The Implications of Equity in Rotational Cropping and Irrigation

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ABSTRACT

Scarcity of resources does not cause problem more serious than inequity in distributing such resources to the public. With this concept to share the scarcity of water, development of rotational cropping and irrigation in Taiwan, particularly during the period of 1950s to1980s had fulfilled its designated contemporary goal of producing adequate food to meet the need of that era with comparatively small amount of water. This achievement might attribute to the technical renovation on water management and heavy investment in the improvement of irrigation facilities. Contemplatively, this practice had enabled water controllers to convince water users that the scarcity of water is being distributed equitably to a maximum extent so that the use of water in the field could maintain orderly, of which might ascribe equally or even more than the technical amelioration and heavy investment to the success and sustainability of water management.

Key words: 1. rotational cropping pattern. 2. rotational irrigation. 3. equity. 4. water scarcity 5. on-farm and off-farm irrigation . 6.sustainability .

1. INTRODUCTION

Taiwan, 142 km in width and 383 km in length, is an island oblong in shape and located in the West Pacific Ocean, east of the Chinese mainland with an area of 35,961 km^2. The climate is subtropical and characterized by high temperature, heavy precipitation, and violent winds. Annual precipitation over the island averages 2,504 mm. The annual availability of water resources from precipitation varies from 60 billion m^3 to 120 billion m^3, of which about 20 to 25 per cent of them were utilized in the last 10 years.

In terms of depth, the annual average precipitation of Taiwan is the third highest in the World; but per capita precipitation being used is about 4,030 m^3/person/year, contrarily this amount is the third lowest compared to the lowest and 2nd lowest of Egypt and India at 951 and 3,795 m^3/person/year respectively. Uneven distribution of precipitation in space and time, together with the lack of suitable storage dam sites due to weakness in geological land formation coupled the difficulties in water utilization in Taiwan. The precipitation utilization rates in the last ten years varied from 22% to 14%. Of the utilized water resources, only 24 to 28 per cent of them were taken from the existing 41 small reservoirs. The shares of water utilization to the sectors of agriculture, domestic water supply, and industry, in the Year of 2000 for example, are about 71.5%, 17.7% and 11.8% respectively. In the same year, paddy rice irrigation, fishery and animal industrial sub-sectors shares 83, 16 and 1 per cent of the total of agriculture respectively.

2. TRADITIONAL APPROACH TO THE WATER SCARCITY

2.1 Tradition of Rotational Cropping

Given the above-mentioned unfavorable precipitation distribution, water shortage for irrigation almost reoccurs once every five to seven years during the dry season of winter; however, the temperature and soil conditions in Taiwan are in favor of growing two crops of paddy rice wherever and whenever water resources are available. As rice is the staple food of the local inhabitants, traditionally, farmers would grow paddy rice as possible as they could when Taiwan was still in the subsistence agriculture. Non-rice crops might be grown after harvesting irrigated paddy at the beginning of dry season. Those non-rice crops, which consumed much less water than paddy, would absorb the residual moisture in the soil after irrigation for germination; then they would grow in the semi rain-fed condition. Once or twice of irrigations depending upon water availability would be given to upland crops. When water resources are sufficiently for growing paddy rice, farmers would grow rice; otherwise the upland crops would be their second choice. This rotational and diversified cropping pattern has prevailed for hundreds years in Taiwan.

There were some cases, when upland crops could not receive sufficient water from irrigation or rainfalls, they would produce lower yield or even being suffered from damages. Farmers practicing this kind of rotational or diversified cropping were usually aware of the existence of risk; however, through their long-term trial-and-errors process, they eventually would gain sufficient experiences to undertake the most profitable diversified cropping in the long run.

2.2 Tradition of Rotation Irrigation during Water Scarcity

The practice of rotational irrigation in Taiwan had been formulated about two hundred years ago in the area where water shortage was inevitable. The time of irrigation was based upon the area farmers owned and determined by burning a length of joss-stick to count the time of irrigation.

After the restoration of Taiwan in from 1945, systematic research on water application methods for paddy rice was conducted in the Chianan Irrigation Association by Prof. C. king of National Taiwan University. Information from these experiments coupled with actual demonstration experiences in the new canal system gave confidence to the irrigation engineers to develop the specifics of "Rotational Irrigation." It has been rapidly displaced the conventional continuous irrigation.

3. IRRIGATION EVOLUTION IN TAIWAN

The history of developing large irrigation schemes in Taiwan could be traced back up to Dutch colonial period from 1609 to 1661; since then Taiwan's irrigation system has been under another four Governments' administration, namely, Ming-Chung dynasty from 1662 to 1683, Ching Dynasty from1684 to 1895, Japan colonial from 1895 to 1945, and the Republic of China after World War II from 1945 up to now. In the last 400 years, the irrigated area in Taiwan had increased from 8,400 ha in 1600s to the highest of 560,000 ha in 1940s, and has decreased to 360,000 ha as of now. The period of Ming-Chung/Chin Dynasty was the only period that irrigation systems were developed and operated totally by the water users, i.e. a real and whole participatory irrigation management (PIM). After adopting mass rice production as the policy for

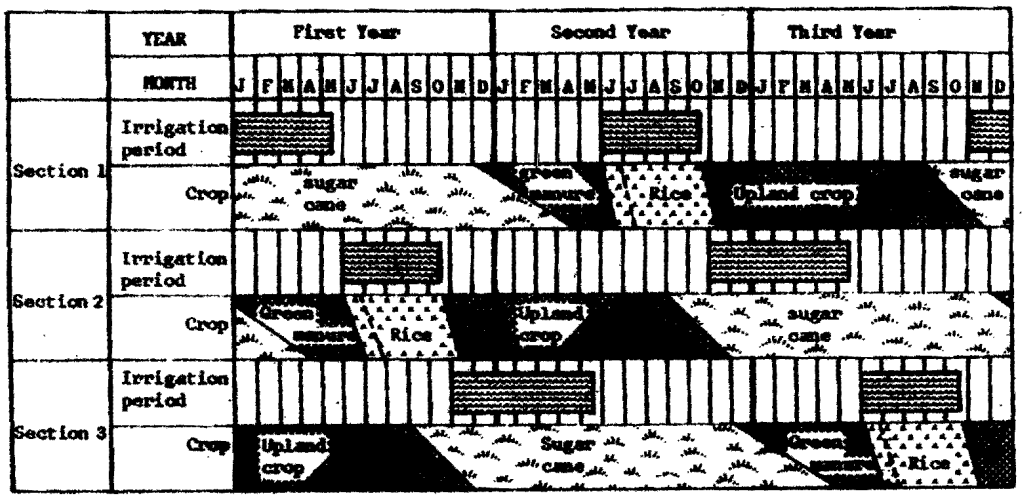
foreign exchange earnings or savings, and food self-sufficiency or food security in 1908, the Government of Japan became involved deeply in the development and management of irrigation systems. Since then, irrigation development and operation has never got rid of Government's different levels of control.

4. DESIGNATED ROTATIONAL CROPPING PATTERN

4.1 Three-year Rotational Cropping Pattern

One of the most sophisticated rotational cropping patterns designed in Asia is located in the Chia-nan Irrigation system situated in the south of Taiwan. It began its operation in 1927 covering a total irrigated area of 150,000 hectares when the system completed its construction. The area comprises about 8 per cent of clay soil and the remaining is sandy loam to clay loam. Annual rainfalls over the area are about 2,500 millimeters (mm). This amount of rainfall should have been sufficient to grow two crops of paddy annually. Unfortunately, the about 91 per cent of annual run-off concentrates in the raining season from May to September each year, and the geological condition is neither in favor to built water storage facilities. As a result, the developed water resources were only sufficient to grow one crop of paddy rice in the monsoon season in the one-third of the total newly developed area. Consequently, a "three-year rotational cropping pattern" was developed and practiced, i.e. Rice (monsoon)-upland crops-sugarcane-green manure, each piece of land within three years. The more details are illustrated in Fig 1 below:

IRRIGATION FOR THREE YEAR CROP ROTATION



Crop rotation → Sugar cane → Green manure → Rice → Upland crop → Sugar cane → green manure → Upland crop → Repeat rotation

Remark: This schedule is for the three year crop rotation pattern. For sugar cane irrigation, from November to March will be irrigated two to three times according to water supply and actual need in field.

Fig. 1 Three-Year Rotational Cropping Pattern

4.2 Corresponding System Design

For enabling the irrigation schemes to carry out "Three-Year-Rotational Cropping Pattern", the entire newly developed irrigation areas were divided into 150-hectare unit each, namely rotational cropping unit; each unit is further subdivided into three sub-rotational units with 50 hectares each. Three major crops, namely paddy rice, upland crops, and sugarcane were grown in each sub-unit by turn within three years as a rotational cycle. The layout of irrigation and drainage canal either on-farm or off-farm system was so designed to fit the practice of the rotational cropping. In this connection, each rotational unit with three sub-units has their own individual off-take gates. In particular, for the design of irrigation system, among all rotation units or sub-units, canals in different units would never be connected or mixed among them.

4.3 The Practice of Rotation Cropping

As above-mentioned, for instance, when one of the three sub-units would receive water sufficient for producing one crop of paddy rice in the summer; the second sub-unit would be given irrigation water only in the dry season of winter or spring for the need of growing sugarcane; while the third sub-unit, growing miscellaneous crops, would receive only the surplus water whenever is available, or frequently no irrigation at all. The next year, the second sub-unit would be given water to grow rice; the third to grow sugarcane and the first to grow miscellaneous crops, and so on. Thus the differential water supply is applied to the three sub-units on a three-year rotation basis.

4.4 Supportive Measures for Rotation Cropping Pattern

4.4.1 Organizing Water Groups

To ensure the success of rotation cropping, Water Users' Groups and Sub-groups were organized according to their units and sub-units. The main task of the organization includes: a leader for each water group would be elected through common election for a three-year service term; and three sub-group leaders would be assigned by the elected group leader The responsibility of water group leader would mainly serve as the followings:

- Conducting fixed term and temporary water group meetings for discussing irrigation and cropping schedule related affairs;
- Conveying farmers' view regarding irrigation, cropping pattern, water fee and matters relevant to the system controllers i.e. the irrigation association;
- Conveying the message from the irrigation association to the farmer; and
- Other relevant matters entrusted by the Government or the irrigation Association

4.4.2 Government's Intervention

In the early stage of the implementation of rotational cropping pattern, the willingness of farmers to follow was not encouraging. The Government had provided a strong support and intervention to make sure the success of rotational cropping pattern. For the most cost effective the use of water at that time, the Government usually gave the first priority to paddy rice, the second to sugarcane, then upland crops the third. It has taken about six (6) years on trial-and-error approach to make the arrangement of rotation cropping pattern to be mature

4.5 Modifications on Rotation Cropping Pattern

The preliminary rotational cropping patter was firstly operated in 1927 during Japanese colonization. After World War II, Taiwan was restored to the Republic of China in 1945. Since then, more water resources were developed to produce more rice to meet the increase in populations. As of the now there are six kinds of cropping pattern prevailing in Taiwan. They are:

(1). Double Paddy Cropping Pattern: rice grows in the both wet and dry seasons each year.

(2). Single Paddy Cropping pattern: rice grows only in wet season each year.

(3). Two Paddy Rice Crops Each Two Years Pattern: rice grows in wet season in the first year and another rice crop grows in dry season the next year.

(4). One Rice Crops in Three Years: rice grows in the wet season once out of three years.

(5). Two Rice Crops in Three Years: rice grows only in wet seasons twice out of three year; and sugarcane or upland crops during the remainder of three years.

(6). Modified Two Rice Crops in Three Years: rice grows once in wet season and other in the dry season of another year out of three years.

5. PRACTICE OF ROTATIONAL IRRIGATION

In general, water delivery for irrigation in Taiwan is not based on the demand of individual farmers. Irrigation usually follows a precise schedule recognizing farmer needs. The method is called rotational irrigation. A conventional continuous irrigation method, whenever water resources permit, the paddy rice field is usually filled with water from transplanting to ripening. This practice might waste much water through deep percolation, evaporation and reductions in the use of effective rainfall. Experiments conducted at several paddy fields for more than six (6) years had demonstrated that an increase in the yield of paddy production could also be achieved.

5.1 Basic Concept of Rotational Irrigation

Rotational irrigation is an intermittent application of irrigation water at a regular time interval and with specified water depths. The amount of water applied to each cycle of the rotation is based on the actual need of crop's consumptive use and irrigation requirement according to the different growth stages of paddy. This method will result in one or two days without water standing on the field. It permits a periodical aeration of the root zone, which is considered to be beneficial to a better growth and production of paddy rice. This concept and practice in Taiwan had already prevailed about two hundred years ago.

5.2 Claimed Advantages of Rotational Irrigation

The above-mentioned experiments and demonstrations found that the rotational irrigation compared to the conventional irrigation has the following advantages. They are:

(1). Rotational irrigation has shown to achieve water saving by 20-25 percent as compared with conventional continuous irrigation in the long-term.

(2). Most cases indicate a higher yield with rotational irrigation.

(3). Rotational irrigation decreases irrigation disputes and helps the development of cooperative atmosphere and order in the practicing irrigation in the rural areas.

(4). Rotational irrigation encourages the use of the common irrigator, by which the farming time on irrigation by individual farmer can be saved resulting in farming efficiency.

(5). Rotational irrigation provides the management's more opportunity to have a better handling drought situations and the rapid fluctuation of water resources.

5.3 Planning of Rotational Irrigation

5.3.1 Paddy Rice Growth Periods

Growing season and irrigation period of paddy rice in those areas where two crops of rice are grown, the first crop is grown during the spring and summer; and the second crop in autumn and early winter. In those areas where only one crop of rice is grown, in the rainy season from June to September, it is called the intermediate crop. Generally speaking, the first crop rice has a longer growing period with a higher yield than the second crop or the intermediate crop rice. The length of growing period also differs with the varieties of rice. The local variety, Tsailai rice, usually requires a longer growing period than the imported variety, Ponlai rice. Research has shown that the growing periods in the main field, from transplanting to maturity, for the first and second crops are 105 to 115 days for Ponlai variety, and 110 to 120 days for Tsailai variety, respectively. The growing periods in the seedling bed for the first and second crops are 15 to 35 days for Ponlai, and 30 to 45 days for Tsaili, respectively.

5.3.2 Irrigation Water Depths in Various Paddy Growth Periods

Based on these main activities of rice farming, the irrigation of paddy rice may be classified into the seedling bed, land preparation and main field stages. The needs of irrigation water depth in each stage are:

- **Seedling Bed:** Seedling bed irrigation, for an area only 1/30 to 1/25 of the main field is irrigated with a design flow of 0.008 m^3./sec each rotational area of 50 ha.
- **Land Preparation and Transplanting:** The irrigation depth for land preparation varies with the workability and permeability of the soil upon saturation; 150 mm is considered to be necessary for sandy soil, and 100 mm depth of water for clayey soil respectively.
- **Main Field:** Daily irrigation depth for main field stage varies from 14 mm to 24 mm for sandy to clayey soils. The normal irrigation depth varies mainly with the type of soil, because the soil texture induces more variability in water consumption than do the climatic factors. The percentage of soil particles below 0.005 mm has been selected as an index to link soil types and the normal irrigation depth. From sandy to medium clayey soils with the percent fines ranging from 8 to 40, the normal irrigation depth ranges from 7.0 mm to 16.0 mm per day. With these data, the normal irrigation depths of three major soil types could be specified for different 10-day periods. Table 1 shows an example of calculating the details of irrigation requirements each different growing stages of paddy. The exercise illustrated in Table 1 appears complicated, but it would be done once for each crop and each different season; then the result would be applicable for another years. The more complex tasks of the planning for the rotational irrigation is calculating the predicted effective rainfalls for each 10-day period. The last 5 years' rainfall record would be the basis for this analysis and prediction, and thus the prediction of effective rainfall is the important regular exercise for each season. During the actual water application, the predicted effective rainfall would be reduced from the irrigation requirement s shown in Table 1. In another words, the actual depth of water application the balance of irrigation requirement by deducting predicted effective rainfalls.

Table 1: Calculation of Irrigation Water Requirement

Growing Stages of Rice	10-Days After Transplanting	Equations for Weighted Irrigation Requirement Calculation	Amount of Weighted 10-Day irrigation Requirement(mm)	Weighted Daily Irrigation Requirement (mm)
Start of transplanting	--	$1/2P+1/2I_0$	1/2*112+1/2*64=88.0	8.8
Continuing of transplanting	1st	$1/3P+1/2I_0+1/3I_0$	1/3*112+1/2*64+1/2*64=90.6	9.1
Initial tilling	2nd	$1/6P+1/6I_0+1/3I_1+1/2I_2$	1/6*112+1/6*64+1/3*64+1/2*58=79.7	8.0
Effective tilling	3rd	$1/6I_1+1/3I_2+1/2I_3$	1/6*64+1/3*58+1/2*53=56.5	5.7
Highest tilling	4th	$1/6I_2+1/3I_3+1/2I_4$	1/6*58+1/3*53+1/2*53=54.0	5.4
Young-heading forming	5th	$1/6I_3+1/3I_4+1/2I_5$	1/6*53+1/3*53+1/2*58=55.5	5.6
	6th	$1/6I_4+1/3I_5+1/2I_6$	1/6*53+1/3*58+1/2*71=63.6	6.4
Normal heading forming	7th	$1/6I_5+1/3I_6+1/2I_7$	1/6*58+1/3*71+1/2*71=69.2	6.9
Miky-ripening	8th	$1/6I_6+1/3I_7+1/2I_8$	1/6*71+1/3*71+1/2*64=67.7	6.8
Starchy-ripening	9th	$1/6I_7+1/3I_8+1/2I_9$	1/6*71+1/3*64+1/2*64=65.0	6.5
Yellow-Ripening	10th	$1/6I_8+1/3I_9$	1/6*64+1/3*64=31.7	3.2
Maturing	11th	$1/6I_9$	1/6*64=10.7	1.1

Remark: this table is an example for loamy soil.

5.4 Practicing of Rotational Irrigation

5.4.1 10-Day Irrigation Interval

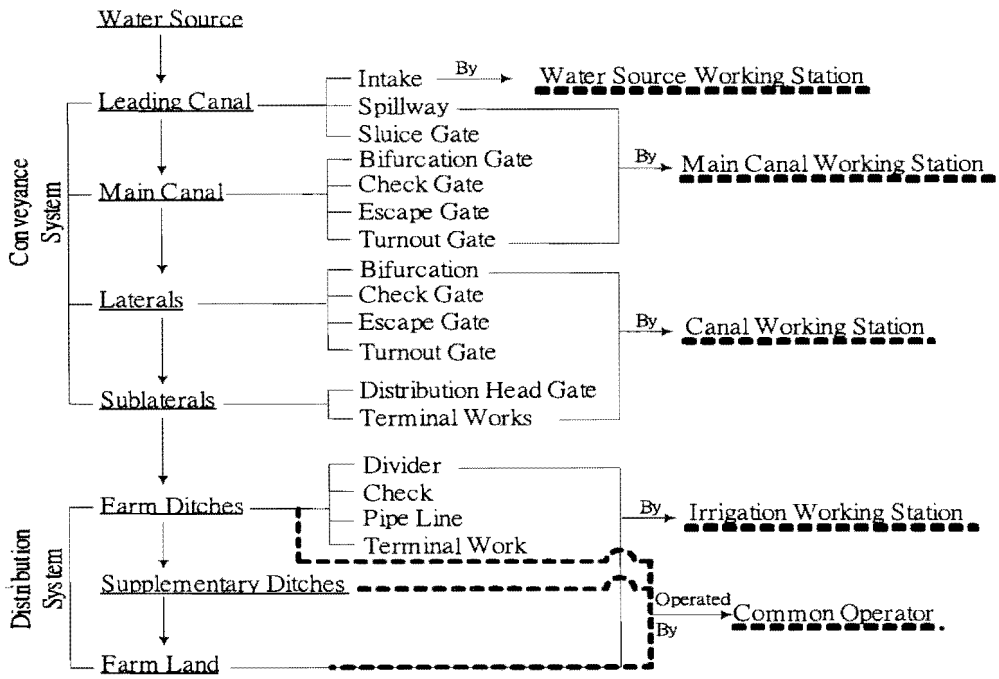
Based on a practical consideration, the average of variation in every10-day period is used as the time interval for irrigation water application; i.e. irrigation water requirement for the system changes only every 10-day period. Within each 10-day period, discharge for canal system remains constant through the 10- day period. Furthermore, each 10-day requirement is used to express as a percentage of the normal irrigation depth on the main field. A normal depth of 100 percent for the 1st, 8th and 9th 10-days; 110 percent for 2nd and 5th 10-days; 80 percent for the 3rd and 4th 10-days; 110 percent for the 6th and 7th 10-days have been adopted successfully in the Chianan Irrigation Association. The example of this planning is shown in Table 1 above.

5.4.2 Water Delivery Schedule

To prepare water delivery schedule, a normal speed of seedling transplanting of about two hectares per day is assumed. For a standard rotation area of 50 hectares, 25 days would be required to complete transplanting operation. To provide a water delivery schedule precisely corresponding to the varying irrigation requirements of different stages of seedlings transplanted in a small and scattered paddy plot is tedious but important. For this, a survey of actual land utilization and irrigation status including details such as the rotation unit and irrigation system; the irrigating and transplanting areas; the previous and intended crops; the intended date of seedling and transplanting; and the name and address of the tiller are essential both for pre-irrigation planning and for post-irrigation evaluations. For the preparation of the overall water delivery schedule for rice irrigation, the computation of weighted irrigation requirements, considering the factors of soil types, crop growing stages, and the pre-decided transplanting schedules, have been adopted successfully by Chianan Irrigation Association. An example is also presented in the Table1. .

5.4.3 Management of Water Delivery System

Successful operation of a canal system practicing rotational irrigation depends not only on proper management of the conveyance system that brings water from water source to the head gate of the distribution system, but also on proper management of the irrigation water within the distribution system. To coordinate the conveyance and distribution system, a series of forms have been designed for recording and reporting the daily irrigation activities. The management system for water delivery is illustrated below:



5.4.4 Water Delivery Management

The management of water delivery from the irrigation plan, to the water conveyance, to the water distribution is the duty of employees of the Association; actually applying water to the each plot of land is usually the job of the common operator or common irrigator. The Common

operators, hired by Working Station, are responsible for actual water distribution including: informing each landowner about the irrigation schedule or irrigation timetable; carrying out the water application to each plot of land in accordance with the irrigation schedule planned by employees of the Irrigation Working Station; maintaining the farm ditches in good condition; any other assignment concerned with water distribution.

5.5 Practice of Water Applications in Rotational Irrigation

5.5.1 Water Distribution to Land

Previously, the main objectives of irrigation were essentially limited to the production of rice, while only a minor part of water has ever been used for up-land crops irrigation. Flood irrigation is the only method of water distribution used for paddy rice over the entire island. There is no special skill developed for the flood irrigation of paddy rice. Paddy rice areas generally have slopes from 0-3 percent, and no difficulty has been experienced with flood irrigation of paddy. The application of water into the field is simply by penetrating several pipes through the dikes of the farm ditches; irrigation water would be diverted to the field by just removing the plug of pipes of the bank of ditch.

5.5.2 On-farm Water Distribution Systems

About two-third of the total irrigation area has been consolidated under the Land Consolidation Project in Taiwn. The shape of farm is regular and the length of runs varied from 100 to 150 meters. Each plot of land in such area is adjacent to irrigation; drainage ditches; and farm road. Water distribution is easy and simple. However, in the area without land consolidation, the farm shape is irregular and the length of run varied from 50 to 200 meters. Some of them must be served by water passing through several pieces of lands. This has been a serious problem for a long time. Conflicts and disputes often occurred when permission for by-pass is not obtained. The quantity of irrigation water is measured only at head gate of the distribution system, the amount applied to each plot is determined by accounting the application time in proportion to the area of plot. The average size of plot is about 0.3 hectares.

5.5.3 Upland Crops Water Applications

For upland crops, furrow irrigation is extensively adopted, and it is especially suitable for the row crops grown in level rice paddy during the dry season. With limited water supply, a better drainage system for removing excess irrigation water at the ends of rows is not used in this area; all water applied to the furrow is supposed to be all stored in the soil. The irrigation water depths for various crops, 90mm for sugarcane and 70 mm miscellaneous crops, measured at the head gate of the distribution are considered to be the most practical water depth of the sufficient water in the downstream portion of the furrow.

5.6 Adjustments of Irrigation Plan in Case of Drought

Adjustment of the water distribution schedule, when serious drought spelled out, must be considered to reduce the amount of water in several less important stages and to fulfill the requirements at critical periods, such as the seedling bed stage, land preparation, transplanting, head forming, etc. Intensive utilization of effective rainfall through strengthening and heightening of the field dikes should also be considered. Different adjustments are specified for canal systems with and without storage facilities as follows:

5.6.1 Reservoir Systems

In general, prolonging the rotation interval without a change of water depth is the most acceptable to farmers and suitable for a large reservoir system. Detailed considerations for the different cases are given below:

- **Drought before irrigation:** Water should be reserved in the reservoir for full irrigation of the stages of seedling nursery to seedling transplanting, then prolonging the rotation interval for main field irrigation or intermittent application of irrigation water for the seedling bed should be carefully considered according to the remaining water and predicted inflow.
- **Drought developed during main field irrigation:** When the water in the reservoir is found inadequate to serve two cycles of rotational irrigation, prolonging the rotation interval will be considered immediately.

5.6.2 Non-Reservoir Systems

- Drought before irrigation: When the available river flow is found to be less than 80 percent of the normal irrigation requirement, the laterals of the whole irrigation system should be arranged into groups to permit group rotation. Different combinations of lateral groups and intermittent intervals may be attempted to achieve an irrigation schedule consistent with the estimates river diversion.

Drought developed during main field irrigation: Different arrangements of lateral groups and irrigation intervals should be developed to meet different degrees of flow reduction.

6. CONTEMPORARY RESPONSIBILITIES

6.1 National Survival and Food Security

6.1.1 National Survival

The existing Government was expelled from Mainland China to Taiwan in 1949. In that era, Taiwan was always being pushed to the edge of civil war. The nation survived with limited foreign military aid and financial assistance. In addition to storing adequate foods to be ready for civil war, exporting agricultural products was the unique, nevertheless very slim, hope for earning foreign exchanges to initiate the national economic development. Effective use of water resources to support the agricultural production was one of the most important measures, which could be considered to save the country in that era. Thus the practice of intensive rotational irrigation to combine with rotational cropping pattern had heavily born the contemporary responsibility of the national survival.

6.1.2 Combination of Rotational Cropping and Irrigation

The rotational cropping pattern was firstly practiced in 1927; while the practice of combined intensive rotational irrigation and cropping started in the early 1950s. Consequently this contemporary responsibility was over at the time when the rice surplus occurred in 1984, following a series of paddy rice fallowing programs has to be continuously implemented. The major achievements of this contemporary responsibility could be summarized below:

- Irrigation became one of the key engines of Taiwan's economy moving from agriculture to industrialization.

- Irrigation along with the introduction of improved seed varieties enabled Taiwan farm economy to meet domestic food demands and become a major exporter of fruits, vegetables, and livestock products. For 30 years, from 1945 to 1975, Taiwan's irrigated agriculture epitomized the ideal. (Bottrall 1981, Levine 1991).
- Irrigation also epitomized World Bank's ideal of full participatory irrigation management (PIM), including farmers' sharing 40 to 60 per cent of cost recovery for the construction cost of irrigation facilities and 100 per cent of O&M costs.

6.2 Fading Economic Importance of Paddy Rice

In the wake of Taiwan's economy started to move toward industrialization, the share of GDP in agriculture kept falling from 32% in 1952 to 1.91% in 2001. Table 2 shows that the percentage of contribution of paddy rice to the total Gross Domestic Products (GDP) was falling from 1.9% in 1985 to 0.51 % in 2001. This fact explicitly indicates that the commodity economic benefit of paddy rice has gradually lost it competitive advantages in sharing the land and water resources to the non-agricultural sectors.

Table 2: Paddy Rice Contribution to Total GDP Units: %

Year	Agriculture Contribution To GDP	Rice's Contribution to Total Agriculture	Rice Contribution to National GDP
1985	5.8%	32.6%	1.90%
1990	4.2%	33.9%	1.42%
1995	3.6%	30. 7%	1.11%
1997	2.7%	29.4%	0.80%
2001	1.91%	26.7%	0.51%

Sources: data from "Basic Agricultural Statistics, C0A. 1986—2001"; and result analyzed by Ko & Chun , AERC Feb. 2003

6.3 Relaxing Intensity of Practicing

From macro economic points of view, the more paddy rice produce, the more national economic losses would be induced. The practice of intensive rotational cropping and irrigation no long requires all the time. The actual practices for both depend on the following situations now:

6.3.1 Rotational Cropping Pattern

The decision on which crops to grow each season ultimately rests with the farmer himself; but the farmer accepts that the water supply constraint imposed by the irrigation association. The decision of farmers on cropping pattern adopted usually based on many factors and they should accept the result of decisions as below:

- Farmers' decisions on cropping pattern may base on crops' price stability, labor requirement and susceptibility to damage by typhoon, heavy rains inundation and strong wind; and
- Farmers in rotation areas display more independence and diversity in their cropping pattern decision than farmers in double paddy areas.

6.3.2 Rotational Irrigation

When the wage rate of labor is becoming dearer, the intensive rotational irrigation is an

extremely expensive practice. Most of cases showed that the profit of such irrigation could not offer to pay for this kind of practice. As such, the practices of rotational irrigation are generally relaxed depend on the availability of water and the profits of irrigation. However, it does not mean that Taiwan has already totally abandoned the practice of rotational irrigation. It has kept flexible as following:

- The intensive rotational irrigation still maintains in the areas where deep ground water is .the unique water resources for irrigation;
- Different intensities of rotational irrigations are still prevailed whenever drought spells out;
- The potential of practicing intensive rotation irrigation still exists in terms of the hardware facilities or the software of knowledge on know-how.

7. THE IMPLICATIONS OF EQUITY AND SUSTAINABILITY

7.1 Equity Implications

Observing that, the officially designated cropping pattern was so often ignored by farmers; and the facilities built and supplicated water management skill developed for practicing intensive rotational irrigation were found under-utilized and partially deserted. This fact does not necessarily lead to the conclusions that, when this contemporary responsibilities was over, and thus it should be totally abandoned now. On contrary, the spirit of equity in allocating limited water to the farmer demonstrated from the both practices is the main supporter for the water controller to convince water users that they are being treated equally at sharing limited water so long as the rotational cropping and irrigation is still practicing.

Awareness of the fact that, equity in water allocation and strictly following designated cropping patter do not guarantee that the farming profits of individual farmer or national income would be the optimal, but they still prefer this arrangement and are willing to take their own risks. The Government also encourages farmers to diversify more their cropping instead of following the designated cropping pattern. This implies that once farmers are treated equally in sharing the water, they accept the result whatever they would receive from farming so long as they make decisions by themselves on what crop to grow..

7.2 Long Term Equity

Regardless of the existing situation that few farmers strictly follow the officially designated cropping pattern, they still accept the arrangements of water allotting schedule in accordance with the designated cropping pattern, but they do not necessarily following the cropping which they receive the water for. For instance, they are scheduled to receive sufficient water to grow paddy, they may or may not grow paddy rice. They would not receive any compensation for the water they do not use if they grow any non-paddy crop and would use less water they own. It is therefore that the actual meaning of designated cropping pattern remained now is just the tool for equitably sharing water in the long terms of season and amenity.

7.3 Short Term Equity

In the wake of participation in World Trade Organization (WTO) permitted in January 2002, paddy rice is no longer the most profitable crop regardless of domestic price support program still

available, but the paddy rice fallowing program prevailing is equally attractive to the farmer who does not have sufficient capability of farming in the field. Particularly, in the rotational cropping area, more than 30 per cent of farms do not grow rice although they are entitled to grow. Consequently, in the normal hydrological year, the amount of water available for irrigation would be often more than the field needs, therefore, the previous strictly rotation irrigation is no long required. Farmer would be in the first priority to use the water to irrigate upland crops if the land is in turn to grow rice. If additional water still avails, they use their water to irrigate any crop in the areas where are not in turn for irrigation. This practice strongly implies that the spirit of equity in sharing water in short terms still remains and sustains now.

8. CONCLUSIONS

The lessons learned after reviewing the practice of rotational cropping and irrigation in the last forty years in Taiwan, it strongly leads to make the conclusions as followings:

(1). If the practice of rotational cropping and irrigation as described in this paper is deemed to be successful, the crystal of success is equity; not the technical amelioration and heavy investments. Without the spirit of equity, this practice would not be sustainable as it is now;

(2) The prevailing national agriculture policy has run from development before 1980s into compensation after 1990s. The existing goals of agriculture policy are mainly at: maintenance of food security, avoidance of widening income gaps between the rural and urban, crop diversification for reducing the agricultural subsidy, preserving ecosystem and biodiversity. To meet this change, modifications on the uses of irrigation water needs to be continued; and irrigation sector should always be ready for the modification. Only the asset of equity should always remains unchanged.

(3). A more intensive rotational cropping and irrigation might have the opportunity to be restored to some extent in the future, if agriculture sector is being pressed to release certain amount of water the to industry and domestic water supply sectors, and the agriculture sector is not willing to further reduce the cultivation areas. Then, restoring practice of intensive rotational irrigation to save water to meet this need would be the most possible area to find the additional water. As such, the facilities and technical know-how for practicing intensive cropping and irrigation should not be arbitrarily deserted now.

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