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Smart Allocation of Water Supply

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Chapter1. Introduction

Asia has grown economically in the last 30 years. At the same time, they are facing the problem of imbalance in the supply and demand of food. Import of food is increasing while domestic production remains stagnant. The idea of sustainability was lacking in the economic development of Asia. If we continue along this path, agricultural production will slow down and put a stop to economic growth.

When we think about the future of agriculture in Asia, the primary role of agriculture is, of course, to supply food and other farm products. We must think about making agriculture sustainable. This means building a recyclable system of agriculture by cultivating of the water resource, preserving the environment, and eliminating the loss of energy. This paper especially focuses on the water resource.

In order to achieve this, Asian countries must cooperate with each other. Introducing water innovation, and trying to change a conscious about water resources. These ideas will lead our society “sustainability development”. We should not take an approach which will slow down economic growth in the future. By implementing technological and structural water innovation, we must promote which is good both for humans and nature.

Chapter2. Current state

2.1. Finite water

Water, which is indispensable for the continuing existence of creatures on earth, is a finite resource which circulates through the system of precipitation and evaporation. For the water circulation on earth to work well, water sustainability must be maintained. This means the natural circulation of water and the artificial circulation of water resources used by people should be well-balanced, so that the water circulation as a whole remains well-balanced, both quantitatively and qualitatively.

About 71% of the earth, where we live, is now made of water. The gross weight of water on earth is 13.9km^3, of which seawater is 97.5% and fresh water 2.5%. Of this fresh water, 1.75% is the Antarctic and Arctic ice, and the remaining 0.75% is underground water and water in marshes, rivers, and lakes. Of this water on earth, however, only 0.0075%, or about 0.001 km^3, can be used.

2.2. Water conditions in the future

It is necessary for us to realize the finite nature of water resources, especially fresh water, because of population growth and industrialization and

urbanization of developing nations. It is estimated that world population will grow to 9.2 billion by 2050. Urbanization, accelerated by the concentration of people in the city, and an increase in grain production are expected to lead to an increase in the demand for household water and agricultural water. The amount of water reserves in Asia is small, compared to its population. While Asia has 60% of the world's population, it has only 36% of the world's water. The structure of the land is such that shortage or depletion of water occurs easily. In parts of China and India, such the state of Tamil Nadu, there is little rain water and people depend on underground water. As the demand for water increases, excessive pumping is carried out, exceeding the amount of underground water replenishment. This is causing the water table to lower by 2 to 3 meters every year. It is increasingly feared that there will be a sharp decrease in groundwater, eventual depletion of groundwater, and an absolute shortage of water in the future.

It is forecast that the urban population will increase from 3.3 billion to 4.6 billion. As a result, the percentage of urban population in the total world population, or the urbanization rate, is expected to rise from 49% to 57%. When we look at the relationship between the urbanization rate and the amount of water used per person per day, we can see that the amount of the water used increases as

urbanization proceeds. The amount of water used per person per day also increases as the size of the city expands. One reason for this may be the higher income of urban residents. However, in general, the amount of household water used in individual households does not increase so much even when the income increases. So we can say that rather than higher income, it is the development of the tertiary industry, accompanying urbanization, which is increasing the demand for water. For instance, in Tokyo during Japan's period of high economic growth, the biggest users of water were hospitals and universities. Together with the increase in the daytime population, this increased the volume of water used.

2.3. Factors of water demand

As developing countries experience economic growth, the people's living standards improve, their lifestyle and consumption preferences change, leading to an increase in the demand for water. Water plays many roles in various areas of society, and it is an essential element in building a sustainable society. At the same time, scarcity of water is leading to competition between different sectors over resource allocation. In concrete terms, as industrial activities expand and living standards improve, the consumption of water for industrial use and household use

increases, and agricultural water is converted to water for industrial use. According to the report of the Asian Development Bank, competition to obtain water is occurring between household water, water for industrial use, and agricultural water. The report also points out a great decrease in the amount of agricultural water in the past several decades in Asia.

Chapter3. Problem

3.1. Problems related to global warming

Factors leading to the lack of water are not necessarily a decrease in the supply of water itself. The problem is that water distribution is not uniform either spatially or time-wise, and water is not always available where people live and where there is demand. In fact, it is said that there has not been a great change in the absolute volume of fresh water on earth. Moreover, the ratio of water intake to the amount of the water resources on earth is only 8.8% a year when the amount is averaged out throughout the world. So it is also possible to hold the view that there is still plenty of water resources on earth.

The Intergovernmental Panel on Climate Change (IPCC) cites some effects of global warming. In southern Africa where there are a lot of deserts, atmospheric pressure is causing air containing steam to go down, making it difficult for clouds to be born. Rainfall will decrease by 10~30% from now, and drought will be accelerated. At the same time, in Asia, where monsoons are generated, and South America, localized torrential rain in a short time is expected to increase the volume of water by 10～40%.

3.2. Water pollution

Because of the industrialization of agriculture, such as mechanization, the use of chemical pesticides, and fertilizers, and increase in industrial waste water due to industrialization, the water quality of underground water and rivers has deteriorated. As a result, the supply of clean water has decreased. Faced with such a situation, and in order to increase the supply of water, cities, agriculture, and industry all over the world have turned their attention to underground water as a source of water for small-scale local water supply businesses and agricultural water. Underground water is stable in water quality, water temperature, and water volume. When compared with surface water, it also has the advantage of requiring little initial investment and little administrative and maintenance cost. However, rapid groundwater development leads to saltwater intrusion, subsidence, and lowering of the water table. In recent years, arsenic, nitrate nitrogen, etc. have also caused the deterioration of water quality.

Moreover, developing nations do not have adequate infrastructure, such as water supply and sewerage. About 1.1 billion people in the region do not have constant access to safe drinking water. This is one person in five. The number of people in developing nations who cannot always use basic sanitary facilities is 2.6

billion, half of the population. Because building sewerage facilities requires large-scale investment and advanced technology, sewerage infrastructure such as sewage treatment facilities has not yet been built in developing countries. This means untreated sewage water pollutes rivers and underground water, which are the sources of water, making access to safe water even more difficult. It is a vicious circle.

3.3. Dam construction for taking in water

Agricultural water accounts for about 70 % of the total demand for water. Irrigation farming is a way of farming which tries to keep the effect of the weather to a minimum and obtain a stable supply of water. It is not possible without a constant supply of water. Irrigation in the Asian monsoon region is practiced mostly in rice paddies, and it is different in the rainy season and the dry season. In the rainy season, the rain is used first, then irrigation is used for what is lacking. Therefore, rainfall and the quantity of water intake change from year to year. Because the quantity of water intake is small and the river flow is large in the rainy season, the possibility of rice paddies running out of water is small. Because the rainfall cannot be expected in the dry season, as a rule, all the necessary water is

supplied by irrigation. In the dry season, the river flow is small, often leading to a lack of irrigation water. Therefore, irrigation has been developed with rivers, lakes and marshes, and underground water as the water source. As a result, dams were constructed to provide a stable supply of water from rivers for irrigation agriculture, and ways were developed to control the volume of water which can be supplied naturally. Dam construction has some problems. Because of the new economic system, community knowhow of traditional water management and maintenance of the ecosystem are lost. Dams were built to store rain water, floodwater, and water from rivers, but most places suitable for dam construction have already been developed, so it is difficult to build more dams.

3.4. Problems of international rivers

There are about 260 rivers in the world today. As some rivers cross national borders and flow through two or more countries, there are many causes for dispute over the ownership and distribution of water. The Helsinki Rule[1] stipulates the use of international water resources. As a dispute over water can be directly life-threatening, these disputes can lead to international disputes over international rivers crossing national borders. Here are some specific examples. In

the Mekong River, *Shaowan Dam*, which China is constructing upstream, is stopping the quicksand, so the Mekong delta and the farmland along the river are getting smaller. The Tigris-Euphrates river system is a water source used by multiple countries. Iran, Iraq, and Syria are all insisting on the right to use the water source. The Nile has a problem, too. If the volume of water decreases greatly as a result of the pipeline plan by Tanzania and Ethiopia upstream, downstream Egypt may receive a devastating damage to its agriculture. Excessive intake of water is destroying the water circulation. The flow of the river is changed for the sake of development. These are some of the many complex factors surrounding the situation of water in the world.

Chapter4. Water Resources Seen from Agriculture

4.1. Water for Agriculture in Asia

Some call the 21st century “the century of water”. It is feared that by 2025 one in three persons on earth will be affected by water shortage. It is highly possible that the world population, which continues to grow, and the expansion of the world economy will disrupt the balance of demand-and-supply of water. Agricultural water accounts for 70% of water demand in the world, and therefore, the paddy-rice cultivation method is often thought to be a wasteful way of using water. But the paddy-rice cultivation method in Asia re-uses monsoonal rainwater, which varies greatly from season to season, by moving the water from upstream to downstream, using the adjustment function of rice paddies. In the monsoonal climate, flood and drought keep recurring. Even in such a climate, Asian societies have managed to feed its huge population thanks to this mechanism of rice paddy cultivation. Although 60% of the people in the world live in Asia, Asia is using only 30 to 40% of farmland and water in the world to feed these people. This shows that, from the point of supporting the population and preserving the natural resources, agriculture in Asia is nearly twice as efficient compared with the world average.

4.2 Water and Agriculture

How did paddies and irrigation systems develop in the first place? It is thought that agriculture began about ten thousand years ago. In the pre-agricultural society, people lived as hunter-gatherers, leading a life not much different from other wild animals. Since then, people settled down to grow crops and keep animals for a living. They no longer had to hunt and gather the food they needed.

But growing crops and taking the harvest from the farmland also means taking natural elements from the farmland, and if people continue to grow the same crop in the same place, the harvest will gradually decrease. If there is not enough harvest, in case the population is small, it is easy to solve the problem. The answer is just move to another land. However, when the population gets bigger, it becomes difficult to find land which can be used as new farmland. It is thought that that is what gave rise to the slash-and-burn agriculture and the paddy-rice agriculture, two ways to re-use the same farmland.

In the Asian monsoonal region, paddy agriculture has been practiced since more than 6000 years ago. Paddy rice that grows mainly in paddies has a feature which makes it distinct from crops grown in non-paddy fields. Oxygen is necessary

for the roots of plants to breathe and grow. Paddy rice can survive under water because paddy rice has an intake function that sends oxygen to the roots. This is another example to show that the kind of crops grown differs greatly, depending on the climate and geological conditions of the region. Asian agriculture accomplished dramatic progress from the 1960's to the 1970's by combining irrigation, plant improvement, and the use of fertilizers. Green Revolution occurred as a result, enabling the elimination of starvation and improving the living standards of the people. From 1970 to 1995, irrigated area in Asia more than doubled, and Asia became the region with the most widespread irrigation system in the world.

4.3. Paddies

Paddies have the role of ensuring that the top soil and natural elements in the soil do not get washed away by the rain, protecting the rice crop from diseases, harmful insects, and sudden changes in temperature, and nurturing the rice crop so that we can obtain a stable harvest of rice, which has been our staple diet from thousands of years ago. Paddies not only nurture the rice crop but also has a beneficial effect on humans, various creatures and the environment.

Water stored in the paddies go through the surface layer soil, middle-soil, then to the groundwater aquifer. In the meantime, dust in the water is removed on the surface of the soil and smaller impurities are removed in the middle-soil, and the water becomes pure. The paddies have the function of water filtration. In addition, paddies keep the water table at a certain level to prevent subsidence, prevent flooding and mudslides, and release moisture to control the rising temperature. Furthermore, paddies provide a habitat for various creatures such as killifish, frogs, and crayfish, as well as migratory birds.

Finally, in Japan, the distance between the mountain and the sea is short and steep, so even if lots of rain falls in the mountains, the rainwater quickly flows to sea. This means that if it does not rain for a while, the water flowing in the river decreases very quickly. When typhoons come or localized torrential downpours occur, paddies can store the rainwater and keep the water and soil from draining right away. As seen from the above, paddies have various beneficial functions so even amid warnings of water shortage, they play an important agricultural role.

4.4. Irrigation

Water is essential for growing crops, but how to grow crops is totally

different, depending on the ecological system of each place. One way to grow crops is to supply water naturally, using water from rainfall and rivers. But often that is not enough. To compensate for this lack and to ensure a stable supply of water, we practice irrigation.

Laying pipe channels for paddy irrigation has become popular with the improvement in the maintenance of paddies. The purpose was to provide convenience of water supply, rationalization of water management, and equality of water distribution. In the case of pipe channels, the control of end hydrants is usually entrusted to each farmer. Farmers must follow a rule in using water because in the water pipeline system, time required to obtain the needed flow of water is short and water distribution tends to become demand-driven. Especially in the case of paddy irrigation, if the farmers do not follow the rule, and open and close the hydrant at will, various problems will arise, such as wasted water and inequality of water supply.

4.5. Facing the future

The IWMI, the International Water Management Institute, forecasts that to satisfy the demand for grains in 2050, we must expand the paddy area by 30% in

South Asia and 47% in East Asia, if the present pace of increase in production continues. If nothing is done about improving the productivity of water, the IWMI also forecasts that the quantity of water intake by paddy agriculture will increase by 57% in South Asia and 70% in East Asia. If we add to this the scarcity of land and water and increase in water use in the urban area, which are already happening now, we can see that such a scenario is clearly not sustainable. This shows that greatly improving water productivity is essential, but it is impossible to accomplish this without the comprehensive improvement of the ① infrastructure ② management ③and policy of irrigation. This paper focuses on water management in the next chapter.

Chapter5. Participatory Irrigation Management

5.1. What is PIM?

To solve the above problem, we propose an idea called Participatory Irrigation Management, or PIM. PIM, or Participatory Irrigation Management, is an irrigation management system in which the management reflects the views of the local farmers, who are the water users, in every aspect of irrigation management and have them participate in the practice. It is now being introduced into many parts of the world. Conventional irrigation projects have achieved a certain measure of success in dealing with basic problems such as poverty and starvation.

PIM has evolved from conventional irrigation projects into a project which aims at human resources development and society development, focusing on individual farmers and regions. As a result, PIM requires the participation of each and every farmer and security of everyone's benefits and burdens. PIM aims to improve the farmers' power of self-government, and deepen and expand the cooperation between farmers and government. When introducing PIM as part of the irrigation development in developing countries, farmers benefiting from PIM must set up a water management structure and agree on a method of management and

maintenance control. They must also solve various problems which arise in the process of implementing PIM, develop a method suited to their district, and make sure it becomes firmly established.

5.2. Awareness of PIM

It is of course important for the water management structure to have problem-solving ability, but another problem is that farmers benefiting from the PIM are often not aware of their own water utilization problems. Sometimes the farmers may have given up solving the problem, and it must be noted that there is a possibility that the problem may not come to the surface at all. If the problem is left unsolved, the farmers may gradually lose interest in the water management structure, fail to make their obligatory payments for water and to provide compulsory services, and eventually leave the organization. This will damage the sustainability of the water management structure.

5.3. History of Irrigation in the Asian Monsoon Region

In many developing countries of the Asian monsoon region excepting those parts with traditionally developed irrigation systems, irrigation facilities improved

greatly after many countries attained independence after World War II. This was carried out with loans from the international development and financial institutions and the help of developed countries. But as many large-scale irrigation facilities built in the 1950's onwards deteriorated with age, problems arose, such as water leakage lowering the efficiency of water conveyance and increasing administration cost. Because of the government's economic circumstances, investment in irrigation was curbed, and rather than new developments which require huge investment, priority was placed on improving the efficiency of existing facilities. But when the price of rice remained low and income from rice reached a ceiling, the farmers gradually lost their enthusiasm for irrigation management.

Based on these circumstances, PIM was proposed around 1980. In 1995, the World Bank took the lead in inviting participating countries, and the international network about PIM, INPIM, was set up. Many irrigation projects in developing countries used to be national development projects whose policy objectives were food self-sufficiency, measures to help poor farmers, and reducing the gap between the rural poor and the urban rich. For this reason, increasing the average crop yield in the district as a whole and improving the farmers' income became the indices for evaluating attainment level. The income gap and inequality among farmers were

not taken into account.

5.4. Convenience of PIM

With PIM, on the other hand, the government does not overlook the inequality of opportunity among farmers and offers a mechanism that corrects this inequality. The purpose of PIM is to develop the ability of farmers to solve their discontent themselves and giving them responsibility. For this reason, PIM gives technological support necessary for the projects. Rather than engineering technology, which is used to correct the uneven distribution of water both spatially and time-wise in the macro scale such as the size of the watershed, an increasingly important role is played by engineering technology in the micro scale such as districts receiving the end profit, together with sociological technology which aims to improve the efficiency of water distribution activity by accumulating the mutual trust and benefit among farmers.

5.5. PIM—the Case in Japan

For this PIM model, Japan's *MIDORI Net* is attracting attention from the international organizations, such as FAO and the World Bank, and developing

countries. *MIDORI Net*'s official name is *Tochi kairyo-ku*, or land improvement district, a farmers' organization with about 6000 organizations in Japan. *Tochi kairyo-ku* carries out a wide range of activities, such as maintenance of farmland and agricultural waterways, and also work together with locals for regional development and the development of local agriculture.

With regard to the use of agricultural water in Japan, public facilities are usually managed by the central government or regional authorities. After 1949, *Tochi kairyo-ku* are establishing and maintaining the facilities. There are 40 thousand km of main agricultural waterways in Japan, and 80% of them are managed by *Tochi kairyo-ku*, as of March 2007. Farmers who are members of each *Tochi kairyo-ku* pay certain dues and provide labor needed for management and maintenance. In this way, they provide the funds and labor needed for the daily inspection of the waterways, repeated use, and taking turns to practice conservation irrigation during the dry season.

5.6. Demand for PIM

Participatory Irrigation Management is one of the key concepts when the shortage of water becomes serious in the future. The idea is indispensable especially

in the Asian monsoon region with heavy rainfall. The greatest feature of PIM is that it is a method which raises the awareness of farmers. Introducing PIM has five merits for farmers. They are the benefits of better self-management, more self-restraint against illegal activities, better management of water use, lower cost, fewer water conflicts, and higher productivity. On the other hand, merits for the government are lower government expenditure on operation, maintenance and management (OMM) of irrigation facilities, fewer government staff needed for OMM, sustainable management of facilities and water resources as well as the preservation of multi-functionality and higher productivity.

Why is it important for farmers to have more awareness of water use? People living in the Asian monsoon region have little awareness that water is finite because this region has much water. Therefore, this region can expect to make a big profit by introducing PIM. Let me give you one example. PIM was introduced in Yon Dong in Vietnam in 2005, and the flow of the river tripled, and as irrigation was stabilized, the amount of rice crops increased by 10% compared with other areas where PIM has not been introduced.

Ways to deal with the increasing demand for water are different from region to region because of the difference in climate, history, culture, and

geographical features, so we cannot show one solution that fits all. However, it is important to design a smart water allocation by making a social system based on the idea of sustainability and awareness that water is finite. In this era of water shortage, I believe the idea of PIM has many good points that are well worth learning for all of us.

Chapter6. Conclusion

With the rapid economic growth of Asia, the demand for water keeps increasing in recent years. Water, which is indispensable for the continuing existence of creatures on earth, circulates through the system of precipitation and evaporation. For the water circulation on earth to work well, water sustainability and control must be maintained. This means the natural circulation of water and the artificial circulation of water resources used by people should be well-balanced, so that the water circulation as a whole remains well-balanced, both quantitatively and qualitatively.

For that, we must improve the awareness of the importance of water management and productivity, and improve the efficiency of water productivity. To do so, it is necessary to take one of two methods. The first is the method to increase the supply of water and the second is the method to increase the productivity of water. These two ways are both important if Asia is to deal with the increasing demand for water, but increasing the supply of water is an expensive project and therefore difficult in Asia. On the other hand, some Asian countries have found a successful way to increase the productivity of water. Though some problems still remain, there is a lot we can learn from these ways to maintain the infrastructure of

rice paddies and irrigation systems and PIM, or Participatory Irrigation Management. Though there are many dams and irrigated paddies in Asia, many of them are not managed well. We believe that water management is an effective means of responding to the demand for water in the future.

----------References----------

[Chapter2]

Miyako Groundwater Conservation Council 「Ⅲ 現在から未来へ、水はだいじょうぶ？」

http://www2.miyako-ma.jp/chikasui/sango/03sango.html#3-01-01

Ministry of Agriculture, Forestry and Fisheries of Japan「危機に直面する世界の水と食料生産」

http://www.maff.go.jp/water/siryo.pdf

Ministry of Economy, Trade and Industry of Japan "Trade White Paper 2008"

http://www.meti.go.jp/report/tsuhaku2008/2008honbun/html/i3410000.html

Mizuho Research Institute 「Mizuho Asia Insight (October 24th, 2005)」

http://www.mizuho-ri.co.jp/research/economics/pdf/asia-insight/asia-insight051024.pdf

MASE toru 「灌漑排水の効率化が必要だ」

http://www.mizu.gr.jp/kikanshi/mizu_18/no18_f02.html

[Chapter3]

宮地邦治 「水不足問題と水関連ビジネス」

http://www.nomura.co.jp/market/report/zaikai/pdf/20090401_2.pdf

SCIENCE COUNCIL OF JAPAN 「変貌する農業と水問題―水と共生する社会の再構築へ向けて―」

http://www.scj.go.jp/ja/info/kohyo/pdf/kohyo-20-t62-2.pdf

JICA 「水分野援助研究会―途上国の水問題への対応―」

http://www.jica.go.jp/jica-ri/publication/archives/jica/kenkyu/03_36/pdf/36_05.pdf

JAPAN WATER GUARD "study room of water!"

http://npo-jwg.com/studywo.html

[Chapter4]

農政ジャーナリストの会/編『"水" 問題の現在』農林統計協会, 2003.11

谷山重孝/著『水が握る日本の食と農の未来』家の光協会, 2010.2

粕渕辰昭/著『土と地球 ： 土は地球の生命維持装置』学会出版センター, 2010.5

農林水産省『平成 21 年度 食料・農業・農村白書』

AKIYOSHI yuuko, MASHIKOA takako "Study on Effective Water Resource Management for Agriculture with Reference to Japan, China, and South Korea"

http://wwwsoc.nii.ac.jp/james2/archive/MR0806/03ronbun-akiyosi.pdf

IWMI annual reports

http://www.iwmi.cgiar.org/About_IWMI/Strategic_Documents/Annual_Reports/index.aspx

Ministry of Land, Infrastructure, Transport and Tourism in Japan 「水資源」

http://www.mlit.go.jp/tochimizushigen/mizsei/c_actual/

中島賢二郎　「水資源を次世代に」
http://seneca21st.eco.coocan.jp/working/nakashima/11_00.html

[Chapter5]

MIZOGUCHI Masaru, YAMAOKA Kazumi “A Role of Participaratory Water Management in Global Water Cycle Research Initiative”
http://soil.en.a.u-tokyo.ac.jp/jsidre/search/PDFs/04/04S15-01.pdf
Ministry of Agriculture, Forestry and Fisheries of Japan「危機に直面する世界の水と食料生産」
http://www.maff.go.jp/water/siryo.pdf
TOMOSHO tatsumi, YAMAOKA Kazumi “A supporting method for problem solving for PIM development”
http://soil.en.a.u-tokyo.ac.jp/jsidre/search/PDFs/06/06005-26.pdf
Japanese Institute of Irrigation and Drainage “On-farm Irrigation Development and Management -Lessons Learnt in Monsoon Asian countries-“
http://www.jiid.or.jp/files/03library/japanese_ver.pdf
National Federation of Land Improvement Associations
http://www.inakajin.or.jp/01katsudou/index.html