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Final Report

Studies on Sustainable Water Resources Management for Irrigation and Drainage (Case Study in Egypt)

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Studies on Sustainable Water Resources Management for Irrigation and Drainage (Case Study in Egypt)

Dr. Harby Mostafa

1. INTRODUCTION

Water is one of the most important inputs of the economic development. Size, type, and location of the economic activities depend on the nature, quantity, and quality and location of the available water resources. The less the water resources are and the more the demand is, the more important water is. This is the case in Egypt, where rainfall is rare and the desert covers most of the country area, except for a narrow strip of cultivated land and urban areas along the Nile river course. The quota of Egypt from the Nile River, which represents the main source of water of the country, hasn't changed since 1959. The Nile River in Egypt has supported the longest civilization over the world, which lasted more than seven thousands years. Egyptians, throughout the history, were skillful enough to efficiently utilize the Nile water. During the middle of last century, they installed an invaluable water structure; High Aswan Dam (HAD), which controlled the water releases pattern over the year.

Like other large rivers, Nile River ends up with a unique delta region that extends over an area of about 2.5 million ha of alluvial soils. Another batch of alluvial soils extends over about 1 million ha along the Nile stem in the upstream. The Delta region is characterized with large tracts of rich fertile agricultural land, overpopulation, unique and delicate environmental conditions caused by the mixing of drainage and fresh water and problems associated with low lying areas such as sea water intrusion. Management of these unique natural resource areas has become more critical as the ecological balance in these areas becomes threatened due to an increase in water exploitation to support population growth and resource development. Increased pressure on these resources, such as increased urbanization and intensification of agricultural development, would result in adverse impacts namely water quality and pollution issues.

1.1 Agricultural Sector

The current cultivated area is in the order of about 3.5 million hectare, the agricultural year is divided into two seasons, i.e. summer and winter. Consequently two crops are usually grown; summer crop and winter crop. In some cases, farmers tend to cultivate a third crop during the period between summer and winter, which may extend for about two months. At the same time there are areas cultivated with annual crops, such as sugarcane and fruit trees. This crop diversification makes the total cropped area 5.5 million ha, i.e. crop intensity of 172%.

Among different regions in Egypt, crop diversification varies according to the climatic and soil conditions. There are two main crops of high water consumptive use, namely sugarcane and rice. The area of sugar cane of about 110,000 ha is concentrated in Upper Egypt, where temperature is relatively high. The Nile Delta is the main area of growing rice especially in its northern part where the soil is affected by the sea water intrusion.

1.2 Origin of Water Research in Egypt

Water resources in Egypt are represented with the quota from the Nile water; the limited amount of rainfall on the coastal areas; the shallow and renewable groundwater reservoirs in the Nile Valley, the Nile Delta and the coastal strip; and the deep (mostly non-renewable) groundwater in the eastern desert, the western desert and Sinai. The non-traditional water resources include reuse of drainage and waste water, and desalination of seawater and brackish groundwater.

Due to arid conditions, Egypt depends mainly on irrigated agriculture (99.8 percent of the cultivated area) to produce food and fiber for its large mass of population. The total cultivated area under irrigation is estimated at 3.4 million ha. The average annual cropping intensity reached a value of 1.9 in recent years, which made the agricultural demands amount to 54 Billion Cubic Meters (BCM).

Pressures on water resources of the country come from all sectors of the economy with the highest demand from the agricultural sector. As shown in Fig. 1, Egypt's annual water requirements are estimated at 70.0 BCM; if compared with available resources (57.7 BCM), the result would be significant deficit. The per capita share of available water resources in year 2010 was 750 m^3, and expected to decrease to 600 m3 per year by the year 2017. To overcome this shortage, part of the agricultural drainage is reused, beside the use of shallow groundwater and non-conventional resources.

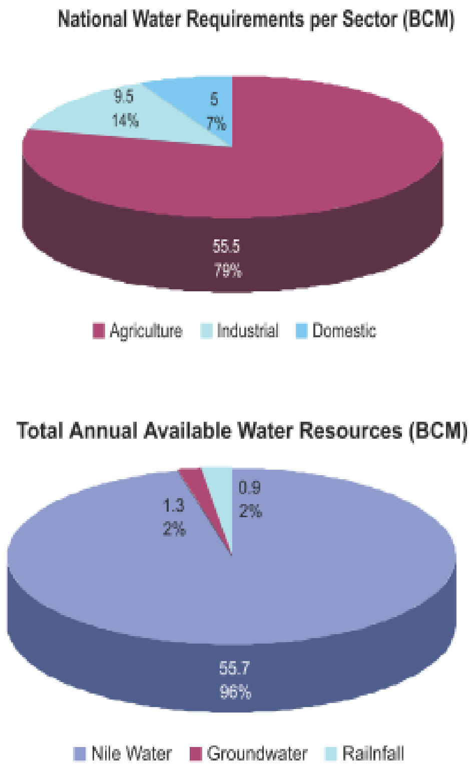

Figure 1: Water Availability and Demand in Egypt

1.3 Study Rationale and Objectives

Improving efficiency of irrigation has long been an important water management goal in order to reduce wastage and save water. However concepts about efficiency have been evolving as people learn how to deal with scarcity.

With the objective to identify significant research programs and projects carried out by research institutes during the last three decades that impacted the irrigated agricultural practices in Egypt, the study will document successful cases of direct and indirect research uptake. Specific recommendation for increasing the research uptake and improving the process of wide dissemination of research results will be highlighted.

Immediate objectives, however, are the:

- Comprehensive documentation of Egyptian experience in irrigation and drainage research uptake.
- Diagnostic performance assessment program for assessing the irrigation water management, applying it to the old lands of the Nile Delta of Egypt and studying the opportunities of improving the management of irrigation water to achieve real saving of water.
- Provision of specific recommendations for taking corrective measures to save irrigation water.

2. RESEARCH STUDIES

In this part we try to conclude in briefly the points that were studied during this fellowship period.

2.1RELATIONSHIP BETWEEN AGRICULTURAL LAND SYSTEM AND WATER USE WHEN APPLYING PARTICIPATORY IRRIGATION MANAGEMENT

Naoya FUJIMOTO, Juniji KOIDE, Naoko OKA, Harby MOSTAFA, Satoshi SAKATA and Mekonne B. WAKEYO

Manuscript presents at ICID conference in Turkey Sep. 29 to Oct 1, 2013

2.1.1 Importance:

- When promoting effective agricultural-water use based on Participatory Irrigation Management (PIM) policy in developing countries, one of the most important concepts introduced is establishing a reliable land tenure system and the nature of water rights.

2.1.2 Objectives

- To identify the nature of water rights at a particular place and clarify the condition of land tenure system at that place where the water rights belong or related to.

2.1.3 Method:

- Using available data from: a) Literature; b) data collected from targeted countries.

2.1.4 Research output

Based on the case studies described:

In the Dry Zone of Sri Lanka:

- Water is the main property that must be considered. Land and land tenancy can be arranged to allow water use, as demonstrated in the *Tattumaru* and *Bethma* systems. Farmers' participation in irrigation management is achieved during *Kanna* meetings, as well as by the enforcement of customary water rights.

In Egypt:

- Water rights are tied to the land. Thus, they are tied to land ownership. Most agricultural land is privately owned. Water is distributed according to a defined time schedule among different land parcels within a certain location based on a conveyance that depends on the land's location and its proximity to the main source of water.

In Ethiopia:

- Land is owned by the state. The state offers land use opportunities to farmers. Water rights that should be connected to land use have often been transferred by farmers. Recently, land certification has created better opportunity for such a transfer than in the past.

In Ghana:

- Traditional systems frequently affect agricultural land-water relationships. In southern regions, the multi-layered and dynamic nature of land rights may negatively affect successful PIM in both owned and rented rice fields. It is crucial to understand the mechanism that operates behind local tenure arrangements (i.e. coping strategy) to foster farmers' organizations.

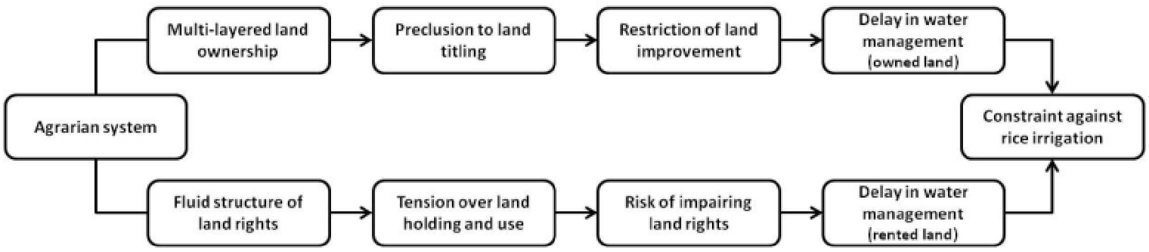

Figure.2 Linkages of agrarian and irrigation system in Southern Ghana

In Japan:

- Japan has determined clearly defined land and water-use rights that ensure fair water allocation and timely fee collection. Clearly-defined water rights also ensure collection of fees from individuals who share water (e.g. municipalities) and improve AWM.

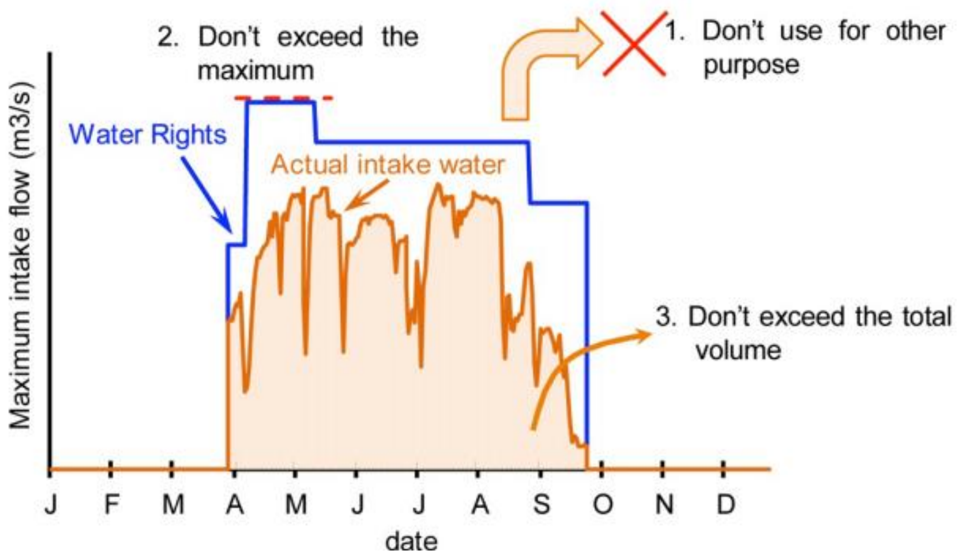

Figure 3: The concept of the restrictions of water right for taking from the river

These results demonstrate that a proper understanding of the relationships that exist between agricultural land systems and water use is critical to the establishment of PIM. Therefore, irrigation projects should be carefully designed to match agricultural land systems and the regulation of water rights in target areas. Thus, it is important to develop land management systems that secure farmers' rights to make rational/optimal use of irrigation water. This has important implications for rice irrigation in particular because it requires relatively high and long-term investments in land development and advanced AWM.

2.2 WATER SAVING SCENARIOS FOR EFFECTIVE IRRIGATION MANAGEMENT IN EGYPTIAN RICE CULTIVATION

H. MOSTAFA and N. FUJIMOTO

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2.2.1 Importance:

- Water shortage has become more frequent and farmers often face deficiencies in water deliveries resulting into reduced yields and incomes. Furthermore, rice normally requires (under traditional methods) a water application of about 2000 mm; an amount much higher than other crops.

2.2.2 Objectives

- produce an inventory, description, and comparative analysis of farm-level water-saving technologies those were already done as an individual research;
- study in detail the aspects of novel technologies and monitor their adoption and impact at irrigation water-saving;
- Suggest some scenarios may help in irrigation management and water saving.

2.2.3 Method:

- To achieve the objectives, the study adopted both descriptive and quantitative analysis. As regards data, the study depended on published and unpublished data for the period until 2012, issued by research organizations

2.2.4 Research output

Two scenarios were suggested, and irrigation water saving was calculated as follows:

1. **Water savings if rice is cultivated according to the actual area**

This scenario suggested no changing in the rice area. According to MWRI and MALR reports, the saline soil area in the Northern Delta about 150,000 ha. For more safety the area calculated as 200,000 ha in this scenario (Fig. 4).

The total applied irrigation in the Northern Delta area calculated as 1.66 billion m^3 whereas it was 4.66 billion m^3 for the other regions. So the irrigation water for the whole rice area will be about 6.32 billion m^3 leading to 43% water savings (11 billion m^3 in traditional cultivation). On the other hand, total rice production will be more than 9 million tons.

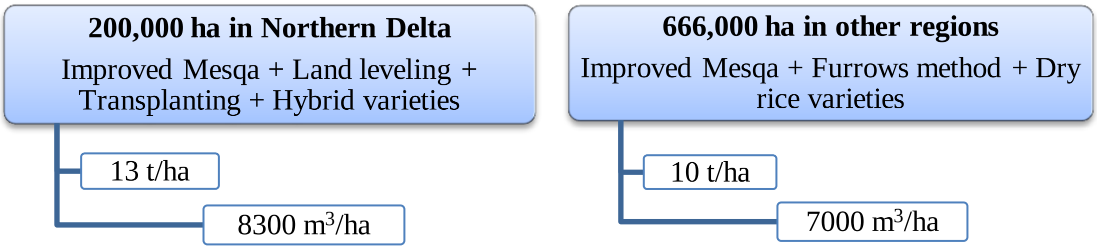

Fig. 4: Schematic diagram for the first scenario (no changing in the rice area)

2. **Water savings from converting 333000 ha of rice cultivation to other crops**

In this scenario, the government has to give more attention to cultivating alternative crops that not only use less water but also give significantly higher returns, and in this way increase the added value per unit of water consumed. So if a plan is designed to cultivate about 333000 ha of high value crops instead of rice (50 % of rice area outside North Delta), the used water will be about 5.32 billion m^3 leading to 52% water savings (Fig. 5). The total rice production will be about 6 million tons per year (4.2 million tons milled rice) which will be enough for consumption with the future needs (until the year 2030). Beside more than one billion LE (Egyptian Pound) as returns from the high value crops (yellow corn and sesame) could be doubled if other high value crops used (mint, chamomile, basil, golden sesame and marjoram).

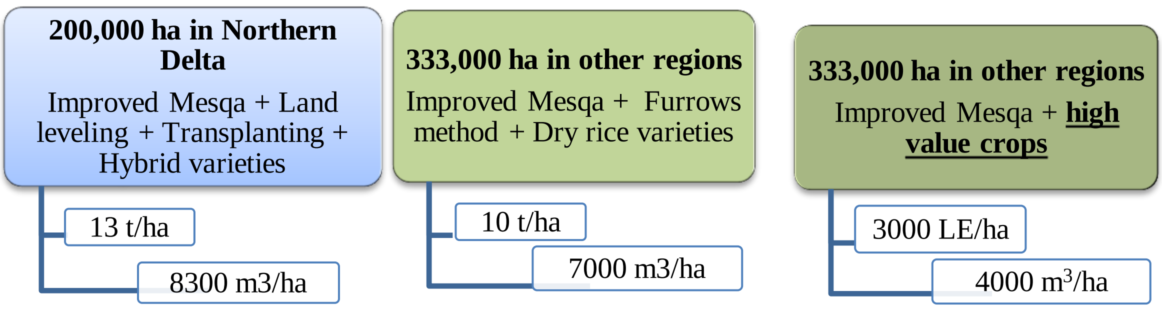

Fig. 5: Schematic diagram for the second scenario (38% decreases in the rice area)

The authors believe that both scenarios will appeal to farmers especially there are no more costs for using some techniques and rising labor wages. On the other hand, both scenarios will increase farmer income beside water savings. So the government can easily begin placement of scenarios, which it is expected to prevail all areas within three years.

2.3 SUSTAINABLE MANAGEMENT-FEE COLLECTION MECHANISM FOR IRRIGATION AND DRAINAGE FACILITIES IN ISLAMIC LAW

Harby MOSTAFA, Naoya FUJIMOTO, Juniji KOIDE, Naoko OKA

Manuscript was submitted to Scientific Papers Series: Management, Economic Engineering in Agriculture and Rural Development

2.3.1 Importance:

- Increasing the environmental stresses on water resources are causing countries to reconsider various mechanisms to improve water use efficiency. This is especially true for irrigation agriculture, a major consumer of water. The physical and hydraulic characteristics of the irrigation distribution system often form a major limit. Also the implementations of irrigation water fees are sensitive to physical, social, and religious beliefs, making it necessary to design allocation mechanisms accordingly

2.3.2 Objectives

- Study the water pricing mechanisms to improve cost recovery for irrigation and drainage facilities under the Islamic law and its impact on water saving. The study tries to find out if there is an irrigation water pricing system that better meets the social, economical, and environmental needs. Also the research tries to highlight Egypt's experience in dealing with the cost recovery in irrigated agriculture.

2.3.3 Method:

- Using available data from: a) Literature; b) data collected from targeted countries.

2.3.4 Research output

Governments should urgently implement sustainable water management policies which rationalize demand to ensure more efficient use. This can be achieved by attaching an economic value to water, measured by the value of the end product from each drop. Governments should implement water efficiency measures, shift from irrigation by flooding to more efficient irrigation systems, introduction of crop varieties that are resilient to salinity and aridity, recycle, treat and reuse wastewater, and develop affordable technologies for water desalination.

Cost recovery for irrigation and drainage services would be limited to those infrastructures that are used solely for direct irrigation and drainage. Cost recovery should ensure that at least the full O&M costs are recovered, because they reflect the service costs of providing farmers with irrigation water and ensuring acceptable drainage.

The area pricing system that accounted for 60% of the sample studied according to the crop or irrigation techniques. It does not encourage water saving for a given choice of crop or irrigation technique, but it does have more effect than the area pricing system on the choice of which crops to irrigate or which irrigation technique to adopt. It can be used to discourage to irrigate certain crops for example, by applying a higher price to crops that consume a large volume of water (such as rice and sugarcane in Egypt).

When the pressure of demand on water resources is high and competition exists between uses of water, quota systems are imposed on agriculture. They then coexist alongside a pricing system whose only objective is to pay for the services of the water provider and possibly for the water itself. Quotas guarantees a limit to consumption which will not be exceeded, at least if the penalties and the laws ensure that it is followed. To get high cost-recovery rates, farmers should not only agree on the costs to be recovered but also see the fees collected are used to maintain and improve “their” system. Having the fees collected go back into the general revenue fund of the state or federal government, provides farmers with a strong incentive not to pay fees. One good approach is to have the water supply entity or the WUA collect and keep most of the fees for use in “their” system.

Mostly, the cost of water represent 10 -20% of the production costs for most crops. As for the vegetable crops, they may be as low as 5%. Might such costs would have a tangible impact on the production, they should be increased (double or more); a trend which is now favored in most countries. In such a case, the farmer will find ways to avoid cultivating the high water-consuming crops.

Since crop charges indicate to the benefit received, it is also recommended the basis for setting service charges to beneficiaries should be crop-related, and reflect water consumption of the crop. Beneficiaries should also have the right to claim if remission of rates in case of crop failure.

There are many factors that might affect the disfavoring of charging for irrigation water. There are economic reasons, as many people are under the poverty line. There are also cultural reasons, as Egyptians take pride in the River Nile, paying for its water will never sound like a pleasant idea to them. However, what might sound possible is charging penalties for landowners who violate the law by cultivating rice or sugarcane, or charging costs for irrigation and drainage for strengthening improves infrastructure.

2.4 MONITORING AND EVALUATION OF IRRIGATION MANAGEMENT PROJECTS IN EGYPT

H. MOSTAFA and N. FUJIMOTO

Manuscript was submitted to Japan Agricultural Research Quarterly (JARQ)

2.4.1 Importance

- Performance of water delivery systems, particularly irrigation systems, needs to be clearly defined and assessed under the current or expected stressed conditions.
- introducing the positive and negative effects could help in operation and maintenance of the system

2.4.2 Objectives:

- clarifying the positive and negative impacts for the Egyptian irrigation improvement program
- Introduce some specific recommendation for improving the management of irrigation water to achieve real saving of water.

2.4.3 Method:

- Using studies and projects implemented by government, donors, regional organizations and research institutions, supplemented with information from national partners was carried out.
- Using a combination of regional field studies and surveys of the relevant literature.

2.4.4 Research Output:

- Increase the efficiency of field irrigation from 45% to 60% which means saving in irrigation water (6000 m^3/ha/season in case of cultivating the short-period span rice). It is strongly recommended continuing the implementation of the full irrigation improvement package in Egypt's old lands, which are served by old irrigation systems. This may result in considerable water saving up to 5 billion cubic meters per year.
- All the previous and current activities for improving old land concentrate on increasing only the distribution efficiency through applying continuous flow s, replacing old earthen mesqa by PVC pipelines and later replacing earthen marwa by PVC pipelines. But, the on farm management activities such as land leveling,

agronomic practices, modified cultivation methods and training will lead to improve the application efficiency. Whether this leads to real water savings is dependent on whether that water is reused.

- The use of GIS and other modern information systems in association with real data and getting the real feedback of the cropping pattern in advance from farmers through WUA's gives a great opportunity for better management of natural resources. Besides, applying on-demand water supply will achieve reliability of water delivery and that can be achieved using rotation flow system or continuous flow system. What would be important is receiving the real data about cropping pattern in advance to enable planning of good irrigation schedule that would help in reducing the gap between demands and supply.
- The irrigation and water management part would include: (a) improvement of farm level irrigation systems for more rational use of water for irrigation; (b) enhancement of water management practices for more equitable distribution of available water; and (c) greater and more effective participation of users and stakeholders in water management for sustained irrigation and improved crop production.
- The main risk to efficient and sustainable use of land and water resources is price signals that persuade farmers to grow crops that are water intensive, such as rice. It can be mitigated by introducing high-value crops that offer viable alternatives. Also, lack of financial resources could limit introducing technologies to use land and water more efficiently, such as farm-level irrigation improvement, laser land-levelling, the use of improved inputs, etc. This may be mitigated by introducing financial services as a key part of the current strategy.
- According to the farmer's surveys, several farmers are aware of the importance of land leveling using laser equipment and its effect in less water and time required for irrigation. However, even when they are willing to apply it, they are unable because being expensive, difficult to coordinate among neighboring farmers, and difficult to arrange between crops. Traditional techniques are still dominant in the IIP areas and few farmers knew about improved irrigation practices. It has been a limiting factor the agriculture extension staffs has little knowledge on simple technique for improving on-farm water use. IAS staff, TV and radio have been the main source of information on these aspects but the poor coordination between services is limiting on-farm impact.
- Without more definite information about the actual changes in water use quantities, on-farm irrigation efficiencies, and future expansion of IIP, the researchers finds it difficult to venture any substantial predictions on the IIP impact on quantity and quality of surface and subsurface drainage water and its reuse, drainage requirements, and replenishable sources of groundwater.

- Integrated water resource management should be introduced at all appropriate levels from field to basin level. Current efforts in irrigation supply management improvement need to be accompanied by improved water demand management measures. There is a need to integrate agricultural improvement technologies into IIIMP and to take advantage of improved water control technology such as controlled drainage. Moreover, educating farmers on where IIIMP water savings are intended to go will become increasingly important at the farm as well as at the mesqa level.
- Broad institutional development should be introduced that is based on stakeholder participation and streamlined within a national water resource policy. Now, existing water user organizations at the branch canal level have no legal recognition. If such institutions are to be operational, their legal status should be clarified as well as their financial situation and their collaboration with the lowest level public authorities.
- The IIIMP should include a campaign to increase awareness of the importance of functions and stakeholder values and focus on the skills required for both water and financial management.
- At the mesqa level, the IIP has reduced the problem of water inequity and supply shortages effectively through a mix of technical and institutional interventions. Current IIP technical interventions imply that a change be made in the water supply systems, from rotational to continuous flow in combination with gravity flow in raised open mesqa canals or buried pipes operated at low-pressure. At the time, continuous flow conditions had not been reached, which renders assessing this intervention incomplete. Constructing lined canals and buried pipes has increased the conveyance efficiency considerably. A centrally operated pumping system has replaced individual pumping, managed by water users who have formed themselves into water user associations. Notably, the shift from individual to collective pumping has resulted in considerable cost savings about one-third.
- Finally, a shift in thinking is required in managing irrigation water. A first is to consider performance across scale. A second is to focus more on quality considerations. Most of irrigation management projects series have done at the same regions in Delta (Kafr El-Shekh and El –Behaira governorates) and at Upper Egypt (El Menia and Asiut governorates) and these regions need only for maintaining the improved irrigation system not for new improving projects. For that the new improving projects have to set up into other regions where the irrigation water saving will be more effective.

3. DOMESTIC BUSINESS TRIPS

3.1 Visiting the LID in Shikoku Island

- We visited several project sites in Shikoku Island in March 2013 to find key elements we must conduct during study to apply in Africa. Water right and regulation on the limitation of water intake were observed. It can draw a further research area by using the pressure-adding pumps like in Tokushima with low-head drip irrigation system.

3.2 Visiting Okinawa Prefecture

- Several project sites in Ishigaki, Miyako and Okinawa Islands in September 2013 were visited. The target was collecting information about the agriculture in Japanese tropical area (JIRCAS –Tropical Agriculture Research Front). Subsurface dames that constructed in Miyako Island were visited. The status of agriculture and rural development in Okinawa were presented by department of Agriculture, Forestry and Fisheries, Okinawa General Bureau.

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