Perspective of Water Quantity and Quality Management in the Brantas River Basin, East Java, Indonesia

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I. Introduction

Indonesia is the world's fourth largest nation with a population of 234 million (July 2007 estimate) and growing at 1.3 percent per-year; approximately 57% of the population live in rural areas. Agriculture accounts for 13% of the Gross Domestic Product, and the 2007 GDP per-capita was US$3.900 (in purchasing power parity terms, constant to 2000 US$). Although Indonesia is a vast archipelago, with a total land area of 1.9 million km^2, roughly half of the population is concentrated on the island of Java (132,500 km^2) due historically to the island's extremely favourable climate and soils. About 64% of Java (and Bali) falls within moist rainfall zones (1,500 to 3,000 mm per-year). Potential crop evapotranspiration rates averages around 1,400 mm per-year.

Java has 3.3 million of irrigated area (Rodger, 2005), close to 43% of Indonesia's total irrigated area. Almost 60% of this area is served either by technical or semi-technical irrigation systems. Renewable water in Java is only 1,540 m^3/person/year, compared to Indonesia average of 15,600 m^3/person/year, reflecting a high population density (Machbub, 2000). In Indonesia, roughly 93% of utilized freshwater resources are withdrawn for irrigation, 6% for domestic and 1% for industries.

Paddy (*Oryza* sp or wet rice) is the most important irrigated crop. Rice is the staple food of Indonesia. More than half of all paddy produced in Indonesia is harvested on Java, and Javanese yields are around 15% higher than the Indonesian average reflecting the concentration of technical and semi-technical irrigation systems, favourable soils and climate, and the historical accumulation of experience in paddy cultivation (Rodgers, 2005).

Harvested paddy area expanded steadily between 1951-2000, actually accelerating, particularly during the final decades of the record. Yields, by contrast, were stagnant during the decade of the 1950's, took off in the 1960's and grew rapidly through the 1970's and 1980's, contributing almost 70% of the total output growth during the period 1961-1990. However, yield growth stagnated in the 1990's, suggesting a combination of transient adverse climatic conditions, impact of recent declines in investments in irrigation and agricultural research, and near-exhaustion of the gains from the "green revolution" crop improvement programs of the 1960's to 1980's. The share of rice output growth during 1969-1990 explained by public investment in research, extension and irrigation was estimated 85%, of which extension accounted for 33% of output growth, followed by irrigation 29% and research at 23% (Rosegrant et.al., 1998). A more recent study estimated that between 1985 and 2000, expanded irrigation and improvements in its quality, accounted for about 23% of rice output growth in Indonesia (Rodgers, 2004).

II. Brantas River Basin

2.1 General Description

Brantas River Basin is located in Java, one the important island in the archipelaic Indonesia. It runs through the western section of the East Java Province. The basin is situated from Latitude 7° 1' to 8° 15' South and Longitude 110° 30' to 112° 55' East. The river mainstream traverses 9 regencies and 5 municipalities. Starting at the upper regions of the river they are Malang, Blitar, Tulungagung, Kediri, Nganjuk, Jombang, Mojokerto, Sidoarjo, and Surabaya City, including portions of Pasuruan and Gresik. A general view of the Brantas River Basin is shown in Figure 1.

Volcanoes within the Brantas Basin are Mount Arjuna (3,339 m), Mount Anjasmara (2,282 m), Mount Butak (2,868 m), Mount Kawi (2,651 m), Mount Kelud (1,724 m), Mount Semeru (3,676 m), and others. Mount Semeru is constantly active. In this century, Mount Kelud has erupted on a large scale an average of once every 15 years: 1901, 1919, 1951, 1966, and 1990. The total volume of ejecta is estimated at 100-200 million m^3 having a decisive effect on local society as well as the environment.

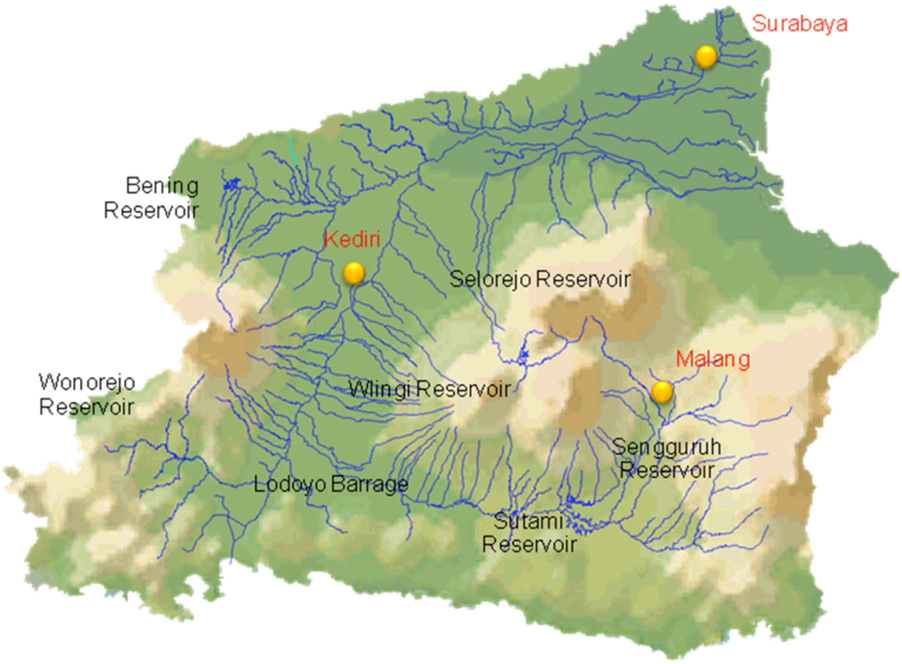


Figure 1 Brantas River Basin (11.800 km^2) in East Java, Indonesia

The Brantas River is characterized by clockwise watercourse centering on Mount Kelud. This is influenced by the process of mountain uplift and the volcanic ranges. The Brantas originates from the southeastern side of Mount Anjasmara located in the center of its basin. The uppermost stream starts its course eastward south around the Semeru volcanic zone, and the runs to the west parallel to the Southern Mountains, which stretch east and west blocking the river's course. It changes its course again to the north to avoid older volcanoes and Mount Wilis, and the runs past the foot of Mount Wilis and Mount Kelud to reach Surabaya City. Thus the Brantas travels past all the majopr volcanic ranges in the basin.

2.2 Physical and Social Features

The average specific runoff of the Brantas River (average runoff per 100 km^2) is 3,4 m^3/sec at the Karangkates Reservoir for the basin's upper branch, and 2,7 m^3/sec at Jabon for the basin's lower branch. Evaporation of the Brantas is 40-50%.

Rice yield in the Brantas Basin 1965 was 1,107 million tons. It went up to 2,299 million tons in 2004 even though there was only a slight increase in paddy field area. A comparison between 1965 and 1993 yields shows that the rate of increase in the Brantas Basin was 2.33 times in contrast to 2.29 times for the entire country. This can be said to be a direct result of advanced intensive agricultural methods, based on the availability of irrigation water in the dry seasons. The rice yield per unit area was 5.67 tons/ha on the national average as of 2004, showing a considerable increase from 3,48 tons/ha in 1965. The yield for the Brantas basin was 3.69 tons/ha in 1965 and 5.48 t/ha in 2004, well beyond the national averages. This was due to improvement of rice varieties, introduction of chemical fertilizers, and an increase in double cropping made possible by secured irrigation water in dry season.

The installed capacity for power generation was 13,600 MW as of 1993. of these, hydroelectric power generation makes up, 2,179 MW, 16.0% of the total installed capacity for power generation. The total installed capacity in East Java is 3,682 MW; of which 275 MW are hydroelectric. The installed capacity for hydroelectric power generation in the Brantas Basin is 263 MW, which are 12.3% of the total in Indonesia and 97.8% of that in East Java. The electrification ratio on Java Island was 76.1% as of 1993, exceeding the national average of 54.7% The Brantas Basin was among the areas on the island with the highest electrification ratio, being 15% in 1970 and more than 85 % in 1993 and 89% in 2005.

The power consumption pattern of Java Island is characterized by peak usage occurring in the evening between 18:00 and 23:00. The State Electricity Corporation (in Indonesian: *Perusahaan Listrik Negara* or PLN) has presented the basic policy that thermal power should be used for the base load during the day and hydropower for peak night use. In order to secure the base load, large-scale, high efficiency thermal power plants (combined cycles technology) had been constructed, i.e Pasuruan Thermal Power Station (operation in 1995) and Gresik Thermal Power Station (2000). But as thermal power plants relies on fossil fuels, that are increasing in cost, construction of a large-scale hydro-electric power plants are also being considered for the Brantas River Basin as a renewable base of power for energy generation.

The population in the basin in 2006 (13,480,000) has doubled of 1960 (8,370,000). Surabaya City alone showed a remarkable increase of 2.27 times compared to the 1.84 times of Java Island during the same period. This is good proof of Surabaya's rapid growth as a commercial and industrial city. With a population of 15,635,527 as of 2004, Surabaya is the biggest commercial and industrial city next to Jakarta. Also, being a port city equipped with modern facilities, it serves as a hub of domestic trade. With the availability of a plentiful labor force, the Brantas River Basin around Surabaya City has become industrialized and urbanized, thereby creating a sharp increase in economic activities.

Table 1 Physical Features of the Brantas River Basin

Main river course: Brantas		Length 320 km	
Administrative Location		**Geo-reference Location**	
Province of East Java (14 regencies or municipals)		110°30'-112°55' EL, 7°31'-8°15' SL	
A.	**Main Tributaries and Basins (in km²)**	11,800	
	Lesti	625	
	Konto	687	
	Widas	1,539	
	Brantas	6,718	
	Ngrowo	1,600	
	Surabaya	631	
B.	**Water Availability**		
	Average precipitation	2,000	mm/year
	Run-off coefficient	0.50	
	Potential flow	11.8	billion m³
C.	**Surface Water Utilization (in mill m³)**	2,934	
	Irrigation water	2,400	
	Domestic-residential supply	158	
	Industry bulk water	131	
	Maintenance flow	204	
	Fisheries	41	

Source: PJT-I

2.3 Water Resources Development and Management

The Brantas River originating from a spring in Sumberbrantas village has been subjected to the erratic and frequent eruptions of Mount Kelud (recorded as far back as 1000 AD) that has affected the river morphology but has created a fertile basin that supports agriculture. The availability of abundant water supply and the fertile area resulted in rapid development, first in the downstream area, which gradually spread upstream. As early as the end of the 19th century, Surabaya River started having difficulty in terms of navigation during the dry season.

The 16 or so sugar cane factories established since the middle of the 19th century and the Brantas delta irrigation area that was developed (Lengkong Barrage, 1857) to cultivate sugar cane and the navigation system started facing water supply problems. The small irrigation systems were gradually integrated into larger irrigation systems. Dikes, which were constructed to minimize local flooding, were gradually unified and extended to cover reaches from the estuary to the middle stream. At the time of Indonesia's independence (1945) the Brantas basin was the most developed river basin for irrigated agriculture and flood protection.

Recent developments in the Brantas basin began with the help of the Japanese government as part of the war's reparations assistance. Under this assistance in 1961 a tunnel to drain the Ngrowo River basin water (tributary to the Brantas River) to the south was constructed to protect the Tulungagung area from flooding. It was then realized that future Brantas basin development had to be based on a «One River, One Plan, One Management» approach. In line with this, comprehensive basin plans were developed starting in 1961. These were periodically reviewed to take up further development in the basin. The planning and implementation phases undertaken so far are**:**

- **Master Plan-I** (1961) that emphasized flood control by developing dams in the upper reaches and river improvement to increase channel capacity;
- **Master Plan-II** (1973) that emphasized irrigation development to support government policy on rice self sufficiency by developing reservoir, barrages, and technical irrigation systems;
- **Master Plan-III** (1985) that emphasized water supply for domestic and industrial users to support the government policy on industrialization and urban development through development of raw water systems and reservoirs; and
- **Master Plan-IV** (1998) that emphasized conservation and basin water resource management to face the environmental and pollution problems through implementation of institutional approaches for proper water governance.

Japanese war reparations and loans, as well as OECF and JBIC grants supervised by OTCA and JICA supported all of the above plans and their implementation. While japanese consulting firms provided the survey, planning, design, and supervision capabilities; as well the Kajima Corporation offered construction guidance. In addition bilateral assistance for water quality management has been provided by the French and Austrian governments and by multilateral donors such as the World Bank and Asian Development Bank for improving the irrigation systems, its management, and basin water management.

The total development in the basin over the past four decades has resulted in the construction of eight reservoirs, four river improvement schemes, nine barrages, three rubber dams and a number of irrigation system construction projects and improvements. Table 2 provides a list of water resources infrastructure with its year of construction, river on which it is located and the purpose for which it is used.

Table 2 Water resources infrastructures within the Brantas River Basin

No	Structure	River	Purpose
A	**Reservoirs**		
	Selorejo (1970)	Konto	Water supply for irrigation, and additional supply for hydro power plants at the downstream area,[1] hydro power generation.
	Sutami (1972)	Brantas	Water supply for domestic, irrigation, industry, hydro power generation, flood control, recreation.
	Lahor (1975)	Lahor	Connected reservoir to Sutami.
	Wlingi (1978)	Brantas	Afterbay of Sutami Hydro power, water diversion for irrigation, hydro power generation, flood control and recreation.
	Bening (1984)	Widas	Water supply for irrigation, hydro power generation, flood control and recreation.
	Sengguruh (1988)	Lesti	Sediment control facility for Sutami Reservoir and hydro power generation.
	Wonorejo (2000)	Bodeng Song	Water supply for domestic purposes, hydro power generation and flood control.
B	**Barrages**		
	Bendo (1963)	Bendo	Water diversion for irrigation and flood control
	New Lengkong (1974)	Porong	Water diversion for irrigation, domestic, and industry
	Gunungsari (1981)	Surabaya	Water diversion for irrigation and flood control
	Jagir (Rehab) (1981)	Wonokromo	Water diversion for domestic and flood control
	Lodoyo (1983)	Brantas	Flow regulator (afterbay) of Wlingi hydro-electric power plant as well as hydro-electric power generation
	Wonokromo (1990)	Mas	Flood control
	Mrican (1992)	Brantas	Water diversion for irrigation
	Segawe (2001)	Song	Water diversion into Wonorejo Reservoir
	Tiudan (2002)	Song	Water diversion into Wonorejo Reservoir
C	**Gate**		
	Mlirip (1978)	Brantas	Water diversion into Surabaya River for domestic and industry purposes.
	Tulungagung (1986)	Ngrowo	Water regulation for hydro power and flood control through Parit Agung Canal and Tulungagung Southern Tunnel.
	Wonokromo (1992)	Surabaya	Water diversion into Mas River
D	**Rubber dams**		
	Gubeng (1990)	Mas	Water diversion for domestic
	Jatimlerek (1993)	Brantas	Water diversion for irrigation
	Menturus (1993)	Brantas	Water diversion for irrigation

Source: PJT-I

2.4 Jasa Tirta I Public Corporation

Jasa Tirta I Public Corporation (PJT-I) established in 1990, based on Government Regulation No. 5/1990 (later replaced by Government Regulation No. 93/1999 to strengthen the organization and permit its jurisdiction to extend to other basins), is charged with managing the water resources in 40 of the more important benefit producing rivers (including the Brantas River) of the basin and to operating, maintaining, and managing the major infrastructure in these rivers.

[1] Two existing hydro-electric power plants are operated downstream, namely Mendalan and Siman.

The Corporation has no role in irrigation management in the basin except to provide bulk water supply to the irrigation systems. It provides comprehensive water resource development (mostly non-structural) and utilization service to fulfill all types of surface water demand, water resources protection, water quality monitoring, flood operation, O&M of water infrastructure, conservation and providing information, recommendations, public campaigns and technical guidance.

The activities of the corporation cover (i) bulk water supply for irrigation systems, (ii) raw water for domestic and industrial purposes, (iii) water supply for hydropower plants, (iv) land rent and limited sand minings, (v) tourism in its working area, and (vi) construction and consulting services. In 2000, the Brantas Corporation was authorized to undertake WRM in 25 rivers of Bengawan Solo River Basin (an inter-provincial river basin lying in Central Java and East Java).

PJT-I is supervised by a supervisory board composed of central and provincial government representatives and is managed by a board of directors headed by a president director. Being a national corporation, the authority to oversee the management and functioning of PJT-I lies with the center through the Ministry of Public Works, with the Ministry of State-owned Corporation (MoSC) exercising a fiscal oversight role.

The day-to-day management of the corporation is with an executive board composed of a President Director, a Director for Technical Planning and Development Affairs, a Director for Financial Affairs, a Director of Operations for the Brantas River and the Bengawan Solo River, and a Director for Human Resources Development. Four regional units (division) in the Brantas basin and three regional units in the Bengawan Solo, manage the field operations and special units undertake research, planning, and quality management.

The main functions of PJT-I are (i) water quantity management, (ii) water quality management, (iii) flood control management, (iv) river environment management, (v) watershed management, (vi) water resources infrastructure management, and (viii) research and development. In carrying out these activities, the corporation coordinates with stakeholders such as the State Electricity Corporation, municipal water supply corporations, private and public sector industries, NGOs, and experts.

The corporation is not responsible for irrigation system management but provides bulk water. In cases where water supply is made from the irrigation system for non-irrigation functions (water supply to industry), the corporation coordinates with the concerned irrigation agency. Thus, much of the management decisions are based on a consultative process through a proactive approach. The corporation is authorized to make most of the technical policy decisions and some policy decisions related to WRM, such as release of reservoir water for flushing, changes in water allocation during times of shortage, reservoir operation, awareness campaign.

The corporation, however, has no policy power in areas such as basin planning, basin infrastructure development and investment, off-stream water quality improvement, tariff fixing etc. In these areas where it is not permitted to make policy decisions, PJT-I works through the administrative and consultative channel to influence decisions. As an organization PJT-I has been very effective in most aspects of the WRM decision-making, coordination, improving resource base, and working with other basin agencies and stakeholders by adopting a proactive management style and having a good working relationship with both formal and informal institutions.

Brantas River Basin is the first river basin in Indonesia who applies Quality Management System of ISO 9001-2000 for design, operation and maintenance of water resources and infrastructure since 1997 as commitment of PJT-I to achieve stakeholders' satisfaction through continuous improvement of the system and responsive actions on stakeholders' complaints as reflection of PJT-I's motto "**Identity by Quality**".

III. Water Quantity in the Brantas River Basin

Present water use in the Brantas River basin is primarily for (i) irrigation, (ii) domestic water supply, (iii) industrial water supply, (iv) hydropower generation, (v) brackish water fish ponds, (vi) recreation and tourism, and (vii) river maintenance flow. The total average annual water utilization for the above uses is estimated to be 2,934 million m^3 and varies from 20% to 25% of the total available water. However, seasonal variations of the availability of water cause water supply shortages in some locations.

3.1 Present Water Use

Irrigated Agriculture

Irrigated agriculture is the largest water consumer in the Brantas basin. Table 3 provides details of the irrigated area (technical, semi-technical and village systems) in the Brantas basin under each of the sub-regions and in East Java as a whole. Of the 907,700 ha irrigated in East Java around 387,100 or 43% is in the Brantas basin. Of this nearly 84,000 ha is supplied from the Brantas River while the rest is served from its tributaries. The main crops in the irrigated area are paddy, sugar cane (*Officinarum sacharrum*), maize (*Zea mays*), soybeans and peanuts (*Arachis hypogea*), the later three crops grown primarily in the dry season are known as the *palawija* crop. The total amount of water diverted for irrigation varies from 2,298 million m^3 per year to 2,448 million m^3 per year. In the dry season a very large proportion of the river flow in the rivers is diverted to irrigation schemes. In all about 70% to 80% of water use is for irrigated agriculture.

Table 3 Agriculture land based on irrigation type

Description	Type of Irrigation (ha)			
	Technical[2]	Semi-Technical[3]	Non-Technical[4]	Total
Brantas R.B.	242,463	31,967	34,669	309,099
East Java Prov in Total	715,494	94,116	98,058	907,668
Brantas / East Java	34%	34%	35%	34%

Source: East Java Provincial Office in Ramu (2004)

The primary impact of development in the basin as it relates to agriculture is in the transformation from low-intensity agriculture to high-intensity agriculture. The cropping intensity in 1960 was around 0.8 but by 2000 had increased to 2.2 (see Table 4) while the area cultivated under irrigation increased from about 247,000 ha in 1970 to around 387,100 ha at present. The following table (Table 11) provides a comparison of the irrigated area and rice production in the years 1970 and 2000.

Table 4 Irrigated agriculture development in the Brantas River Basin

Description	Unit	Year				Comparison			
		1970s		2000s		Brantas/E.Java		2000s/1970s	
		E. Java	Brantas	E. Java	Brantas	1970s	2000s	E. Java	Brantas
Rice									
a) Production	mill ton	4.66	1.43	9.22	2.99	0.31	0.32	1.98	2.10
b) Irrigated area	10^3 ha	1,129	246.85	1,158.12	387.11	0.22	0.33	1.03	1.57

2 Technical irrigation: designed headworks and canal system, operated at all season.

3 Semi-technical irrigation: designed heardworks and canal system, with operated temporary

4 Non-technical: rudimentary irrigation system developed partially (village based)

Description	Unit	Year				Comparison			
		1970s		2000s		Brantas/E.Java		2000s/1970s	
		E. Java	Brantas	E. Java	Brantas	1970s	2000s	E. Java	Brantas
c) Harvest area	10^3 ha	1,129	314.28	1,713.75	546.61	0.27	0.31	1.51	1.74
d) Yield	ton/ha	4.13	4.55	5.38	5.47	1.10	1.02	1.30	1.20

Source: Central Bureau of Statistics, Indonesia in Ramu (2004).

It is seen that in the three decades both the cropping intensity and per-hectare yields have increased due to improvement in rice variety, increased agricultural inputs, and provision of assured water supply in the dry season.

Irrigation Management

Irrigation management and decision making has primarily been a provincial subject. While the center has been investing in irrigation development and improvement activities, much of the water management and cropping pattern decisions are left to the district/provincial levels. At the lower end, the water user association (WUA) manages the water distribution and the O&M aspects in the tertiary blocks (50 to 150 ha in size) while the field offices (Cabangs) of the provincial agency were responsible up until 2000 for the water management aspects in the irrigation system, including its O&M. Since 2000 this responsibility has shifted to the district level agencies. The irrigation committee (consisting of various agencies but no stakeholders) at the district level decides on the cropping pattern for the next cropping season and the pattern of water allocation. In the case of the Brantas basin, the Provincial Water Resources Committee (PTPA) decides on the water allocation among various users from the resources, which determines the rule curve for operating the storages. In the absence of a water rights system, decisions on water diversion to irrigation systems is left to the water resource agency based on historical operation procedures and PTPA/PPTPA guidance. Conflicts among users in the irrigation system (upstream-downstream conflicts, conflicts between uses) are normally handled by the water agency through negotiations. In some cases there have been examples of exchange of water use rights between users and types of uses.

Between the year 2001 up to 2007 East Java has implemented, on a pilot basis, the Irrigation Management Transfer program (IMT) in which part of the management and associated decision making is transferred to the Federation of WUA (GP3A). Stream level committees, known as *induk*, work with the water agencies in deciding on the water allocation, O&M program, and management of the system. The GP3A in some cases have taken on small maintenance works. Currently there are about 11 *induk*, 144 GP3A, and 963 WUA in East Java that are participating in this program. In the Brantas basin presently there are 2 *induk*, 39 GP3A, and 286 WUA covering 33,362 ha that are functioning based on IMT principles. It is hoped that with the spread of the IMT program all irrigation systems and irrigation management will be fully decentralized so that the farmer organization in partnership with the district level water agencies makes all the decisions on the investment, operation, maintenance, and management aspects.

The centerpiece of the reform is the new Water Law No.7/2004, which was debated in Parliament for over eight months, for the first time addresses issues related to water rights, beneficiary participation, cost recovery, basin planning and management based on an integrative approach, regional authority over basin, formation of central or regional public sector corporations that are self-financing, formation of a National Water Council and Regional Water Councils with stakeholder participation, etc.

However, a major drawback is imposed in the Water Law No 7 of 2004, related to irrigation management and its cost recovery. The water sector reform under Government Regulation No 77 of 2001 envisaged launching the Irrigation Management Transfer Program (IMT) under which part of the management of the irrigation system and associated decision-making would be transferred to the farmers association known as Water Users Association (WUA) or GP3A. This would not only permit WUA/Farmer Federations to invest in rehabilitation, upgrading, and O&M of the primary, secondary, and tertiary systems but also permit them to undertake civil works through contracts, or self-help (*swakelola*).

The water law has, however, reversed this by restricting farmer associations' role to the tertiary system while giving the authority for funding and management of primary and secondary systems to the government. It has further restricted the decentralization approach by allocating all authority for irrigation systems larger than 3,000 ha to the central government and for irrigation systems from 1,000 ha to 3,000 ha to the provincial governments. Only irrigation systems below 1,000 ha will be under the authority of the district level governments. This situation, obstructs the IMT process that has been enacted in the Brantas River Basin since 2001; no further details could be added presently.

Domestic Water Supply

In the Brantas basin, raw water for domestic purposes is provided for fourteen regional water supply enterprises known as Perusahaan Daerah Air Minimum (PDAMs) that provide treated drinking water to urban areas. The domestic raw water supply in 1960 was around 73 million cubic-metres, which by 2000 increased to 293 million cubic-metres (see Figure 1). In 2008 the total volume of water taken from the Brantas River Basin for domestic purposes was around 293 million cubic-metres. The two major users are the Surabaya and Sidoarjo domestic water supply companies, where piped water supply coverage is about 35.4% and 36.8% respectively, with surface bulkwater consumption of 7.85 m^3/s and 0.75 m^3/s respectively (2008). Water use for domestic purpose are found to be inelastic (Valiant, 2007). The domestic water supply demand is rapidly increasing in Surabaya, and this may result in higher diversion from the Surabaya River, thus encroaching on the minimum river flows required during the dry season. Currently the Surabaya River's water quality (due to urban pollution) has been a limiting factor.

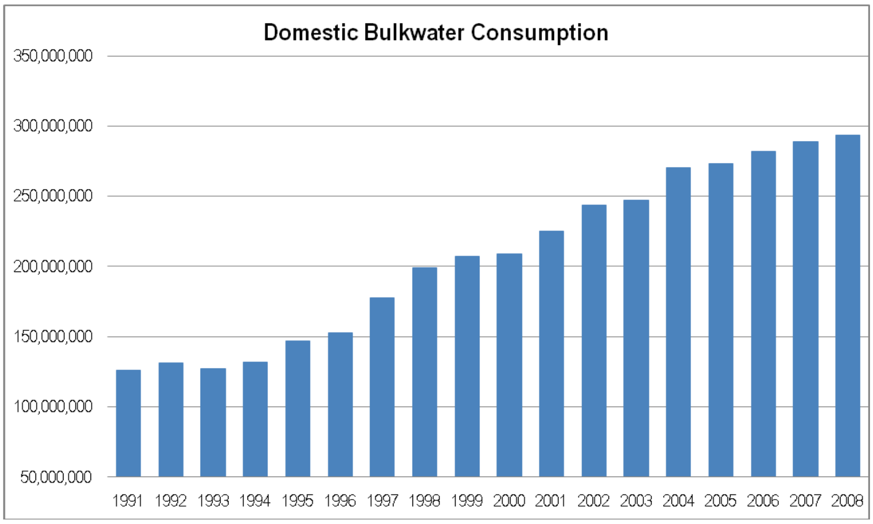


Figure 2 Domestic bulk water consumption from surface water bodies in the Brantas River Basin

Domestic water supply is a fully decentralized activity. The domestic water supply companies (in Indonesian: *perusahaan daerah air minum* or PDAM) are managed as public corporations under the authority of the district government. The East Java Water Resources Office is the responsible agency (on behalf of provincial governor) for issuing licenses for raw water abstraction based on the recommendation of PJT-I while the

Brantas Basin Corporation (PJT-I) is responsible for water allocation. On average, the Ministry of Public Works decides the the raw water tariff once every two years by the Ministry of Public Works, based on the recommendation of the provincial governor and is approved by Ministry of Finance. Currently the tariff is Rp 66/ m³ as against the computed cost of Rp 96.5/m³. The conflict resolution role primarily rests with PJT-I.

Industrial Water Supply

Due to reliability of water supply in the Brantas basin for industrial use and the port facilities in Surabaya, investment in industrial development has increased sharply. Total industrial production has increased from Rp 41.9 billion in 1970 to Rp 7,723 billion in 2000 and currently accounts for over 77% of East Java's industrial production. The industrial water demand in 1970 was around 50 million cubic-metres, and in 2000 it was 293.5 million cubic-metres (see Figure 2). In 2008 around 293.5 million cubic-metres of industrial water was supplied from the Brantas River to about 120 registered industries. Two biggest industrial consumers are the food products (yeast and sugar factories, both of them grouped under the ISIC Code 10) and the paper industries (ISIC Code 17), which take 54% and 33% respectively, of the total industrial bulkwater usage (Valiant, 2007).

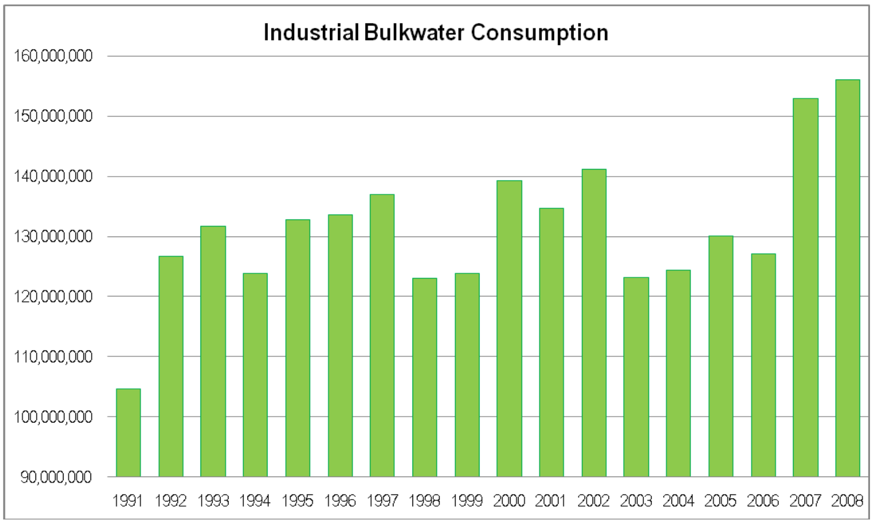


Figure 3 Industrial bulk water consumption from surface water bodies in the Brantas River Basin

The industrial water supply is regulated by licenses issued by the East Java Water Resources Office based on the recommendation of the PJT-I, which has responsibility for allocating water. The water tariff is normally revised at two-year intervals based on a tariff formula and decided by the Ministry of Public Works based on the recommendation of the provincial governor. Currently the industry pays Rp 132/m³. Water use for industrial purpose are found to be elastic at certain price levels (Valiant, 2007). The industries seems to react on tariff change and it affect the overall water use at different rate of tariffs. Much of the decision-making and authority in water allocation and tariffs rests with the provincial agencies.

Hydro-electric Power Generation

The total installed hydropower capacity in the basin has increased from 31 mw (170 million kwh/year) in 1970 to around 240.2 mw (1,200 million kwh/year.) in 2000. The average energy production based on hydro power in the Brantas is close 1.024 GWh annually (10 years average). Table 2 below provides a list of hydro-electric power plants in the basin, including its average energy production (average varies due data length).

Table 5 Hydro-electric power plants in the Brantas River Basin

Power Station	Start Up	Installed Capacity	Annual Production Average[5]
		MW	GWh
Selorejo	1972	4.5	24.3
Sutami	1973	105	454.5
Wlingi[6]	1978	54	158,6
Lodoyo	1983	4.5	36.8
Bening[7]	1984	0.7	0.0
Sengguruh	1988	29.0	78.2
Mendalan-Siman	1922	20.0	144.6
South Tulungagung	1991	36.0	127.3
Wonorejo	2002	6.5	16.8
Total		260.2	1046.5

The hydro-electric power plants are owned and operated by the state electricity company (PLN) while PJT-I operates the dams and provides the bulk water for power generation. PLN pays PJT-I a tariff for water supply, which is reviewed each year and is approved by the Ministry of Public Works based on the recommendation of the Ministry of Finance (MOF). This process takes a long time. The current PLN tariff for water supply for hydropower generation is Rp 66.29/kwh generated. Currently there seems to be little or no conflict in water use between hydropower needs and other consumers/users.

Flood Control

An extensive flood protection scheme has been implemented in the Brantas basin. Flood protection has been one of the main components in all the three Master Plans (1961, 1973 and 1985) that have been implemented. The schematic of the Brantas River flood and drainage scheme that has been implemented is presented on Figure 3. The three reservoirs (Lahor, Sutami, Wlingi) and the two retarding basins (Ngrowo with a 45 million cubic-metres capacity and Widas a 28 million cubic-metres capacity) along with the Lengkong flood gates to divert water into the Porong River to reduce flood flows in Surabaya River and protect the town of Surabaya coupled with the dike system have prevented flooding in the mainstream of the Brantas River since 1990. A flood warning system provides early warning for operation of the floodgates at the various locations. Prior to implementation of the flood scheme nearly 60,000 ha used to be inundated annually and the town of Surabaya experienced flooding frequently. PJT-I is responsible for O&M of the early warning system and the major flood infrastructure.

3.2 Water Allocation Process

Water allocation in the Brantas River basin is based on a water allocation plan, which is discussed and agreed upon by representative of various categories of water users, as well as by Jasa Tirta I Public Corporation in a coordinated team called the Coordination Team of Water Resources Management in Brantas River basin which established based on Ministry of Public Works Decree No. 248/KPTS/M/2009 on February 9, 2009.

5 Average varies in years among the HEPP stations depending on the data length.

6 The HEPP was not operated for 11 months in 1990-1991 due to clogging of the Mount Kelud explosion debris.

7 PLN has not operate the HEPP since 1985 due certain inefficiency reasons.

3.3 Issue and Challenges

The main issue and challenge related to water allocation in Brantas River basin in the near future is the difficulties to allocate water due to increasing water demand and limited supply capacity that may cause conflict of interest among users. The limited supply capacity is caused by the decrease of effective storage capacity of the reservoirs in the basin due to severe land erosion and sedimentation.

The Brantas River basin has eight reservoirs with a total initial gross storage capacity of 647.0 million m3 and effective storage capacity of 479.6 million m3. Because of sedimentation, the gross and effective storage are now decreasing to 390 million m3 (60%) and 341 million m3 (71%) respectively. This situation will be in risk considering the impact of global climate change on water resources i.e. the increase of frequency and magnitude of drought.

By assuming that the actual bulkwater in Brantas River Basin is 46.32 m^3/s (viz. river mainstream 44.49 m^3/s, other streams 1.17 m^3/s, springs 0.54 m^3/s and other natural flows 0.12 m^3/s) it could be seen that water shortage will be 13.37 m^3/s (for the year 1998), increase to 17.17 m^3/s (2000), 20.31 m^3/s (2005) and thereof the deficit will increase to 25.96 m^3/s and 42.83 m^3/s by 2010 and 2020, respectively. See Table 6 for details.

Table 6 Surface water balance for the Brantas River Basin

Year	1998	2000	2005	2010	2020
Actual demand	59,69	63,49	66,63	72,28	89,15
Calculated supply	46,32	46,32	46,32	46,32	46,32
Balance	-13,37	-17,17	-20,31	-25,96	-42,83

Source: SRPCAPS (1999)

To improve the critical water shortage as mentioned above, a demand and supply management plan had been exercized. This management plan relies on increasing efficiency in water usage, optimizing reservoir operational patterns and developing other water resources infrastructure to ammend the water supply.

Increasing water efficiency is aimed at: (i) improving irrigation efficiency which is assumed could save the whole scheme of 6.2 to 6.7 m^3/s of water especially by concentrating on farms in the lower reach of the basin; (ii) reduce unaccounted water and domestic water supply loss which is assumed to save water from 0.14 to 7.32 m^3/s; and (iii) enhance recycling and reuse among water users industries which is expected to save from 0.47 to 45.18 m^3/s.

In terms of optimizing reservoir operation pattern, it is foreseen that a step-wise change in reservoir release pattern could save 3.6 m^3/s (1998-2004) to 3.2 m^3/s (2005-2010) and 2.8 m^3/detik (2011-2020).

On the other hand, construction of the necessary infrastructures to improve bulkwater supply are assumed as follows:

1. Wonorejo Reservoir in the Tulungagung Regency is expected to boost bulkwater supply to Surabaya by adding 8.02 m^3/s to the Brantas mainstream (whereas 5.5 m^3/s is released from the reservoir and another 2.5 m^3/s from a distinctive push back scheme). This reservoir has been completed and operates since the year 2000.

2. Additional water from the Umbulan Spring in the Pasuruan Regency conveyed by pipe to the lower reach of the Brantas Basin to serve domestic needs, is expected to add 4.45 m^3/s starting by the year 2000. However, this plan is not yet executed.

3. Beng Reservoir (147 million m³) in Jombang Regency and Kedungwarak Reservoir (54 million m³) in Nganjuk Regency is expected to be constructed in order to add bulkwater supply 9.5 m³/s and 3.5 m³/s respectively. These reservoirs are expected to be operable in 2010 dan 2015.

By incorporating the afore mentioned plan, a new water balance could be drawn as in Table 7. It could be seen that Wonorejo Reservoir (operated since 2000) has improved the current water shortage but, however, as the plan of conveying water from the Umbulan Spring is delayed, and both Beng and Kedungwarak Reservoir are not been officially committed to be constructed, then the present situation is still critical.

Table 7 Calculated water balance for Brantas River Basin based on the demand and supply management plan

Tahun	1998	2000	2005	2010	2020
Balance	-13,37	-17,17	-20,31	-25,96	-42,83
Usage Efficiency	5,66	6,44	8,29	10,82	17,19
Balance	-7,71	-10,73	-12,02	-15,14	-25,64
Reservoir Optimization	3,60	3,60	3,20	3,20	2,80
Balance	-4,11	-7,13	-8,82	-11,94	-22,84
Infrastructure Development		8,02	12,47	21,97	25,47
Final Balance	-4,11	0,89	3,65	10,03	2,63

Source: SRPCAPS (1999)

IV. Water Quality in The Brantas River Basin

4.1 Water Quality Overview

Population density and economic activities within the basin, deteriorate the surface water quality in the Brantas River Basin and thereby amplifies significant impacts to the river ecosystem and livelihoods.

The existing water pollution sources are primarily from domestic and industrial wastewater while agricultural and other sources also contribute to water quality degradation. Of the pollution loads, domestic wastewater from the Malang and Surabaya urban areas generate the maximum amount of pollution load. In dry season this exceeds the assimilative capacity of the river. The industrial pollution is mainly from pulp and paper factories, sugar factories, chemical industries, textile factories, and the food processing industry.

The two top industry producing biochemical oxygen demand (BOD) are 5 factories of yeast and derivatives (estimated at 158 ton/day) and 10 sugar factories (estimated at 128 ton/day). Although return flows from the irrigated area are low in the dry season, fertilizer and agrochemicals pollute the rivers and reservoirs. Livestock pollution in some reaches is prevalent. Solid waste and seepage from solid waste dumps produce significant quantities of organic pollutants.

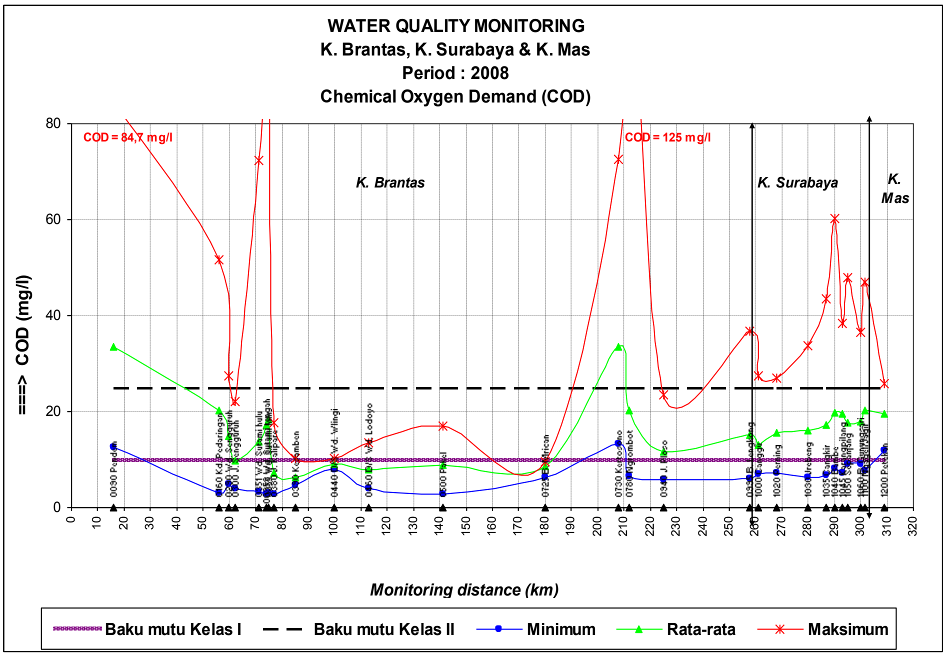
At present the Surabaya River along the Surabaya city organic pollutants heavily pollute area and Brantas River along Malang city area. BOD in these reaches is about 10 to 20 mg/l and 8 to 15 mg/l, respectively. Chemical oxygen demand (COD), ammonium (NH_4), and nitrogen dioxide (NO_2) also exceed the water quality standards in the mainstream and tributaries of the river year round. In most of the reservoirs, eutrophication is in progress because of nutrients flowing into the body of water.

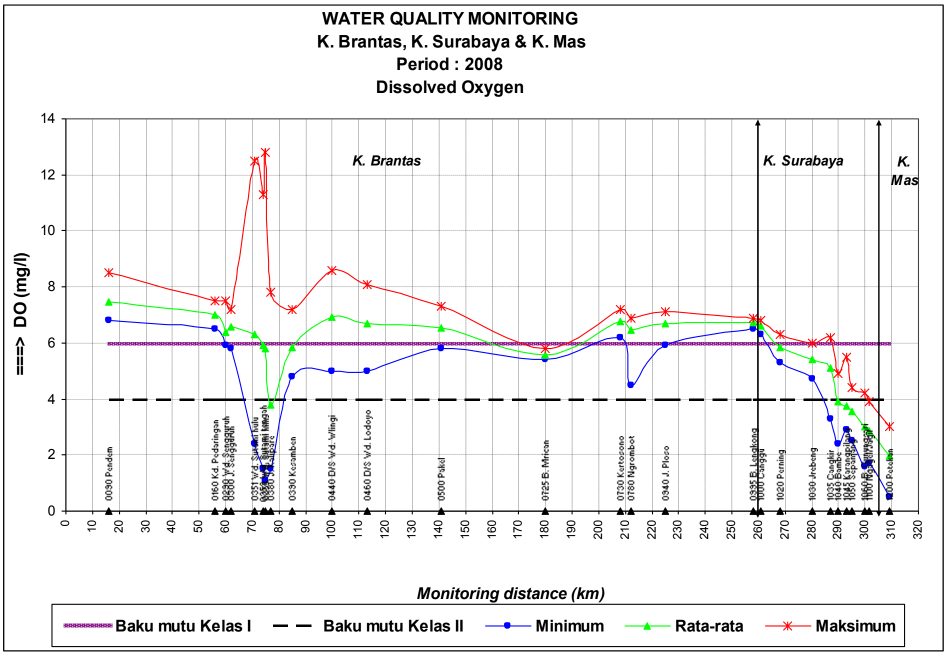
High values of phosphorus and low transparency have been recorded. The water quality in the reservoirs monitored shows BOD levels of 5.6 to 63.2 mg/l and COD varying from 13.7 to 128.9 mg/l as a monthly average. Ambient water quality standards have been set for the different reaches of the rivers. The Brantas

River from Widas River confluence, Surabaya River, and Porong River are classified as ‘B’ class (fit as raw water for drinking) and all other rivers as ‘C’ class (fit for fishery and husbandry purposes).

The basin itself has 51 sampling points of off-line monitoring stations along the river system and 47 points at potential industries pollution sources, 10 points at domestic disposal outlets of hospital, hotels and public sanitations, which is installed since 1988 (see Attachment 1). River water and wastewater monitoring are principally taken on a monthly basis; except for the lower part where river water is used for drinking water purposes, the monitoring is performed on weekly and daily schedule basis.

Since 1999, the Government of Indonesia in cooperation with Indonesian Institute of Science has developed a Brantas River water quality monitoring by installing 23 on-line water quality monitoring stations along the Brantas River (see Attachment 1). The monitoring objectives have been taken into consideration are water use, baseline data, inventories, regulations and guideline development, law enforcement, modeling and discharge permit development.





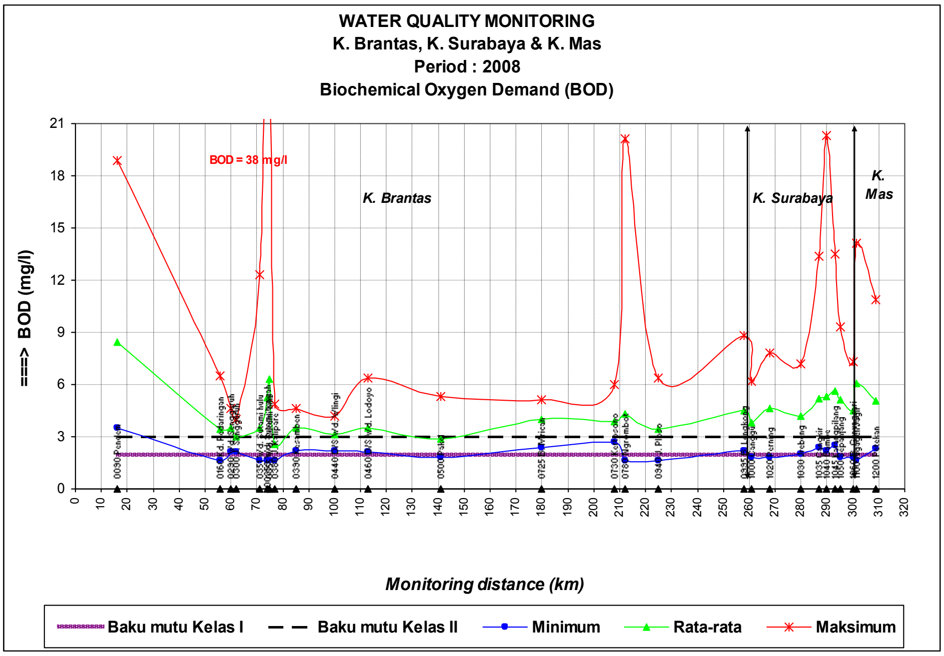


Figure 4 Certain water quality parameters of 2008 for the Brantas River Basin

The criterion for selection of sites has been the reduction of pollution load, improvement of water quality and using the on-line data for river basin management. Ideal locations for the stations will be close to point source (with the intention of controlling emissions), metropolitan areas (public health priority) and drinking water intake points (safe water for human consumption). These conditions have been fulfilled in selection of sites for the installation of on-line monitoring stations.

As part of water quality management an extensive water quality monitoring system has been set up and operated by the Brantas Basin Corporation. The total water quality monitoring points set up under various programs is around 200. These include ambient water quality monitoring stations in the rivers and reservoirs and monitoring of point sources from industrial and urban outfalls.

The monitored parameters include physical, chemical, microbiological, and heavy metals and are monitored on a regular basis. The average annual concentration of BOD, COD and DO for the Brantas River and Surabaya River is presented on Figure 3 for the year 2008. Current water management calls for a minimum river flow of 7.5 m^3/s in the Surabaya River to keep pollution loads within limits. During the dry season attempts have been made to release flows from upstream reservoirs as slug flow to flush out pollutants. This has proved to be expensive. Over the 10 year period there has been considerable water quality improvement, although the BOD, COD and dissolved oxygen (DO) values are still higher than the standard ('B' Class) in the downstream reaches of the Brantas and Surabaya Rivers. The total BOD load of 330 t/day comprises of 205 t/day (62.1%) due to domestic waste and 125 t/day (37.9%) due to industrial waste. The PROKASIH plan for 2000 to 2005 is to reduce these loads by 50%.[8]

4.2 Issues and Challenges

Increase of population at Brantas River Basin and various economic activities, has direct impact on water quality in the basin, and could be foreseen in the following facts:

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[8] For greater details of the water quality issues reference should be made to the *Surabaya River Control Action Plan Study* of 1999.

1. Domestic bulkwater supply for Surabaya City is provided mainly from Brantas surface water. As a matter of pollution accumulation, the river's water has a low dissolved oxygen (DO) level, thus creating water purification difficulties and rises the cost of water treatment.
2. Increased water pollution are frequently worsen by shock loadings, especially in the dry season when natural flows in the rivers are at the minimum.
3. The occurrence of increased turbidity during the rainy season inflicts the increase of sediment contents caused by degradation of the upstream catchments area.
4. Eutrofication symptoms at the Sutami Reservoir caused by the accumulation of nitrates (N) and phosphates (P) elements. This symptoms creates significant problems, like: algae blooming, deterioration of freshwater faunas and organic depravement.

In the 2008-2009, PJT I has conducted environmental research in identifying macroinvertebrate compositions in the upstream of Brantas River Basin. The richness of macroinvertebrate community composition in a waterbody can be used to provide an estimation of waterbody health. The results of the research shows that in the upstream of Brantas River Basin has already classified as organic polluted water with several level, from fairly subtansial pollution likely until substansial pollution likely (according family biotic index).

From these facts and information, it could be assessed that the following challenges needs to be considered:

1. Pollution control needs enforcement especially to control illegal waste dumping (shock loadings) and punish obstination to the regulated effluent charges.
2. A waste permit system must be throughfully enacted as a basis for pollution management and effluent fee charges.
3. Control of domestic waste, as a non-point source of pollution, remains difficult if there is no mentality reform and a complete investment for sanitation at the urban areas.
4. Agricultural waste is a complex problem that precipitates from extensive use of fertilizers and pesticides in farming practices. Agricultural pollution load remains high and more difficult to detect; is often neglected and forgotten as an after taste of the green revolution.

V. Perspective Analysis

As economic instruments and irrigation management transfer at the farm level would be more difficult to implement in the Brantas River Basin, conserving water up to a very high level will adversely impacting farmers income. Alternative instruments to save water and control water quality are discussed as follows.

5.1 Enhanced Irrigation Efficiency

Volumetric cost and other incentives only succeed in inducing significant change in levels and patterns of irrigation water use, if efficiencies in water allocation exist that could be eliminated. Three type of inefficiencies has been found by previous research (Rodgers, 2004): physical inefficiency, operational (and managerial) inefficiency, and allocative (or economic) inefficiency. The potential for real water savings was analyzed based on the Brantas simulation model (Rodgers and Zaafrano, 2003). Agricultural land area in the basin can not be expanded, additional irrigation would be possible in the dry season, however.

Physical efficiency is defined as the ratio of water use beneficially to water withdrawn for that purpose, here at the irrigation system scale. It is a statement about the quality of the design and construction, and the existing condition of the infrastructure itself, and by implication, the accumulated investment in the maintenance of the infrastructure. SRCAPS (1999) estimated overall Brantas Delta Irrigation Scheme (in the lower reach of the basin) at 27%, with an intake efficiency 61%, a system operation efficiency of 56%, and a tertiary and on-farm efficiency of 79%. These estimates embodied both physical and operational sources of inefficiency.

Operational efficiency refers to effectiveness by which system managers are able to match the special and temporal patterns of demand with effective supply. It encompasses the knowledge of this pattern of demand, of the hydraulic behaviour of the system and the flexibility which they respond to transient circumstances, such as meteorological events. An estimate of the water savings from the removing operational inefficiency can be obtained through optimizing the pattern of gross abstraction based on observed historical pattern of planted area. Under this comparasion, gross abstraction to Brantas irrigation system can be reduced by 640 million cubic-meter per year. Assuming the roughly 30% is returned as drainage, net savings of roughly 450 million cubic meters can be obtained. These are, however, not fully realizable savings, due to remaining uncertainity of basin operators, regarding corpping pattern and cilmate data, among others, and due the impossibilty of achieve near perfect operational efficiency within the irrigation system.

However, if current losses to operation inefficiency could be reduced by around 45%, it might be possible to divert roughly 200 million cubic-metres from irrigated agriculture to other uses.

To summarize the efficiency estimates: (i) the technical efficiencies of Brantas surface irrigation systems are below the realizable potential levels, but not unussual for Asian surface irrigation standards; (ii) there is a substantial degree of operational inefficiency in bulk irrigation deliveries, as evaluated at system offtake points, representing a significant opportunity to increase effective basin supplies through improvement in operational protocols including cooperation with other related agencies; (iii) there is a modest degree of inter-sectoral allocation inefficiency, specifically a relative under-supply of municipal water supply corporations and to, a lesser extent, industrial demand and corresponding to it, an over-supply to irrigated agriculture. These results indicates that the primary sources of inefficiency are beyond the influence of individual farmers or water user groups of the farmers.

5.2 Water Rights and Incentives for Efficiency

Rationing by quantity is an alternative to rationing by price. Rodgers and Zaafrano (2003) examined the combined impacts of volumetric rights and market mechanisms on allocation efficiency and farm sector welfare. Three scenarios were developed and compared with baseline optimalization. The first scenario is a fixed water right, the second is water right with brokerage, and the third scenario is water rights with market mechanism where the users can engage in private or two-party transanctions without brokerage.

From the various scenario comparaisons, the study underlines that more water could be saved by simply establishing transferable water rights, either by brokerage through the water managing agency, or by trading water freely in a market mechanism. The study found out that well-established water use rights, combined with an economic incentive operating at the margin (for water rights with brokerage mechanism) are capable of producing an efficient allocation at the nearly at the same level as pure markets. In addition, efficiency is gained without penalizing the income of the poor farmers.

However as the Water Law No 7 of 2004 does not impose economic instruments on farmers and it retracts the irrigation management transfer by handing over irrigation operation and maintenance responsibility to the government budget based on the size of its area it could be said that findings of the afore mentioned study could not be fully implemented. As the water law confine water use rights on domestic and industrial usages, agricultural is out of the border of rights.

It could be summarized that the best short term to conserve water is to improve allocation of water among users especially the irrigated farm lands, by increasing operational efficiency. Afterwards, if farmers are not entitled to obtain a water use right then it is necessary to establish a base of compensation as water may be transferred in allocation terms to urban-industrial users, particularly under drought conditions. Farmers could be given incentives as packets of reward for using water efficiently. The saved water could then be transferred by simply correcting the allocation at a higher operational level than the farm.

Water Governance in the Basin

There are four main institutions in the basin that have direct responsibility in river basin water resources management are: (i) the East Java provincial water office; (ii) the Brantas Public Corporation (PJT-I); (iii) the Brantas R.B. Public Type Organization, and (iv) the basin coordination committee.

The East Java Water Resources Office manages water through agencies that were set up in 1998 (on the transfer of the provincial field offices) as part of decentralizing basin water resources management from the center to the provinces and basin. These agencies operate, maintain, and manage the infrastructure and the water resources in the rivers that are not under the jurisdiction of PJT-I. They manage mostly the second, third, and fourth order rivers (around 1,510 rivers) in the Brantas basin that do not have major infrastructure or do not have major water benefits except irrigation. These agencies manage the inter-district irrigation system and acts more as field regulatory arm of the East Java Water Resources Office. These agencies are the lowest level agency where input for regulatory decisions (abstraction licensing, effluent discharge licensing, flood plain use, etc.) is made. Agencies act as the field offices of the East Java Water Resources Office and provide the operational support.

PJT-I was established in 1990, based on Government Regulation No. 5 of 1990 (ad later replaced by Government Regulation No. 93/1999 to strengthen the organization and permit its jurisdiction to extend to other basins), is charged with managing the water resources in 40 of the more important benefit producing rivers (including the Brantas River) of the basin and to operating, maintaining, and managing the major infrastructure in these rivers. The Corporation has no role in irrigation management in the basin except to provide bulk water supply to the irrigation systems. It provides comprehensive water resource development (mostly non-structural) and utilization service to fulfill all types of surface water demand, water resources protection, water quality monitoring, flood operation, O&M of water infrastructure, conservation and providing information, recommendations, public campaigns and technical guidance.

The activities of the corporation cover (i) bulk water supply for irrigation systems, (ii) raw water for domestic and industrial purposes, (iii) water supply for hydropower plants, (iv) sand mining, (v) tourism in its working area, and (vi) consulting services. In 2000, the Brantas Corporation was authorized to undertake WRM in 25 rivers of Bengawan Solo River Basin (an inter-provincial SWS lying in Central Java and East Java).

Being a national corporation, the authority to oversee the management and functioning of PJT-I lies with the center through the Ministry of Public Works , with the Ministry of Finance (MoF) exercising a fiscal oversight role. The Minister, who draws his powers from the water law, has supervisory control. The supervisory board has five members representing the Ministry of Public Works, Finance, Energy, Agriculture, and local government (with three-year terms) and undertakes general supervision of the corporation's program, work plan, and budget.

This is the only institutional setting in which the provincial government of East Java (for Brantas basin) and Central Java and East Java (for Bengawan Solo basin) can directly interact with the work of the corporation and influence the water resources management in the basin, apart from the authority it exercises through other agencies in the basin. To a large extent the central ministries' (Public Works and MoF) role overshadows the supervisory board's functions in the operation of the corporation.

The third imporant institution in the Brantas River Basin is the Brantas R.B. Public Utility Organization. This discussion group was established by the Ministry of Public Works decree No. 248/KPTS/M/2009 on February 9, 2009. This organization is entitled with various responsibilites, basically representing government obligation for public services, like rehabilitation of water resources infrastructures and construction of new infrastructures.

The fourth organization is the Water Resources Coordination Team consists of river basin organizations in the basin (Jasa Tirta I Public Corporation and Brantas R.B. Public Utility Organization or in Indonesian: *Balai Besar Wilayah Sungai Brantas*), Provincial and Regency/Municipal Government Agencies (agencies related to regional planning, water resources, agriculture, environment, health, forestry, transportation, industry, energy and natural resources, coastal and fishery, education, etc) and non-governmental organizations (consist of water users organizations/associations for irrigation, domestic use of water and industries, electricity, forestry, etc).

Prior to the establishment of the Coordination Team of Water Resources Management in Brantas River basin, in order to avoid conflict among water users in the Brantas River basin, a Provincial Water Resources Management Committee (in Indonesian: *Panitia Tata Pengaturan Air* abbreviated as PTPA) was established based on the East Java Governor's Decree No. 59 of 1994. The committee, which was responsible to the Governor, was supposed to be a coordination body where decision on all management aspects in water resources (planning, implementing, supervising, controlling and funding) in its respective area was made.

VI. Conclusion

Indonesia is blessed with soils and climate that are advantageous for irrigated agricultural production, although population pressure and economic development, particularly on the densely populated island of Java have resulted into increasing competition among the various water users. The Brantas River Basin could serve as best example on how the water shortages and water quality degradations are evident as a logical consequence of the vast population and its activities within the basin. Competing demands between irrigation sector, domestic users and industries, environmental flow requirements and the limited natural flows, are examples of the problem. Exercize on the water balance of the Brantas River Basin and a glimpse of the water quality problem will give further understanding on the overall condition.

The Indonesian Government holds clear authority over the water management. In the past, the unitary system of the Indonesian Government with state control over the water sector created a more vertically integrated structured than a horizontally one. However, major efforts are now being done to decentralize and deconcentrate the water resources development and management activities. The new Water Law No 7 of 2004 that replaced the old Water Law No 11 of 1974 has strengthened water resources management by giving a role to the stakeholders and improving the regulatory and administrative mechanisms. It has strengthened the cost recovery concepts from water users except from public sector irrigation users. Whilst, major weaknesses of this law is the reversal of the decentralization process in the irrigation subsector and failure to promote explicitly the irrigation management transfer to the farmers' organization. Another intricating aspect is that the economic instrument is not fully applied for farmers at all levels.

From all types of efficiency discussed, physical, operational and economic efficiencies have the potential for improvement in the Brantas River Basin. Water saving for domestic users mainly relies on reducing the conveyance loss and cutting the unaccounted water. While, the same saving for industries is more possible by the advent of better recycling and reuse technology. However, as a result of the relative profitable and limited technology to water savings technology for paddy cultivation (wet rice farming), the existence of terrace irrigation system in some areas where the irrigation water flows across fields through terraces and not canals, and the lack of control over water supply reliability at the tertiary block level, farmers have limited room for conserving water. Research on water-saving techniques for paddy cultivation indicate that it will be difficult to maintain yields if water inputs are substantially reduced. The option is then to adopt a less-water cultivation method but the feasibility of practicing such management intensive cultivation technique on wider scales will depend critically on the redesign of the surface water irrigation system and management protocols to permit greater precision and coordination of the water control.

Increase of population at Brantas River Basin and various economic activities, has also a direct impact on water quality in the basin, in effect contributing to the overall productive decrease in the basin. Lower water quality tends to creae water purification difficulties and rises the cost of water treatment. On the side, increased water pollution frequently degradate the enviornment and livelihood. Shock loadings, especially during the dry season when natural flows are limited is a common threat to the river. While corresponding to the season, increased turbidity during the rainy season inflicts the of sediment contents caused by degradation of the upstream catchments area. Agricultural and domestic pollution load – as non point source of pollution – remains difficult to be solved, unless radical changes are made to redesign the agricultural practices and the public sanitation in most urban areas within the basin.

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Tjoek Walujo Subijanto (born 1946) graduated as mechanical engineer from Brawijaya University, Indonesia (1981), specialization diploma in water resources management from the Ecolé Nationale des Travaux Public de l'Etat at Lyon, France (1985). Appointed as Operational Director of PJT-I (2001-2007) and since 2008 as President Director.

Harianto (born 1953) graduated as civil engineer from Brawijaya University, Indonesia (1983), specialization diploma in river engineering from the International Hydraulic Education at Delft, Netherlands (1991). Appointed as Corporate Secretary of PJT-I (2005-2007) and since 2008 as Director for Planning and Development.

Raymond Valiant (born 1969) graduated as water resources engineer from Brawijaya University, Indonesia (1996), masters in civil engineering from the same university (2007). Presently employed at Jasa Tirta I Public Corporation for the Brantas River Basin.

Attachment 1

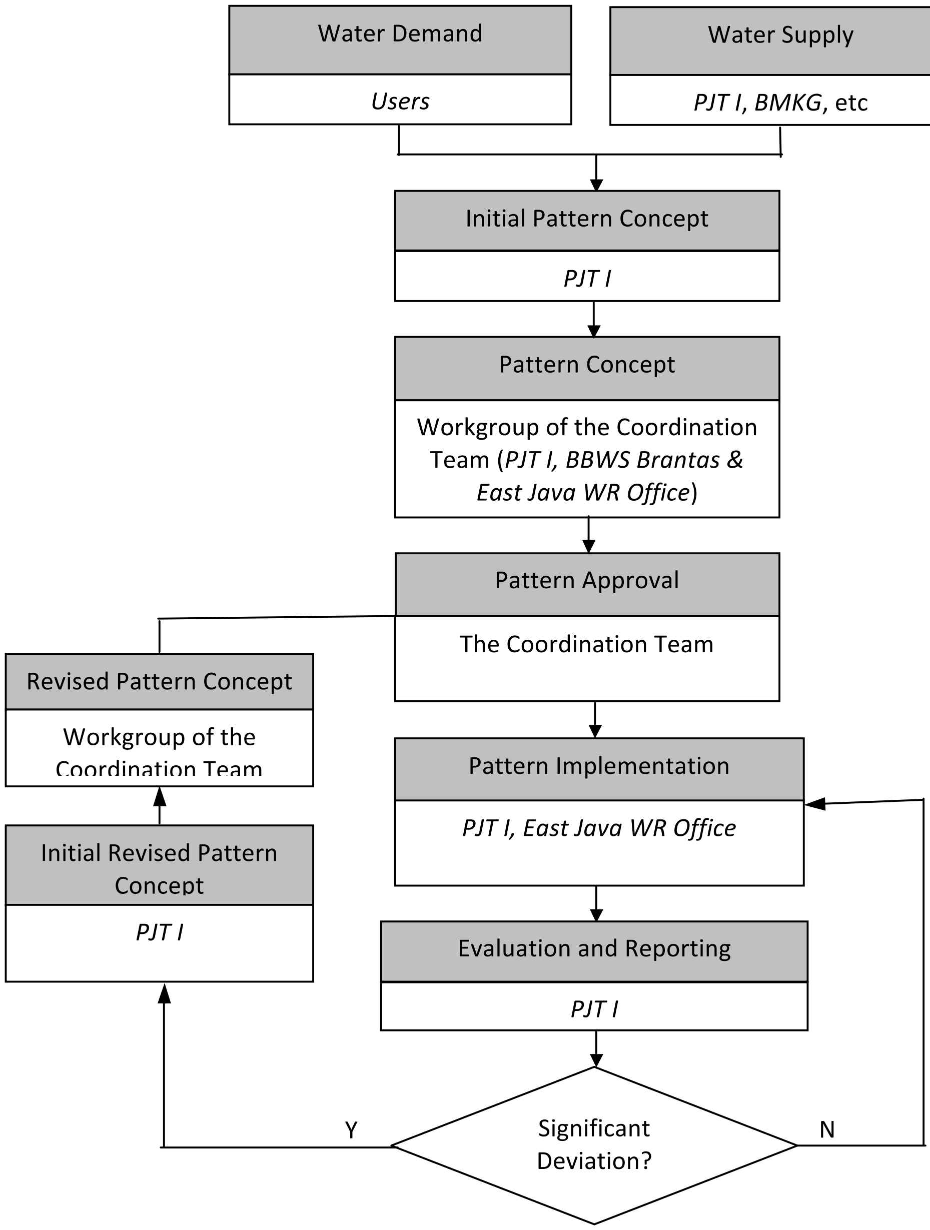

Figure 5 Water allocation flowchart in the Brantas River Basin

Attachment 2

Table 8 Water quality sampling stations at the river course and reservoirs within Brantas River Basin (off line sampling)

No	Location	River	Period	No	Location	River	Period
Malang Regency				Nganjuk Regency			
1	Pendem Bridge	Brantas	3 months	28	Mekikis Bridge at Kertosono	Brantas	3 months
2	Kedung Pedaringan	Brantas	Monthly				
3	Sengguruh Dam	Brantas	3 months	29	Ngrombot Tambangan	Brantas	Monthly
4	Sengguruh Bridge	Brantas	3 months	30	Bening Dam (up)	Widas	3 months
5	Sutami Dam (upstream)	Brantas	2 weeks	31	Bening Dam (middle)	Widas	3 months
6	Sutami Dam (middle)	Brantas	2 weeks	32	Bening Dam (down)	Widas	3 months
7	Sutami Dam (downstream)	Brantas	2 weeks	33	Lengkong Bridge	Widas	Monthly
8	Lahor Dam (upstream)	Biru	Monthly	Jombang Regency			
9	Lahor Dam (middle)	Biru	Monthly	34	Ploso Bridge	Brantas	Monthly
10	Lahor Dam (downstream)	Biru	Monthly	Mojokerto Regency			
11	Kalipare Bridge	Brantas	Monthly	35	Lengkong Barrage	Brantas	Monthly
12	Metro Bridge	Metro	Monthly	36	Canggu Tambangan	Surabaya	Monthly
13	Lahor Dam (upstream)	Konto	Monthly	37	Jetis Bridge	Marmoyo	Monthly
14	Lahor Dam (middle)	Konto	Monthly	38	Perning Bridge	Surabaya	Monthly
15	Lahor Dam (downstream)	Konto	Monthly	Gresik Regency			
Blitar Regency				39	Jrebeng Bridge	Surabaya	Monthly
16	Kesamben Bridge	Brantas	3 months	40	Cangkir Tambangan	Surabaya	2 weeks
17	Wlingi Dam (downstream)	Brantas	3 months	41	Bambe Tambangan	Surabaya	Monthly
18	Lodoyo Dam (downstream)	Brantas	3 months	42	Kali Tengah Estuary	Tengah	2 weeks
Tulungagung Regency				Sidoarjo Regency			
19	Pakel Tambangan	Brantas	3 months	43	Porong Bridge	Porong	Monthly
20	Wonorejo Dam (up)	Gondang	3 months	44	Ciro Bridge	Mangetan	Monthly
21	Wonorejo Dam (middle)	Gondang	3 months	45	Kali Pelayaran Intake (downstream)	Pelayaran	Monthly
22	Wonorejo Dam (down)	Gondang	3 months				
23	Tiudan Barrage	Gondang	3 months	46	Delta Tirta Intake	Pelayaran	Monthly
24	Plandaan Bridge	Ngrowo	Monthly	Surabaya Municipality			
25	Kendal Bridge	Tunnel	3 months	47	Karangpilang	Surabaya	2 weeks
Trenggalek Regency				48	Sepanjang Bridge	Surabaya	Monthly
26	Bendo Water Gates	Ngasinan	Monthly	49	Gunungsari Barrage	Surabaya	Monthly
Kediri Municipality				50	Ngagel / Jagir	Surabaya	2 weeks
27	Mrican Barrage	Brantas	3 months	51	Petekan Bridge	Mas	Monthly

Table 9 On line water quality monitoring sampling stations within the Brantas River Basin

Code	Location	Type	River
WQ01	Upstream Pendem Bridge	1a	Brantas
WQ02	Downstream Kendalpayak Bridge	2	Brantas
WQ03	Sengguruh Dam	3	Brantas
WQ04	Sutami Dam	2	Brantas
WQ05	Selorejo Dam	2	Konto
WQ06	Wlingi Dam	1	Brantas
WQ07	Lodoyo Dam	1	Brantas
WQ08	Downstream Tambangan Pakel	1	Brantas
WQ09	Downstream Ngujang Bridge	2	Brantas
WQ10	Upstream Mrican Barrage	1	Brantas
WQ11	Downstream Cheil Jedang	3	Brantas
WQ12	Downstream Ajinomoto	2	Brantas

Code	Location	Type	River
WQ13	Upstream Tambangan Canggu	1	Surabaya
WQ14	Downstream Jrebeng Bridge	3a	Surabaya
WQ15	Krikilan Intake	3a	Surabaya
WQ16	Karanglo	1a	Surabaya
WQ17	Upstream Karangpilang Intake	3a	Surabaya
WQ18	Kayoon Intake	2a	Mas
WQ19	Ngagel Intake	3a	Surabaya
WQ20	Downstream Mangetan Gate	1	Mangetan
WQ21	Upstream Kertosono Old Bridge	1	Brantas
WQ22	Upstream Dam Porong Canal	1b	Porong
WQ23	Upstream Lesti Bridge	1	Lesti

Note:

Type 1b : pH, Temperature, Conductivity, DO

Type 1 : pH, Temperature, Conductivity, DO, Turbidity

Type 1a : pH, Temperature, Conductivity, DO, Turbidity, Water Level

Type 2 : pH, Temperature, Conductivity, DO, NH4, PO4

Type 2a : pH, Temperature, Conductivity, DO, NH4, PO4, Water Level

Type 3 : pH, Temperature, Conductivity, DO, NH4, PO4, Turbidity

Type 3a : pH, Temperature, Conductivity, DO, NH4, PO4, Turbidity, Water Level