeholders

2. Financial & Management

a. ***Financial support*** for the sustainable water resources management, supported by all beneficiaries.

Key Issues:

- Stakeholders' participation (including the biggest consuming group: farming)
- Financial accountability

b. ***Funding*** water resources management for the welfare and safety of the people and environment conservation is only possible whether the government is willingly to take part (contribute) its shares.

Key Issue:

- Lack of funding to achieve the Brantas River Basin strategy goals

c. ***Community awareness, education, and participation*** become important since people play an important role in utilization & conservation of environment and its resources.

Key Issue:

- Capable and willing community of active and constructive participation in the conservation (in broad sense) of natural resources in the Brantas River Basin.

d. ***Decentralization*** in regard to this nation-wide policy, all natural resources are owned by the respective Local (Regencies / Municipal) Government.

Key Issues:

- Water is a flowing resource that encompasses both administrative and economic boundaries.
- Role sharing and water resources prioritization (national, regional and local levels)

3. Laws and Regulation

a. ***Watershed conservation*** in the Brantas River Basin is currently carried out by a number of agencies with unclear demarcation of their rules and responsibilities.

Key Issue:

- Each agency concerned has its policies, strategies, objectives, rights and responsibilities. Unclear authority and mechanism lead to difficulties in coordination.

b. Limited water availability may be occurring in the future due to enormous amount needed and limited location to built a new reservoir. At present, there is no regulation to ensure the beneficiaries to use water more efficient.

Key Issue:

- The water right is necessary to be introduced to the beneficiaries to ensure the water availability and also to support them to take care of water availability (through efficiencies, water recycling etc)

c. ***Water quality*** is a complex problem requires sufficient fund, long term monitoring and commitment of all parties concerned i.e. Government, water user etc.

Key Issue:

- Implementation of effluent charge as one of economic instruments is needed in controlling water pollution.
- Law enforcement to polluters is needed in controlling water pollution.

d. ***River environment management*** should include the use of riverbank and also how to keep the sustainability of river and its infrastructure.

Key Issue:

- In order to control land use in river area, it is necessary to establish a proper river environment management supported by proper regulations, included here is law enforcement to avoid all illegal activities that cause degradation of river and its infrastructures such as sand mining activity etc.

e. At present ***funding*** for water resources management is not sufficient to implement a proper WRM.

Key Issue:

- The funding for WRM should be supported by proper regulations.

V. Future Prospecting Basin

Jasa Tirta I Public Corporation was established to solve managerial, personnel and financial problems that loom over the completed water resources infrastructure in the Brantas River Basin. This task was achieved, not in a perfect sense, but as a role model for other river basins in Indonesia, this corporate body is an example of what proper management can do to extend the development benefits to its beneficiaries.

After 10 years management by the corporate body, it was found that the following benefits could be extended to the beneficiaries.

Table 4 Management benefits of Jasa Tirta I Public Corporation in the Brantas River Basin

Beneficiaries	Unit	1990	2000
Flood control (main stream)	Inundated areas	None	None
Irrigation	Cropping intensity	1.8 / year	2.2 / year
Hydropower[2]	Million kWh/year	910	1,200
Raw water for domestic	Million m3/year	125	206
Raw water for Industries	Million m3/year	115	129
Water quality[3]	BOD average	12–16 mg/liter	4–9 mg/liter
Water res. Infrastructures		Fair	Relatively better

As it could be seen, flood control in the mainstream is maintained with a designated capability to control 50-years return period flood. Higher than before, hydroelectric power generation in the basin is optimized from 910 kWh annually to an amount of 1,200 million kWh annually. Agricultural cropping intensity in the basin has increases from 1.8 to 2.2 / year. In matter of water quality, the average water quality in the basin is approaching to designated standards, eventually it has not yet fully achieved its target.

In the future, the Brantas River Basin will face diverse problems due to the pressure of the population growth and squeeze of the industrialization pace. Water demand will increase significantly, while the supply remains limited. Previous assessments to the East Java water balance of the urban areas of Gresik, Bangkalan, Surabaya, Sidoarjo and Lamongan shows the importance of developing new sources of surface water to cope with the growing demand like Genteng Dam, Kedungwarak Dam and Beng Dam.

On the other hand, supply improvement shall not put an end solution to the whole situation, as demand management is also important. Altogether with improvement of irrigation, water re-use and recycling, and remaining storage utilization, the Brantas River Basin is expected to cope with Gresik, Bangkalan, Surabaya, Sidoarjo and Lamongan water demand up to the year 2020. Keeping the Brantas River as backbone of the prosperity is the main vision of all stakeholders in this heritage basin.

[2] Including Mendalan and Siman HEPP

[3] Biological Oxygen Demand (BOD) standard for the designated river class is less than 6 mg/liter.

VI. Conclusion

1. The Brantas River Basin has experienced integrated water resources development that resulted into diverse water resources infrastructures for flood control, power generation, irrigation and bulk water supply, etc. This integrated water resources development is carried out based on “One River, One Plan” principle and is based on a series of master plans that involves stage-wise planning in accordance to the national development requirements.
2. As a professional institution, Jasa Tirta I Public Corporation is responsible to develop a proper management system and technology application for basic and advanced water resources management in the Brantas River Basin. Purpose of the corporation covers technical aspects, financial aspect, and management aspect.
3. Some challenges are identified as the most likely to have significant impacts on future water management in the Brantas Basin i.e. economic growth, social shifts, environment degradation, shifts of paradigms. Some issues also are identified regarding watershed degradation, limited water availability, water quality degradation, flood hazard, threatened river environment, water resources infrastructure degradation, financial support, funding, community awareness, education, and participation.