AN OUTLOOK OF INFRASTRUCTURAL HERITAGES OF IRRIGATION IN INDONESIA[1]

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Despite that irrigation in Indonesia since the old days has long been played a very significant role in the history of the country's development, however, the technical irrigation infrastructure has only been introduced by means of civil engineering undertaking between the end of the 19th century and turn of the 20th century. During the initial stage of technical irrigation, the implementationsuffered from lack of technical expertise, so the main irrigation structures such as barrage and weirs were constructed by means of trial-and-error approach. Then it was not surprising that many of the major irrigation structures were in fact collapsed by the large flood incident before even the construction completed. Other structures were found over designed to accommodate huge safety factors, and hence the structures were highly inefficient from both civil engineering as well as economic justification. The term of stainable development was merely considered by development engineer from the lasting quality of the water infrastructure as artificial resources, and less attention were paid for sustaining the functionality by means of effective and efficient operation and maintenance O&M. This condition became exceptionally worsened during and after the World War II. From a series of experiences in irrigation implementation, it gives strong supports that management of irrigation, drainage, and flood control system is much more important than construction of facilities per se'. This matter have been apparent through the ancient traditional irrigation system in Indonesia that has been highly sustainable with active participation of local population. In contrast, modern system of major engineering works has not fully achieved the expected performance – some modern irrigation systems had been failure to achieve the targets due to a number of socio-technical constraints, including the lack of community participation as well as inappropriate O&M. In an attempt to review the impact of the post war on top of the substantial impacts of economic crisis, this paper is presenting an outlook of infrastructural heritages of irrigation in Indonesia, giving special discussion on the drawbacks, as well as the future perspectives. It is expected that from the lesson learned on infrastructural' heritages of Irrigation in Indonesia, it will enhance a good opportunity to deepen the sense of "natural and cultural friendly engineering" on water infrastructures and eventually contribute the raising of awareness and hence public participation on O&M of water infrastructures.

Key Words: Infrastructural Heritages; Irrigation; Water Resources Infrastructures

I. INTRODUCTION

Historical Background: From the historical perspective, Irrigation has been practiced on Java Island for rice crop since the ancient time with the simple and least sophisticated structures. These have been recognized through the ancient

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infrastructural heritages which are still in operation today. However, the technical irrigation infrastructures by means of civil engineering undertaking had only been introduced between the end of the 19th century and the turn of the 20th century AD. This was more significant when the Dutch Colonial Government applying the so called *"Ethical Policy"*, by fostering Irrigation, education and transmigration program to enhance the development of its colonies.

Since after independence, irrigation development Irrigation in Indonesia has been developed through five year development plan with implementation of several major projects including Jatiluhur, Citarum River in West Java, the Brantas River Valley Development, regional plan in East Java, Sempor Dam and irrigation Project, and Bali Irrigation Project. The water sources come from has several river streams with the total internal water resources of the country stood at 2,530 BCM (1987) of which a quantity of 16.6 BCM was being withdrawn with an allocation of 76% to agriculture, whereas the irrigated area in 2009 was 7.4 M ha. These achievements have been possible through the supports of large number of irrigation infrastructures, weirs, from small, medium to large structure category, along with the implementation of drainage and reclamation of lowlands for agriculture in Indonesia since the Dutch Colonial Period.

Drawback of Irrigation Infrastructural Sustainability: Through a long term development implementation the infrastructural heritages, especially the ones that have been constructed during before the country's independence, have been suffered from damages due to inadequate O&M undertakings. And after independence, in fact were also suffered from the same problems because the country was concentrating its effort to provide new infrastructural facilities to meet the post independence accelerating demand. With the down fall of the country's economy that have been experience by the country, it has been evident that the capacity to perform operation and maintenance (O&M) of the developed infrastructures continuously lacking behind.

Learning from a series of experiences in irrigation implementation, it gives strong supports that management of irrigation, drainage, and flood control system is much more important than construction of facilities per se'. This matter has been apparent through the ancient traditional irrigation system that has been highly sustainable with active participation of local community for hundreds of years without major problems. In contrast, modern system of major engineering works has not fully achieved the expected performance – some modern irrigation systems, in fact, had been failure to achieve the targets that had been previously envisaged due to a number of socio-technical constraints, including the lack of community participation as well as inappropriate O&M.

II. OVERVIEW OF IRRIGATION DEVELOPMENT IMPLEMENTATION

2.1. The Ancient Irrigation Techniques

According to the existing folklore as well as some ancient inscriptions, there are adequate reasons to believe that irrigation development in Indonesia must had been practiced longer before the Hindu Era. Much of the traditional communities believed that the first Hindu migrant had found the local irrigated paddy had been widely cultivated by

the local people in the lowland plains of Java. Thus, during the Hindu Era, the Hindu Emperors had strongly believed to have been fulfilling adequate food supplies of the peoples through the widely practiced irrigation technique for paddies.

For illustration, the stone inscription from Dharmawangsa Emperor dated 958 Caka-Year or 1037 AD stated that a series of dyke construction works were undertaken by the emperor at the Waringin Sapta, next to the Brantas river banks for protecting human settlement as well as agricultural areas in the vicinity of the middle reach of the Brantas River Basin (belongs to the East Java Province, today).

2.2. Traditional Agricultural Heritages

Following the ancient irrigation techniques, there some evidence of the traditional agricultural heritages that are still currently practiced today. The traditional irrigated agricultural practices had been descended from generation to generation by the ancient Indonesian civilizations. These among others are the *"Subak"* System in Bali Province, *"Dawur Pranatamangsa"* in Central and East Java Provinces, *"Tuo Banda*" or *"Siak Bandar"* in West Sumatra Province, *"Tudang Sipulung"* in South Sulawesi, *"Panriahan Pamokkahanan"* and *"Siauga Parjolo"* in North Sumatra, *"Panitia Siring"* in South Sumatra and Bengkulu Provinces, including some institutional based traditional agriculture such as *"Ulu-ulu Desa"*, and *"Ulu-ulu Vak"* in Central Java, *"Raksa Bumi"* in West Java, *"Ili-ili"* in East Java, *"Malar"* or *"Ponggawa"* in Sumbawa Island, and *"Kejrueng Blang"* in Aceh Province, despite of the modern irrigation practice today.

These in themselves are the concrete explanation of the past existence of irrigation based agricultural practices, though they do not give indication of the exact date of the initial inventions.

2.3. New Irrigation Technique

Early at the beginning of the Dutch Colonial Era in Indonesia (referred to by the Dutch Colonial Government as the *"Netherland Indie"*) not much effort were addressed to irrigation development due to their special attention on spice trade. This was the case because the Dutch still give concentration of spice products rather than irrigated agriculture, which by nature, considered as public services oriented undertaking. Apart from that, irrigation infrastructures were still available to provide adequate food supplies for the people. There were a number of irrigation works and expansion of paddy cultivations in Bali Island and in Java as well as on the Outer Islands through mutual aid (*gotong royong*) system. Irrigation for private lands was also constructed in the Tangerang Plain, Bekasi and Cikarang, as well as in the vicinity of Batavia (Jakarta, today) and Bogor for land-lords. Among others are the Ciliwung Katulampa, Cisedane Empang and Cibalok, which are still in operation after more that 250 years, though their physical conditions are increasingly deteriorated.

Pioneering Period: Due to the lack of technical experience in the early development stage of irrigation for agriculture, irrigation planning and construction implementation were undertaken almost without any basic technical and agro-climatological data. At that time, practically no data on hydrology, hydrometry, geology, topographical maps as well as laboratories to back up the planning and technical design available. And hence, the technical designs were merely conducted based "trial-and-error" approach. Not

surprisingly, that many irrigation schemes were failure to meet the objective previously intended in the design. For example, the Sampean Weir in Situbondo, which was constructed in 1832, had been totally collapsed before it could be fully utilized. It was only in 1887 the weir was reconstructed with permanent structure that made it strong enough to perform water diversion till present.

2.4. Irrigation Development for Supporting Transmigration Program

As the follow up of the Ethical Policy "goodwill strategy" referred to as the *Ethische Politiek* with the slogan of three major endeavors: Irrigation; Emigration; and Education; the Dutch Colonial Government commissioned a study in 1902, to examine the possibility of resolving the problem of over–population and land fragmentation on Java as a potential source of political tension and unrest, by moving people from Java to the sparsely populated areas in other parts of Indonesia, supported by Irrigation development program. The objective of the resettlement program was not only to reduce the population pressure on Java but also to contribute to the development of sparsely populated "Outer Islands" *(Geertz, 1963)* by providing more manpower for agricultural development (Gany, A. H.A.; 1993.)

At the follow up stage, irrigation development priorities were set up for the eastern coast of Sumatra, then, set up for South Sulawesi. Subsequently, the irrigation development priorities were directed toward other Outer Islands, with special focus on the transmigrant destination areas. Unfortunately, the development was practically terminated in 1930's due to severe economic crisis.

2.5. Immediate Post Independence Period

Initial Develoment Initiative: Earlier after Independence, the Government made a series of irrigation development planning both for short term, medium term as well as long term, with special priority on the short term objective, which was the "three-year" development plan from 1951 up until 1953. However, under the limited potentential of financial as well as human resources, the short-term development plan had never been materialized, till the new plan (Five-year Development Plan of 1956-1960) launched.

The subsequent developmen plan of 1961-1968 also faced the same problems and constraints, which unable it to be fully implemented. During this period, practically no irrigation development was undertaken till the political situation under the New Order Government had been stabilized.

Five-Year Development Plan: Under the New Order Government, the socio-political condition gradually became stablized, and the confrontation policy was replaced with the closer economic and political relationship with the neighbouring countries. During which, the stabilized political condition brought about new opportunity for the country to conduct new economic development policy. At the First Five-year Development Plan, water resources development had been prioritized by the Government of Indonesia. Despite that the development had been given special priority, the budgetary allocation had only been possible for large projects, and hence, the distribution of irrigation development has not not been possible to reach the entire parts of the country.

These programs have been initiated in two major river basins, namely the Jatiluhur in West Java Province and the Brantas River Basin in East Java Province. The two river basin projects have extended their activities, not only for irrigation, hydropower and flood control, but also for raw water supplies, city flushing, aquaculture development, as well as water based recreation and sports.

2.6. Multiple Purposes Water Resources and River Basin Development:

In an attempt to make the optimum advantage of water resources development andmanagement, the project implementations in general has been based upon integrated river basin approach as far as possible. This approach is especially implemented for river basins that are interdependent or having the same impacts, or belongs to the shared water ecosystem or environmental impacts from each other for being served the same areas.

During the first 25 years long term development program (1969-1984) there were seven multiple purposes and river-basin development projects namely: the Brantas River Basin Project; the Jratunseluna (Jragung, Tuntang, Serang, Lusi, Juana); Bengawan Solo; Serayu; Citanduy; Citarum; and Jenebrang River Basin Projects. Following the river basin development projects, the management of Brantas and Citarum River Basins have been transformed into state owned companies, the Jasa Tirta-I for Brantas River Basin Project, and Jasa Tirata-II for the Citarum River Basin Project.

2.7. Irrigation Works:

Approaching the first long-term development program, the physical condition of irrigation in Indonesia had been under highly deteoriorating condition. Irrigation infrastructures including canals and structures were practically suffered from severe damages due to the lack of maintenance. It was estimated that the remaining service function of irrigation system was between 40% and 60% of the overall capacity. During which, Indonesia had been suffered from severe deficit of rice production as the staple diet of the people.

Under such condition, the effort was concentrated on the implementation of Operation and Maintenance (O&M) of the existing facilities while pursuing the immediately affordable repairs to increase the serviceability of the irrigation infrastuctures. The development of new schemes had been concentrated on quick yielding projects, while extending irrigation areas through improvement, rehabilitation and upgrading of the already existing schemes.

Lowlands (swamps) Development: Parallel with conventional irrigation schemes, Indonesia posess a huge lowlands potentials scattered over the country, in particular on Sumatra Island, Kalimantan, and Irian Jaya (Papua). The development of inland swamps had long been practiced in Indonesia with mostly paddy cultivation, and occasionally with inland fisheries. So far as the water availability is still accessible, the water control for agriculture conducted by means of regulating the water level and tidal movements at the drainage channels. The tidal swamps also posess a huge potential for agricultural development in Indonesia. Out of the total of about 30 million ha of lowlands, about 15% suitable for agricultural development.

2.8. River Improvement and Flood Control:

River improvement as well as flood control in Indonesia poses variety of categories ranging from regular repairs to the very urgent works that must be undertaken as soon as possible, such as river improvement works due to natural disasters, and prevention works for protecting certain objects from severe river degradations.

Other category of river improvement works associated with the routine maintenance and river protections, as well as prevention from periodical flood strikes also conducted. Early in 1930's a number of river maintenance and improvement works were conducted at Citanduy River at the boundary between West Java and Central Java Provinces, such as stabilization of river flows at the meandering parts of the river.

Reservoir and Weir: Initially, people suspected that the provision of irrigation infrastructures would resolve all problems concerning water allocation and distribution for agricultural purposes. With the availability of irrigation networks, provision of irrigation water would no longer become problematic to meet the farming demands at appropriate time and quantity.

Early at the beginning of the 1920's development of reservoirs became more and more demanding, particularly for supporting sugarcane plantation on Java Island. Among the reservoirs that previously intended to support water supplies for sugar crop plantation, the Gunung Rowo, Gembong, Penjalin, Malahayu, and Situ Patok were the most popular ones during that period. At the initial stage, priority was given to irrigation areas at the water scarcity areas such as Pacal and Prijetan reservoirs in South Bojonegoro District, as well as Tempuran Reservoir in Blora District. Following this pioneering period, many scattered reservoirs, ranging from small, medium to large categories have been constructed in Indonesia.

Groundwater Development: Despite the comparative advantage of the utilization of groundwater relative to the surface water however, the development alternative was not feasible. The development of groundwater resources began to conduct at the followup stage of the first five year development program by initiating experimental pilot projects at the water scarce areas such as at Gunung Kidul in Yogyakarta Special Province and on Madura Island. During which, the groundwater development was not only limited to agricultural purposes, but also extended to a number of utilizations for the livelihood of the people – for domestic, livestock, and house-yard gardening.

III. HIGHLIGHTS OF IRRIGATION STRUCTURAL DEVELOPMENT

3.1. Evidence of the Earlier Infrastructural Heritages

Historical Evidence of Ancient Irrigation Civilization: Based on the historical evidence, one of the earliest irrigation and water resources structure in Indonesia is Harinjing Structure was developed in the Kepung Village at Brantas River Basin Area in the year of 808 AD, then followed by reconstruction in the year 921 AD and rehbilitation was conducted in 927 AD. Unfortunately, no more artifact left except a big stone which is believed to be the ruin of structural foundation of the weir **(Angoedi, 1984., p.25).**

The structure is believed to be constructed as a weir in combination with river dyke (harinjing dyke) to facilitate irrigated agriculture and flood protection in the vicinity of one of Brantas River tributary area, by means of *"gotong royong"* or mutual aid system by the people concerned.

Hydraulic Structure in Indonesia: As far as the historical records that have been unveiled till up to now, it is clearly apparent from the Tugu Stone inscription that the earliest ancient hydraulic structure in Indonesia is the Chandra Baga diversion channel near Cilincing River in the Vicinity of Jakarta Metrupolitant City now. The channel was believed to be constructed at the year 500 AD by King Purnawarman for facilitating the flood control of Jakarta land plain.

3.2. Some Stone Relief Concerning the Water Utilization at the Ancient Temples

Inspite of the historical evidence of the developed technology of irrigation and water resources hiritages in Indonesia, it is apparent that the Indonesian ancestors has long been experienced to developed and managed water resources and irrigation technology as well as environmental water water ecosystem.

From several reliefs found at the Prambanan Temples, it is clearly seen that the civilization of water technology had already been developed to provide water as well as conservation for sustainable environmental ecosystem – which is clearly illustrate that the water technique is not only intended to provide water for human livelihood, but also for the sustainability of flora and fauna.

The ancestral messages concerning culture and irrigation technology for paddy cultivation, for instance, clearly depicted by the stone reliefs kept at trowulan museum in East Java **(Figure 1.)**, in which shown how to transplant paddy seedlings at the lowland bounded paddy field. This evidence clearly shown upland paddy cultivation which must apply seed broadcasting technique. Therefore the paddy cultivation shown at the stone relief must have been representing the utilization of water for softening the land cultivation **(Figure 2.)**. However simple the technology which were utilized by the ancestor, it indicated that they had already applied special effort for irrigation water. If the relief's **(see also Figure 3 and 4.)**, which were perfectly crafted at the massive stone during the era of Borobudur Temple, Perambanan, at the 7-8th century AD, it is obvious that the irrigation or water technology must had been older than the temples.

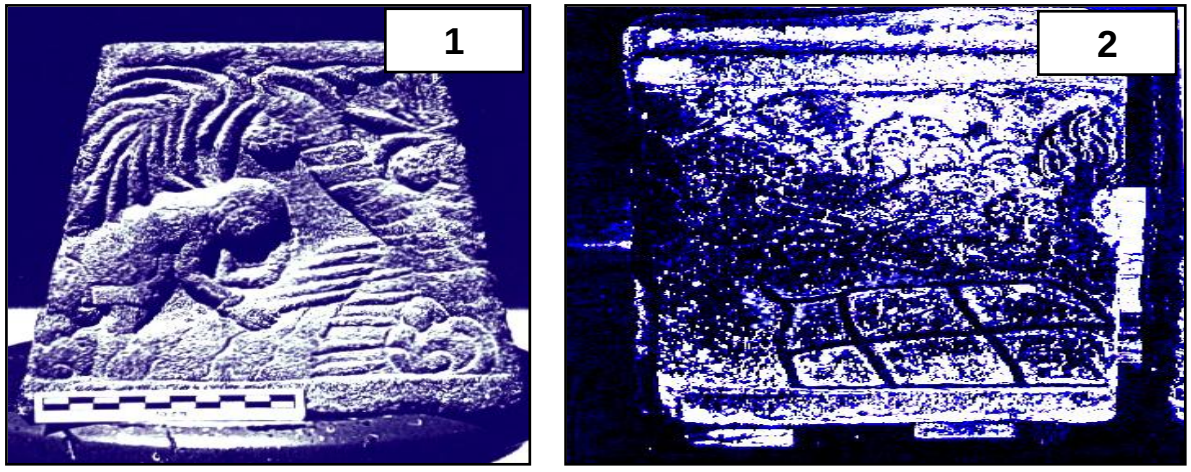

Figure 1. A stone relief of the temple at Trowulan Museum, shown the paddy cultivation by means of low land bounded paddy field. **Figure 2.** A stone relief from the temple at Trowulan museum depicting the bird eye view of low-land bounded paddy field at the rural area.

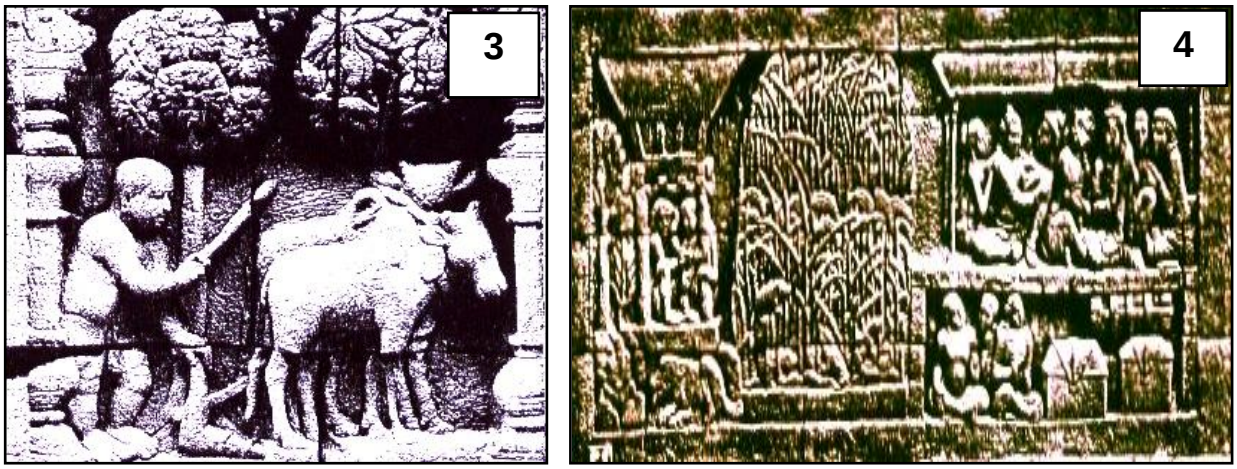

Figure 3. The relief of Borobudur Temple showing the technology of land preparation by cattle power. **Figure 4.** The relief of Borobudur temple showing the farming activities for pest control (including birds and rats) at the ripening stage of the paddy cultivation.

3.3. Ancient Technique and Simple Irrigation System:

Design and Construction: During the Hindu Era, the ancient technique was so simple, making use of local materials. The local materials are mostly recommended, in such a way that the construction would not costly, and the rehabilitation as well as repairs would be easily undertaken without necessary to import construction materials. For instance, many structure of the water weir in the medium and large rivers were made of loose stone and boulder, in combination with soil and bamboo leaves, branches, or organic filament, anchored to the bamboo pegs to fill the voids.

Simple Irrigation System: The Indonesian Archipelago posesses quite a large number of ancestral heritages, both in terms of software as well as hardware, including system and institutional aspects of irrigated agricultural heritages which are still applied in this modern era. For instance, heritage of rice terrace on the Island of Bali, Lombok, Java, Sumatra, Sulawesi, and other agricultural system scattered over the country. The traditional irrigated agricultural heritages had been handed over from generation to generation through oral messages without any evidence about the time since the technology had been applied**.**

In many places in Indonesia, the simple irrigation structures are still operated and maintained by the rural community, because most of them would easily conduct the repair of the damages due to annual floods, using locally available material, and participatory approach in terms of mutual aid or *"gotong royong".*

For illustration, one of the key successes of sustainble irrigated agriculrural implementation in "Subak" System in Bali Island is the "simplicity" principle, in such a way that the message can be adapted by the local farmers, however simple their educational background. As the matter of fact, such simple technology could be descended down from generation to generation, till today. See **Figure 5,** simple water measurement device *(tektek)* invented by Subak in Bali.

Figure 5. Simple water measurement devive *(tektek)* invented by Subak in Bali.

From the perspective of modern irrigation technology, the accuracy is not least presize in comparison with the modren measurement device the people known today. Under the traditional management system, irrigation heritages are mostly sustainable and adaptable by people from generation to generation. The main rationale of the sustainable practice has been incorporated with the "simplicity" principles. Most techniques can be adopted without involving sophisticated learning process. This is perhaps one of the rationale why the artifact of infrastructural heritages had never been uncovered.

IV. HIGHLIGHT OF TECHNICAL IRRIGATION INFRASTRUCTURAL HERITAGES

At the beginning, the technical Irrigation during the Dutch Colonial Era, it has been stated that technical irrigation has only been widely implemented in Indonesia since earlier at the turn of the 20th century. Since then the technical infrastructures have been operated and maintained following the development capacity of the government, and the O&M capacity of the farmers. Following the economic condition of the country and the development process of water resources and irrigation infrastructures, the infrastructural heritage have been suffered from severely lack of O&M undertakings, so

do the physical condition. Based upon the recent structural inventory, the overall structure of irrigation infrastructural condition have been represented by a total irrigation area of 7,769,733 ha having served with dams, weirs, and facilities at the main, secondary systems, consisted of large, medium and small structures, scattered over the provinces in the archipelago.

Pioneering Irrigation Technique: Following the implementation of Compulsory Agricultural Policy, which was initiated by Johnnes Van den Bosch (1830-1833), the Dutch Colonial Government since then, directly involved in agricultural management.

For this purpose, the Dutch Government dispatched Ir. Van Thiel to Situbondo to erect a weir in Kali Sampean River in 1832. The construction of this weir made of teakwood framework structure, filled with stone and boulder. The width of the weir was 45 m and the height ws eight meters. For improvement, it was replaced by masonry structure in 1847. Up until 1876 many temporary weir had been constructed by means of "Trial-and-Error". In 1850 the Sampean weir could no longer utilized, as the teakwood material for routine maintenance had no longer available. Up until 1876 temporary weir structures had been constructed, and at the same year the masonry weir completed, but the weir did not last long as well.

Through a long term development program, the weirs have been improved from time to time, following the demand for structural improvement as well as irrigation targets as well as adjustment with objectives of the structural improvement toward sustainable development. The implementation, have been conducted through routine maintenance, special maintenance and rehabilitation as well as reconstruction as if necessary.

Irrigation infrastructures' pioneer under the Transmigration Program: In 1902 the Dutch Colonial Government commissioned a study to examine the possibility of resolving the problem of over–population and land fragmentation on Java where the large local population surplus was regarded by the Dutch as a potential source of political tension and unrest. This study recommended moving people from Java to the sparsely populated areas in other parts of Indonesia.

In order to catch up the rapid escalation of population", the irrigation development priorities were directed toward the Outer Islands' areas, with special focus on the "Transmigration" Program, during which, many irrigation infrastructures with different kinds of types and models have been constructed, which was to some extend, more as experimental diversification to accommodate the local requirement, physically as well as operationally.

4.1. Multi-Purposes Water Resources Development:

Under the 5-Year Development, the role of water resources was expanded to cover not only irrigation but also flood control, drinking water, sanitation, urban flushing, transportation, environmental conservation and water based sport & recreation, hydropower etc. During this stage of development many water resources and irrigation infrastructures were developed. This includes the headwork and reservoirs scattered over the country. Among the many infrastructures, the Curug Weir in which Sediyatmo Pump is used, at the Jatiluhur scheme has been considered to be a unique heritage of

water resources structures, which was planned and developed under the supervision of Indonesian engineers.

4.2. Dam, Reservoir and Headwork:

With the spread of irrigation infrastructural development in Indonesia, the water demands increasingly important during the first decade of the 20th Century. In an attempt to meet this escalating demand, a series of dams and reservoirs were constructed. Till 2004, there are 117 large dams and 3,666 small dams (pond and *embung*) have been constructed in Indonesia. The total storage capacity is estimated at about 6 km^3. The first large dam was built in Central Java in 1914 by the Dutch Colonial Government. Before independence (1945), a total of 16 large dams were built in Central and East Java for Irrigation purpose. The dominant type of the dam is fill type of dam consisting of 63 earthfill dams (53.3%) and 38 rockfill dams (32.5%) due to their cost effectiveness, material availability and suitable geological condition. There are 11 concrete dams (9.4%) has been built mostly for hydraulic power generation.

V. PROBLEMS, CONSTRAINTS AND DRAWBACKS OF IRRIGATION INFRASTRUCTURAL DEVELOPMENT AND MANAGEMENT

5.1. Drawback of Irrigation Infrastructural Sustainability:

Planning, Design and Construction: Due to the lack of technical experience in the development of irrigation for agriculture, irrigation planning and construction implementation were undertaken almost without any basic technical and agro-climatological data. At that time, practically no data on hydrology, hydrometry, geology, topographical maps available, as well as no laboratories to back up the planning and technical design. And hence, the technical designs were merely conducted based on subjective assumptions and by means of "trial-and-error".

During after independence, infrastructural planning and technical design, had also been facing critical situation, where not much data available, partly because during the war, the data collection and management were also distracted, and hence data availability, especially on hydrology and hygrometry had almost been non-existence.

Operation and Maintenance: During the peak acceleration of infrastructural development, most development engineers were concentrated their effort on construction aspect of the development, and less attention on sustaining the function as well the structural support to the community. It is not surprising that the development within 1980's has brought the country into a successful effort to attain self sufficiency in rice production in 1984, though the acchievement was not sustainable.

Learning from a series of experiences in irrigation implementation, it gives strong supports that management of irrigation, drainage, and flood control system is much more important than construction of infrastructural facilities per se'.

Socio-Economic and Institutional aspects: The subsequent problems of irrigation operation and management are that the farmers, who are expected to participate actively, had yet having adequate incentive to continuously cultivating food crops. Despite that the institutional and organizational arrangements of traditional agriculture, has long been set up and managed through regular meeting amongst the members, due to lack of capacity to maintain sustainable crop production, the farming circumstances had continuously been constrained by a number of non technical aspects, including the poor market potential, as well as poor agricultural production.

5.2. Sustaining the Infrastructural Condition:

Principle of Sustainability: Learning from traditional irrigation management heritage it has been identified that the sustainability of irrigated farming practices were based on their capacity to maintain "harmonious-togetherness" among their farming community in addition to their ability to maintain a "proper balance", of relationship between "human" and "nature" on reciprocal basis. The basic principles that make their activities sustainable are due to application of techniques by means of "simplicity principles", so that every member could apply them without sophisticated learning process.

Institutional Arrangement: In order to be able to implement appropriate interrelation ship amongst the parties involved in infrastructural operation and management, all the organizational concerns, including the Government, and Non Government Organization must perform effective working relationship and participatory measures in all aspects of development and management. This has been obvious since the old days, where management could only be implemented successfully when all the partied concerned are performing their duties and responsibilities through appropriate insitutional arrangement.

Enhance Socio-Cultural and Economic Adaptations: It has been identified through a long term implementation that the indigenous capacity of the traditional farmers is still conducive to socio-cultural and economic adaptation. However, the socio-cultural dimensions are continuously impeded by the shift of values, due to inconsistent socio-cultural adaptation such as the "mutual aids" culture *(gotong-royong),* which no longer exist after the community had a sort of cultural disorientation. This has been particularly the case due to excessive external supports without adequate consideration on socio-cultural dimensions and eventually the community suffered from dependency attitude, socially as well economically.

Participatory Approach through Water User Association (WUA) and WUA Federation: Historically, the ancient farmers organized themselves to manage irrigation canals and infrastructures. Today, in spite of the absence of mutual aids and sense of belonging as well as sense of participation to the public related activities, the farmers must organize their activities through Water User's Associations (WUAs) in small irrigation scheme areas. While in the larger irrigation scheme the WUAs formed coordination mechanism amongst them in terms of Water Users Association Federation (WUA's Federation).

Maintaining Sustainable Environment: With the existence of the substantial impacts of climate change, many aspects of irrigation O&M of irrigation infrastructure should be taken into consideration, including water saving, and sharing the water for environment

or E-Flow, that has become the issues of maintaining sustainable environment. For example, the implementation of plot-to-plot irrigation system that have been adopted by many traditional farming community, used to be blamed as wasting water, but today, from sustainable environmental practice, it has been considered as sustainable and environmentally friendly water utilization.

VI. CONCLUSION AND RECOMMENDATION

Learning from the long journey of irrigation civilization of Indonesia's history, the role of irrigation remains and will continue to be important. As the matter of fact, Irrigation is not only a matter of technical, but also the matter of social, cultural, economic, religion, beliefs, tradition, ethics, and political concerns. So the development technology approach that have been implemented for many years, must be shifted to comprehensive development and management approach, involving all the stakeholders in terms of participatory approach. For present and future approach the indigenous technologies should not be overlooked in planning, development and management of water resources and irrigation infrastructures.

Allocation of O&M Budget: Despite the costly budgetary investment, the need for consistent improvement of irrigation techniques without jeopardizing human and nature must be pursued with support of the government and the beneficiaries concerns. This is a must, that O&M of Infrastructural Heritages must be fully disbursed in line with the magnitude that had been contributed for making the acceptability feasibility study, in terms of technical, social, economic, as well as environmental justifications.

Advanced Irrigation Alternatives: The future development must consider irrigation alternatives, (e.g. Micro irrigation) followed by post production, agro-industries. Also irrigated paddy field, has potentials for development of other functionalities, such as leisure agriculture, and agro-tourism, therefore the efforts must be in line with ecological as well as living functions of irrigation.

Key to Sustainable Infrastructural Heritages: Further to the technical efforts, the following aspects will have to be considered important in the future: (1) Planning must not overlook social, cultural, economic, religion; (2) Application of participatory Irrigation Management (PIM) approach is essential, including consideration on maximization of "externality function" of irrigation; (3) The success or failures of irrigation also lies on effective institutional arrangement; (4) Participatory of WUA's or WUAF's must be consistent throughout the entire development and management process; (5) The "structural" as well as the "non-structural" approaches are two sides of a coin which is absolutely inseparable; (6) Flood and drought management, and water related disasters must be considered in the future Integrated Water Resources Management (IWRM).

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