AGRICULTURAL WATER MANAGEMENT SYSTEMS IN INDONESIA: CURRENT STATUS AND POLICY DIRECTION

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ABSTRACT

This paper highlights current status and policy direction of agricultural water management systems in Indonesia. The scope of policies include management responsibility, investment and institutional development. As a consequence of government investment in water resources, especially in public irrigation system, the management of irrigation dichotomized into community and government approaches. Further intervention into institutional domain of local communities occurred in 1970s and 1980s in responding to Green Revolution technology and the policy to meet self-sufficiency in rice production. Such policy intervention, however, has weakened the internal dynamics of local communities and increased the burden of government in operation and maintenance of irrigation system, mainly of large-scale irrigation system. Within the framework of decentralization and related to strategies of adaptation to climate change, there is a need to empower the local communities and to redefine the acceptable roles between government and local communities in irrigation management by taking into account constraints to the shift in jurisdictional boundaries.

Keywords: Indonesia, irrigation system management, policies.

INTRODUCTION

The threat of climate change is now considered an established fact. Using General Circulation Models simulation, the weather experts have predicted that global warming will intensify the hydrologic cycle; more intense rainfall will occur in fewer spells; both floods and droughts will become more intense; the floods will be more frequent; the rainfall will shift towards winter; and there may be a significant reduction in the mass of glaciers, resulting in increased flows in the initial few decades but substantially reduced flows thereafter. Climate change is expected to alter the present hydrological resources and add pressure on the adaptability of future water resources. It has the potential to impact very significantly on both the availability of and requirements for water.

An increase in mean temperatures would increase the energy flux for evapo-transpiration. The increased potential evapo-transpiration in the forests could trigger major changes in the environment, and it would result in an increased crop water requirement in the farms. The changes in seasonal temperatures could change the crop seasons. The Intergovernmental Panel on Climate Change (IPCC) identifies food systems as a key area vulnerable to climate change (IPCC 2007). Obviously, the importance of water to food production cannot be overstated.

Food production depend on water. In developing countries 70-80% of accessible fresh water is used for agriculture. Approximately 40% of the world’s food is produced on 17% of the cultivated land which is irrigated (Serageldin 1995). The Food and Agriculture Organization of the U.N. has said that 60% of the additional food needed to meet the needs of the earth’s growing population through the year 2050 will have to be produced on irrigated land (FAO 1996).

Estimates of incremental water requirement to meet future demand for agricultural production under climate change vary from 40% 100% of the extra water needed without global warming. One consequence of greater future water demand and likely reductions in supply is that the emerging competition between the environment and agriculture for raw water will be much greater, and the matching of supply and demand consequently harder to reconcile (FAO, 2011).

As the reliability of water supply will often decrease and supplies become more variable within
season and over time, the extent to which irrigation areas can be maintained, intensified or expanded will depend on the combinations of impacts and contexts in a given situation. The need for water storage will increase. Storage options will need to be flexible and have low capital and operating costs.

Agricultural water use in Indonesia is expected to face serious water scarcity from the combined effects of climate change. Not only is this true in Indonesia, but also in most developing countries, where there is lagging water infrastructure development, and rapidly increasing populations (OECD 2008). In several regions, water scarcity has become a limiting factor for economic development. The sector will also be impacted by more active storm systems, especially in the tropics, where cyclone activity is likely to intensify in line with increasing ocean temperatures.

Water resources have played an important role in the development of Indonesia over the past decades. Agriculture, mainly rice, still plays strategic and important roles in Indonesian economy, social life and politics. However, in the future, the supply of water tends to decrease due to the watershed capacity. Storing water is also decreasing due to other environmental degradation, while the demand tend to increase since the needs for water in industrial, agriculture and human needs are increasing. Therefore the growing issues need to be addressed to achieve the goals, namely: (1) water scarcity and drought impact on food crop production; (2) floods and submergence impact on food crops; (3) pest and disease outbreaks in response to climate change.

The future incidence of climate change can only be conjectured, but it is likely to have particular impact on the small farmers living in marginal areas who have to cope with least knowledge and resources. Experience has shown that programs can be adapted to help, particularly through technological innovations such as minimum tillage and improved water management. Future research and technology transfer will have to focus increasingly on helping small farmers cope with climate change.

Country background

Indonesia (Fig. 1) consists of about 17,508 islands of which 6,000 are inhabited. The principal islands are Java, Madura, Bali, Lombok, Sumatra, Kalimantan (Borneo), Sulawesi (Celebes), Sumbawa, Sumba, Flores, Timor, Papua (West New Guinea), and Maluku (Moluccas). The gross area (including inland water surfaces) of Indonesia 1,904,350 km², though the gross country area including the domestic seas is about 9,600,000 km².

Currently, Indonesia’s population is estimated at about 241 million with a growth rate of 1.39%. It is the world’s fourth most populous country. Around 53% of the population live in rural areas.

Republic of Indonesia is divided into 34 provinces. Each province consists of districts and cities. Total number of districts and cities are more than 400. Province, districts, and cities have their
own local governments and parliamentary bodies. Since the enactment of Law Number 32 Year 2004 regarding Local Government and Law Number 33 Year 2004 regarding Financial Balance between the Central and Regional Governments, the local governments have greater role and autonomy to administer their own areas. These policies have changed the governing approach of the state from the previously centralized to become decentralized, and delegate authority of the central government to regional governments with the exception of foreign, defense and security, judicial matters, religion, fiscal and monetary policies. Furthermore, there are significant changes in the financial balance between the central and regional governments.

The country is the largest economy in Southeast Asia and a member of the G-20 major economies. Indonesia's estimated gross domestic product (nominal), as of 2010 was US$706.73 billion with estimated nominal per capita GDP was US$3,015, and per capita GDP PPP was US$4,394. The industry sector is the economy's largest and accounts for 46.4% of GDP (2010). This is followed by services (37.1%) and agriculture (16.5%). However, since 2010, the service sector has employed more people compared to other sectors. This accounts for 48.9% of the total labor force, and is followed by agriculture (38.3%) and industry (12.8%). Agriculture, however, had been the country's largest employer for centuries. It contributes to more than 40% of the country's labor. Indonesia was the country hardest hit by the Asian financial crisis of 1997–98. Against the US dollar, the rupiah dropped from about Rp. 2,600 to a low point of 14,000, and the economy shrank by 13.7%. The Rupiah stabilized in the Rp. 8,000 to 10,000 range, and a slow but significant economic recovery has ensued. Since 2007, however, with the improvement of the banking sector and domestic consumption, the national economic growth has registered an annual growth 6% and this helped the country weather the 2008–2009 global recession. The Indonesian economy performed strongly during the Global Financial Crisis and in 2011, its GDP grew by 6.4%. The country regained its investment grade rating in late 2011 after losing it in the 1997. However, as of 2010, an estimated 13.3% of the population lived below the poverty line, and the unemployment rate was 7.1%.

**Water resources in Indonesia**

Indonesia is the 5th among the richest countries in annual renewable water resources (FAO, 1999). However, this amount of water is not well distributed all over the country. In Java island, for example, where the population reaches to a number of 65% of the total population of Indonesia, the water only available is 4.5% of the total national water available or about 30,569.2 million m³/year. Unbalance distribution of water consequently addresses to surplus and deficit water as described (Table 1). Papua is the island having the biggest amount of available water and has been predicted to at least not have a deficit until 2015. Despite the fact that the number is not as high as in Papua, deficit will also not happen in Sumatra, Kalimantan, Maluku and West Nusa Tenggara. It is

<table>
<thead>
<tr>
<th>Islands</th>
<th>Available Water (Million m³/yr)</th>
<th>Water Demands (Million m³/yr)</th>
<th>Surplus/Deficit (Million m³/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sumatra</td>
<td>111,077.7</td>
<td>19,164.8</td>
<td>9,912.9</td>
</tr>
<tr>
<td>Java</td>
<td>30,569.2</td>
<td>62,927.0</td>
<td>-32,357.8</td>
</tr>
<tr>
<td>Kalimantan</td>
<td>140,005.6</td>
<td>5,111.3</td>
<td>-134,894.3</td>
</tr>
<tr>
<td>Sulawesi</td>
<td>34,787.6</td>
<td>15,257.0</td>
<td>-19,530.6</td>
</tr>
<tr>
<td>Bali</td>
<td>1,067.3</td>
<td>2,574.4</td>
<td>-1,507.1</td>
</tr>
<tr>
<td>West Nusa Tenggara</td>
<td>3,508.6</td>
<td>1,628.6</td>
<td>-1,880.0</td>
</tr>
<tr>
<td>East Nusa Tenggara</td>
<td>4,251.2</td>
<td>1,736.2</td>
<td>2,515.0</td>
</tr>
<tr>
<td>Maluku</td>
<td>15,457.7</td>
<td>235.7</td>
<td>15,222.0</td>
</tr>
<tr>
<td>Papua</td>
<td>350,589.7</td>
<td>128.3</td>
<td>350,461.4</td>
</tr>
<tr>
<td>Total</td>
<td>691,317.6</td>
<td>110,762.3</td>
<td>584,555.3</td>
</tr>
</tbody>
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Source: Sjarief (2003) as recited from Sutopo, Kompas 27/03/2003
not only fresh surface water such as those stored up in the lakes, rivers, dams, depression areas, water storages etc., groundwater, brackish water, salty sea water are also available. Two-thirds of the country area is covered by sea water. Unfortunately, the amount of available water decreases due to several reasons. One is prior to impact of extreme climate condition. Global and local climate change affects much on the current water resources status. The water stored in the dams, for example, has already declined as the capacity of the dam and the rainfall intensity and pattern have changed.

Lost of water in catchments area is also major determination of water status in Indonesia. The major factors determining the lost of water are: (a) rapid growth of land use change; (b) increase the degraded (critical) land; (c) increase the distribution of degraded watershed; and (d) other factors affecting the change of hydrological function of the watershed.

The results of estimation carried out by Soenarno and Syarief (1994) indicate that the aggregate availability of water in 1995 remained higher than the demand for it (122697 Vs 63720 mill. m³/year. Nevertheless, three river basins have been in deficit situation or the demand for water in the basins is higher than its supply. The demand versus the supply of water in the three Basins can be described as 3,406 Vs 4 471 mill. m³/year in Cisadane-Ciliwung River Basin; 6619 Vs 7670 mill m³/year in the downstream of Citarum River Basin; and 4 637 Vs 4 788 mill m³/year in the downstream of Brantas River Basin. The study also classified the major river basins in Java into five classes by the degree of water scarcity (very high, high, moderate, low and secure). From 28 major river basins in Java, the numbers of basins by the degree of water scarcity are three basins (very high), eight basins (high), three basins (moderate), seven basins (low), and three basins (secure), respectively.

The increasing number of critical river basins continues. In 1985, there have been 22 critical river basins out of 85 river basins. The number of critical river basins increased to 35 river basins in 1990 and 60 river basins in 1995; 20 of which have been classified as extremely critical. The critical river basins are located particularly in Java, Sumatra, and Kalimantan.

Water resources status has also deteriorated due to the impact of climate change. Volume of water during the period of El-Niño and La-Niña is fluctuated and varies from season to season. This leads to the change of available water stored in the dams. During the La-Niña event, the stored water in the dams exceeds the volume of water in the normal years. In contrast, water scarcity is almost the major phenomenon that has been facing the community in every occasion to cover their need for domestic, industry, agriculture purposes.

**Brief history of water infrastructure development in Indonesia**

The water infrastructure development could be divided into several stages as follows (Sugiyanto and Samekto, 2008; Gany, 2010; Pasandaran, 2010):

- **The period before Dutch Colonization.** The simple irrigation for paddy field had been done by the people in the year 1037. Then, Hindu Kingdom (Majapahit) continued to develop some water resources system to avoid floods and to build irrigation system in East Java. Subsequently, during the era of Islam Kingdom in Central Java (Demak – Pajang - Mataram), rice had been exported to the neighboring kingdoms.

- **The period during Dutch Colonization.** The Dutch Colonization took place from 1600 to 1942. Some examples of water infrastructures during this period are Subak Irrigation System (build by water user association in Bali), Small Scale Irrigation System (by Villagers in Java Island). Development of Dams was done during 1920 to 1942 with the capacity up to 30 millions M³, such as, Malahayu Dam and Sempor Dam in Central Java, Pacal Dam and Prijetan Dam in East Java, Setupatok Dams in West Java and many dams in Java with the capacity of less than 10 millions M³.

- **The period under Japan Army occupation.** During this period (1942 – 1945), the infrastructures that were finished are Doboku Weir (irrigation), Tulung Agung Tunnel (flood control), Citanduy River (flood control), Solo City (flood control), Irrigation System along North Coast and South Coast of Java. There were some irrigation infrastructures that were not fully finished due to the war, i.e. Small Irrigation in Simalungun (North Sumatra), Klingi and Betitiang (South Sumatra), Way Sekampung (Lampung, Sumatra) and Sadang and Jeneberang (South Sulawesi).

- **The period after proclamation of independence.** The development of water infrastructures was done by continuing from the past plan by the program of eight years terms development plan. Water infrastructures finished were:
Jatiluhur Dam (West Java, 1967), Darma Dam (West Java, 1962), Sutami Dam (East Java, 1972), and Cacaban Dam (Central Java, 1959). The dams mentioned had multipurpose functions, such as for irrigation, flood control, hydro power, water supply for domestic use, fishery and tourism, etc. The developments of water infrastructures have reached significant result during the period after the 1969 program implementation of the long term development plan.

**Current status of irrigation in Indonesia**

Actually, the economic crisis (1998) is not the sole factor causing the current weakening of food security in Indonesia. Empirically, food security over the last ten years has been weakening since food supply, especially from domestic production, cannot be raised significantly due to several factors. First, the country is not able to increase productivity of food commodities. Second, there was failure in minimizing land conversion from agricultural use to non-agricultural use. Third, capacity of paddy field tends to decrease because of deterioration of irrigation performance as a result of late rehabilitation.

Performance of irrigated agriculture in publicly managed schemes is generally lower than its technical and economic potential. The performance of the large-scale irrigation schemes has been particularly unsatisfying. In most of these schemes, farmers often receive poor water service, and reliable and timely irrigation service delivery is the exception rather than the rule. The major causes of poor service delivery are commonly located in the interrelated problems of bureaucratic institutional setup and rigid technical design, both of which generally originate in the top-down, planning-led approach to irrigation. Bureaucratic institutional setups for large scale irrigation have contributed to poor service delivery in a vicious circle of insufficient funding, inadequate operation and maintenance, and system deterioration, often leading to the need for successive rehabilitation. Technical design has suffered from the same top-down approach. Many schemes were constructed with inflexible delivery patterns, which are suitable to deliver water according to preset schedules, but are incapable of responding to changes in demand by the users.

Many innovations are possible in water management, agriculture, and ecological management that would improve productivity or conserve water. Experience is that farmers may well be aware of technological options, but do not invest in technology unless pushed by cost incentives or pulled by profitable market opportunities. In addition, farmers have to minimize risks, particularly risk of access to adequate quantities of water at the right time. Thus, secure water entitlements and demand-responsive water service are key factors in encouraging farmers to invest in new technology. Irrigation development has been driven by food supply imperatives—particularly food self-sufficiency considerations—rather than by market demand. As a consequence, large scale irrigation schemes have generally been built to produce low-value staples. Not surprisingly, small farmers cannot pay the full financial cost of water, let alone the opportunity cost. Despite the strong arguments for recovery of the cost of supplying irrigation water (incentives to water productivity, covering scheme costs, environmental concerns, equity), in reality, irrigation is heavily subsidized almost everywhere. On the social side, despite the contribution of agricultural water management to poverty reduction, few investment programs explicitly target the needs of the poorest by taking into account key factors affecting their livelihood, such as distribution of land holdings, security of water entitlements, the vulnerability of irrigation tail-enders (that is, irrigators whose plots lie at the bottom end of the water distribution system and who receive only residual water), and the appropriateness of technology to the situation of poor households.

The existing irrigation system in Indonesia covers a command area of roughly 7.2 million hectares (ha), comprising 4.8 ha government-managed irrigation systems and the balance farmer-managed irrigation systems (Fig. 2). In the areas where gravity irrigation was not technically feasible, pump irrigation systems have been developed for the sake of poverty alleviation. By 2003, for about 900 pump irrigation units comprising medium and deep wells have been developed with command area of 35,240 ha (DGWRD, 2003). The existing schemes mostly reflect the results of irrigation development during 1980 – 1995 period.

To date, the technical status of irrigation schemes areas are attributed to the following factors:

- the irrigated areas are concentrated in Java (3.3 million hectares or 46 % of the total irrigated areas) comprising 31.5 % technical irrigation, 10.5 semi-technical irrigation, and 15.7 % simple irrigation (farmer-managed irrigation);
• the establishment process of newly developed irrigation schemes is very slow because farmers are not capable of developing rice fields by their own efforts due to constraints in finance and land property rights;

• the total number of irrigated rice fields in Java is steadily decreasing due to conversion to other uses such as industrial, living areas, highway, and tree crops plantation.

Paddy (wet rice) is the most important irrigated crop. More than half of all paddy rice produced in Indonesia is harvested in Java, and Javanese yields are around 15 percent higher than the Indonesian average, reflecting the concentration of technical and semi-technical irrigation systems, favorable soils and climate, and the historical accumulation of experience in paddy cultivation.

Irrigated paddy cultivation, long the dominant abstractive and consumptive user of water, is facing increased competitive pressure from other sectors. These include municipal and industrial users, aquaculture, as well as the natural environment via demand for waste dilution flows. Investments in water supply augmentation, specifically in dams, weirs and related structures, remains an important strategy to counteract increased pressure on water resources. However, opportunities for economically rational investment in large-scale physical infrastructure are increasingly scarce on the densely settled and extensively developed island of Java.

Harvested paddy areas expanded steadily between 1971-1995, and continued to accelerate. However, growth yield stagnated in the 1995-2005, suggesting a combination of transient adverse climatic conditions, impacts 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 1970s–1990s. A 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).

While about 80% of domestic rice production comes from irrigated areas, food security is uncertain because of problems that have constrained public irrigation performance and sustainability. Sustaining rice and food production also requires an effective irrigation O&M program instead of deferral of routine maintenance and dependence on periodic externally aided investment for irrigation scheme rehabilitation. Also, government’s investment strategy of maintaining rice security through expansion of irrigation and swamp reclamation on the Outer Java Island needs review, particularly with respect to the choice of most cost-effective and environmentally sustainable interventions.

Over the last two and a half decades, irrigation development program has been the major factor affecting the growth of rice production in Indonesia. The program grew rapidly in the first three PELITAs (1969-1984) before considerable slowdown of the rate of investment and completion of targeted area took place in PELITA-IV.

In the past, irrigation investment strategy was also aimed at fostering sustainable growth of paddy production and self-reliance in rice. The long-term strategy of irrigation development is
based on two premises. First, the performance of existing irrigation facilities needs to be improved and protected from external disturbances. Second, additional irrigated land resources are needed as a source of income and food security (Pasandaran, 2010).

Constraints and challenges

Indonesia is strongly influenced by ENSO cycles (e.g., El Niño typically results in widespread droughts and La Niña results in flooding in Indonesia), which could exacerbate drying and/or flooding trends. The El Niño induced droughts of 1997-1998 caused massive crop failures, water storages, and forest fires in parts of Indonesia and if climate model projections of stronger, more frequent El Niño events materialize (Tsonis et al., 2005), Indonesia may experience even more adverse impacts, including less food production and increased hunger. For example, a recent study that looked at assessing the risks of climate change in Indonesia rice production suggests that under future climate projections, there is a significant 30-day delay in the onset of monsoon season and a substantial decrease in precipitation later in the dry season (Naylor et al., 2007), which when combined with temperature increases of up to 4°C (for every 1°C increase in minimum temperature, rice yields decrease by 10%; Peng et al., 2004), will lead to massive drops in rice production. A temperature increase beyond 2.5°C and the resulting drop in rice yield would incur a loss in farm-level net revenue of 9 to 25% (Lal, 2005).

Nowadays, Government of Indonesia is facing several constraints and challenges in the current effort on agricultural water development, such as:

- **The slowing down of rate of irrigation expansion.** Irrigated area in Indonesia grew from 1.2 to 7.2 million hectares (ha) between 1974 and 2010. The pace of development was faster in the early years and slowed considerably in the later years. In some areas, the potential for expansion is limited. For example, the water resources of numerous rivers have been fully exploited, especially in Java, Bali, Lombok, and some provinces in Sumatera dan Sulawesi. On the economic and financial side, the unit cost of development has increased. Since the ’90s, investment policies have changed: (i) recent investment patterns within irrigation have aimed more toward increased efficiency and sustainability of water use, for example, in system rehabilitation, improvement, and operation and maintenance; and in management, institutions, and policy, all of which have lower investment costs than the capital-intensive works of system development, (ii) government has focused more on general budget support for and investments in social development (education and health) and the environment than on irrigation development.

- **Water availability for irrigated agriculture is decreasing.** Irrigated agriculture accounts for more than 80% of water withdrawals from surface and ground water of consumption of water withdrawn. However, withdrawal percentages differ widely by areas and by island. It means, this large share does not in itself mean scarcity, because in some islands (Sumatera, Kalimantan, Papua) withdrawal take up only a relatively small share of potentially available resources.

- **Water management for rainfed agriculture has been underdeveloped.** Rainfed farmers (food commodities) typically farm marginal lands or dry lands, with little or no access to a controlled water source. The Green Revolution largely bypassed these farmers. Improvements in yields and water management have been scant, and the growth of rainfed production through extension of the cultivated area has kept incomes low and has harmed the environment. The availability of land for extensification has contributed to the neglect of options to move up from rainfed agriculture to access to controlled water sources—from simple supplementary irrigation to the development of large-scale schemes. As a result, rainfed farmers have remained poor. The technological options for improved water management in rainfed agriculture have been piloted and developed over the last decade, but are seldom implemented on a large geographical scale.

- **The environmental impacts of agricultural water management have been neglected.** In Java and some provinces in Sumatera, irrigation water withdrawals exceed 80% of its total. Inevitably, the tension between agricultural production and protection of natural resources has grown. Environmental costs and risks of irrigated agriculture have become clearer: there is land degradation and erosion; loss of environmental water flows; pollution; destruction of natural habitats and livelihoods through drainage of wetlands and
through land expansion and deforestation; and waterborne diseases.

**Policy direction in agricultural water management**

Dealing with food security in Indonesia, one should not overlook the importance of rice. Rice provides more than half of the total calories and protein in Indonesian diet. Moreover, rice production is the main source of income and employment for more than 19 million rural families. Experience has shown that the absence of adequate national rice supply may create political and social disorder. Households’ ability to purchase adequate amount of rice is the first and foremost measure of poverty. On the other hand, the growth of food production over the last ten years has been declining and consequently bringing about fragile national food security. The situation has been getting worse because of climate change.

With increasing scarcity of water resources, concerns about the distribution of the resource between the main users of agriculture (irrigation), industry, and households have become more pronounced. Agriculture still accounts for the majority of water withdrawals. The fact that the cost of new irrigation schemes is on the rise, and that public financial resources available for capital expenditures are dwindling, only compounds the situation. Dealing with those concerned, water used for irrigation will have to be diverted to meet the needs of urban areas and industry while remaining a prime engine of agricultural growth.

Since rice is the main source of food in Indonesia, attempt to improve food security is extremely dependent upon irrigation development. Therefore, the problems are very complex for several reasons. First, the competition in the use of water resources is getting tighter because of the increasing demand for water by households, industry, and other economic sectors. Second, the availability of water is getting scarcer due to the failure to minimize the degradation of water resources. Since the economic crisis took place in 1997, the degradation rate of water resources has even been worse due to the expansion of deforestation in catchment area caused by increasing incidence of rural poverty. Third, decentralization Laws have changed natural resource management. In relation to water resource development and its implication for food security and poverty reduction, the implementation of decentralization can be positive or negative. It is positive if interdependency principles are taken into account in policy formulation and the implementation of policy is effective. Conversely, decentralization becomes negative if the goal of development is to maximize regional economic growth without taking into account the interdependency principles for the shake of efficiency, equity and sustainability.

Water harvesting is becoming very important to cope with sustainable management of water resources. There are different techniques of water harvesting that have been successfully applied as part of water resources management in catchments area in Indonesia. Channel reservoir, on-farm reservoir or “Embung”, infiltration ditches, infiltration well, water harvesting dikes, etc. Channel reservoir with cascade system is one of many rainfall and runoff harvesting techniques, which has been proven to be an effective method to reduce peak runoff, extend the time response to runoff generation and to some extent to increase available water for irrigation during the dry season (Subagyono and Pawitan, 2008).

Water infrastructure budget comes from the central government level through Central Government Annual Budget and at the local level through the Local Government Annual Budget. The budgeting in the central level are conducted through coordination between institutions which involve National Development Planning Agency (BAPPENAS) and Ministry of Finance to develop Annual Government Work Plan. The financing sharing between central and regional (district and province) government are regulated base on the management responsibilities as stated on related law. In addition to those, funding from community as well as private sector are enhanced to support the development of water infrastructure.

The level of administration decentralization in Indonesia has reached district level. Decentralization in water resources are implemented by distributing authority and responsibility in river basin and irrigation management. In river basin, central level governs the authority and responsibility of international (inter-state), national (inter-provinces), and nationally strategic river basins. Provincial government is responsible to manage inter-districts river basin, while district government manages the district river basin. In irrigation management, the authority and responsibility are divided based on coverage area of irrigation scheme:

1. Large irrigation schemes that cover more than 3,000 hectares are managed by central government;
(2) Medium irrigation schemes with common area larger than 1,000 hectares and lower than 3,000 hectares are managed by provincial government;

(3) Districts manage small irrigation scheme (less than 1,000 hectares).

In line with decentralization, there is a need to define the acceptable roles of both the government and local communities in the whole process of land and irrigation system development simultaneously. To anticipate the shortage of production capacity, agenda on policy reforms is a need to empower the local communities outside Java to do pioneering work in land development in the areas which are considered feasible for new irrigation system.

In general, water resources management in Indonesia is done by the holistic achievements through the conservation and efficient use of water resources in order to maximize and sustain benefits for the society. Based on related regulations and national development planning documents, the policy direction in agricultural water management are as follows:

(a) Encourage integrated water resource management process inter sector and inter region in central level, province level, district/city level, and river basin level;

(b) Balance water resources conservations and its utilization to reach the sustainable water for the utmost welfare of the people in a fair way, for current generation and the next generation;

(c) Balance the social function and economic value of water to ensure the fulfillment of each person’s basic needs and water utilization as economic resource which can create value-added concerning the conservation and maintenance cost.

(d) Develop budgeting system of water resource management considering cost recovery principle and community’s social economic condition.

(e) Develop institutional arrangement in water resource management which can open the opportunity to increase the community participation.

Higher priority will be given to the development of small scale water reservoir, while greater considerations are to be given to the construction of larger water reservoir, due to the more complex issues involved, mainly related to social and environmental issues. The small scale construction will reduce the degree of concentration of costs and risks at one particular area and population.

The efforts to conserve water sources are carried out not only for conserving the quantity but also for maintaining the quality of water. Efforts to conserve ground water need to be continuously enhanced through recharging, making of water absorbing wells, or by applying other appropriate technologies. In order to protect water sources and avert floods, it is necessary to conserve water source sites and to safeguard river basin areas. The main activities for this scheme are:

(1) development and rehabilitation of reservoirs, small dams, lakes and water storage facilities;

(2) operation and maintenance of reservoirs, small dams, lakes and water storage facilities;

(3) Conservation of lakes and small dams include rehabilitation of green belt in conservation areas;

(4) Improvement of water resources management in river basin

Since flood causes a lot of property lost as well as threaten food production, it is also necessary to protect settlements and irrigated agriculture areas from flood. Flood control infrastructures that are considered urgent to be improved in Indonesia, are; (1) Bengawan Solo Flood Control Scheme, (2) Makassar Flood Control Scheme, (3) Sampean Flood Control Scheme.

The utilization of water resources for irrigation will be focused on efforts for increasing the functions of existing but not yet functioning irrigation schemes, the rehabilitation of irrigation areas that are functioning but have been in disrepair, and increasing operation and maintenance activities. In order to secure the water supply for agriculture, government has implemented the upgrading and rehabilitation of irrigation schemes, operation and maintenance of irrigation and swamp schemes which are Central Government authority (over 3000 hectares). In upgrading and rehabilitation irrigation area less than 3000 hectares, the Central Government allocates its budget to the Local Government through Special Allocation Budget (Dana Alokasi Khusus – DAK). The main activities for this policy are:

(1) improvement and development of irrigation scheme, swamp, and ground water irrigation;

(2) rehabilitation of irrigation scheme, swamp, and ground water irrigation;

(3) operation and maintenance of irrigation scheme, swamp, and ground water irrigation;

(4) improvement of participatory irrigation management in supporting national food
Dealing with adaptation to climate change, designs of water resources infrastructure are adjusted to be more accommodating. For now, the planning of water resources infrastructure designs in Indonesia are made to anticipate both the high intensity of rainfall with the short of duration and longer dry season.

To promote water use efficiency, the government of Indonesia is also doing the campaign to save the water both in irrigation and non agricultural uses. It is based on the critical condition of water resources in Indonesia that influence the poverty, starvation and reduction of the economic, social and culture growth. The movement of water saving consists of strategic components which are: (1) infrastructure development and land structure; (2) land and forest rehabilitation including water resources conservation; (3) Control of the water damage; (4) Quality management of water pollution, (5) Saving water consumption and demand (6) efficient use of water resources to keep it sustainable.

**CONCLUSION**

The challenge for Indonesia is to create appropriate and effective adaptation strategies to address climate change and its impacts by building resilience and resistance. Action needs to take place at all levels; from national – local levels. Because climate change will compound environmental and socio-economic problems, it is critical that all sustainable development policies and initiatives include climate change adaptation and resilience building.

Unlike in the last decade, irrigation development in the future needs new approaches for several reasons. (a) Irrigation development fund is limited; (b) The cost of irrigation investment is getting higher; (c) The availability of highly potential land for paddy fields is getting more limited.

The essential, feasible solution to the problems is to raise water use efficiency in agriculture (particularly in paddy fields that have been the major rice producing centers) and to develop conservation-based farming in catchment area of each river basin. In this context, the community empowerment needs to be increased in supporting the appropriate infrastructure development for resilience farming.

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