STUDY ON WATER USE PLAN FOR REASONABLE IRRIGATION OPERATION AND MANAGEMENT

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ABSTRACT

The major function of irrigation is to supplement water to growing crops with the quantities which cannot be sufficed by the nature, in order to ensure food productions. The conventional water use plan for irrigation operation and management is made based on the stance of "supply" which takes into account the amount of irrigation water diverted from water sources, then flowing through various levels of canals, and reaching farms for the needs of normal growth of crops. This concept implies that the supply side dominates the "demand" side; and its adjustment to the fluctuating water sources is much dependent on the operator's experience, in case there are not established irrigation operation criteria to cope with changing water sources. Under such a circumstance, when the system operator are absent, and few appropriate personal are available to replace them, then the conventional irrigation operation mechanism is often discontinued. With an aim to solve the aforesaid implication in irrigation operation, in this paper are examined and probed the following issues, on the basis of irrigation at right time and with proper quantities :

1. Relation between diverted amounts of water (Q_s) and farm requirements (Q_d)
2. Distinctions between conveyance loss (S) and factor of loss (K)
3. Influence of diverted amount of water (Q_s) to irrigation efficiencies (E)
4. Relation between irrigation efficiencies (E) and irrigation time (t)

Water use plans for reasonable irrigation operation and then studied and discussed, from the view point of irrigation management.

INTRODUCTION

The most difficult of O&M in irrigation areas with abundant water sources which tap water from river by gravity lies in the formulation of a reasonable water-use plan that would respond to the fluctuations in the river water level and maintain the water level during the conveyance.

The history of irrigation in Taiwan has been over 300 years. The facilities and technologies came mainly from traditional China Mainland, however, they have also merged the technical merits from the Netherlands, Japan and the United

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States, and thus formed the unique Taiwan irrigation system. For example, the three-year rotation cropping system of alternating paddy rice and upland crops, and the drought season measures responding to water shortage.
However, due to lack of basic concepts of water-use plan and the complexity of the irrigation system in Taiwan, problems on balanced supply and demand of water can only be overcome through the experience of the manager. Once the manager left the original irrigation operation system, there is no way to maintain. Nonetheless, it has introduced a set of irrigation programming that would correspond to actual practice.

LITERATURE

Taiwan is a rice producing country with unique characteristics while the Tropic of Cancer trespasses through it, and two crops of rice can be harvested each year. The average annual rainfall reaches 2,510 mm, however, the wet and dry seasons are significant. The amount of rainfall in wet season (May to September) accounts for 80% of the annual total rainfall. Thus in Taiwan, the harvest in dry seasons must be depends on irrigation. The irrigation industry of Taiwan has been developing under this unstable water shortage conditions.
The set of irrigation programming is carried out in three stages as follows in Taiwan.
1. First Stage: The Irrigation Association formulate conveyance system programming. Step as follows:
(1) Formulate irrigation rate for tertiary unit
The Irrigation Association. in accordance with the meteorological and soil parameters estimates irrigation area of paddy that can be completed by the unit discharge(1 cms) of turnout of the tertiary unit based on past experiences. This is the so-called irrigation rate for tertiary unit ($IR_N(I,J)$:ha/cms) as show bellow.

$$Q_N(I,J) = \frac{A}{IR_N(I,J)} \quad \text{.......(1)}$$

which I = 1 represents the 1st crop of rice, I = 2 represents the 2nd crop of rice, J =l...m, m represents ten days or half month, $Q_N(I,J)$ (cms) represents discharge needed by farmers to complete irrigation of area A (ha).
(2) Formulate conveyance loss for each degree of cannel
The Irrigation Association uses the discharge of inflow (Q_i:cms) as a foundation to record the discharge of outflow (Q_o:cms) for each degree of cannel after passing through channel during normal period to establish conveyance loss S as shown below:

$$Q_L = Q_i - Q_o \quad \text{.......(2)}$$

$$S = \frac{Q_L}{Q_i} \quad \text{.......(3)}$$

which Q_L (cms) is loss of discharge in cannel thus:

$$Q_i = \frac{Q_o}{1-S} \quad \text{.......(4)}$$

(3) Irrigation Water-Use Plan
Based on equation (1) and equation (4), formulate conveyance system programming. The table 1 shows the discharge of each dergree of cannel .

Table 1 The Discharge of Each Dergree of Cannel

Degree of Cannel	Main (3)	Lateral (2)	Division (1)
Conveyance Loss (S(i))	S(3)	S(2)	S(1)
Discharge of Inflow (Q_i)	$\prod_{i=1}^{3}\frac{1}{(1-S(i))}\times\frac{A}{IR_N}$	$\prod_{i=1}^{2}\frac{1}{(1-S(i))}\times\frac{A}{IR_N}$	$\frac{1}{1-S(1)}\times\frac{A}{IR_N}$
Discharge of Loss (Q_L)	$\prod_{i=1}^{3}\frac{S(3)}{(1-S(i))}\times\frac{A}{IR_N}$	$\prod_{i=1}^{2}\frac{S(2)}{(1-S(i))}\times\frac{A}{IR_N}$	$\frac{S(1)}{1-S(1)}\times\frac{A}{IR_N}$
Discharge of Outflow(Q_o)	$\prod_{i=1}^{2}\frac{1}{(1-S(i))}\times\frac{A}{IR_N}$	$\frac{1}{1-S(1)}\times\frac{A}{IR_N}$	$\frac{A}{IR_N}$

Planned amount of planned diversion of water sources (Q_S) for said tertiary unit is shown in Equation 5.

$$Q_s=\prod_{i=1}^{3}\frac{1}{(1-S(i))}\times\frac{A}{IR_N}\qquad(5)$$

Upon completion of formulate conveyance system programming, the Irrigation Association will give this to the Working Stations of the Irrigation Association and distribute amount of water in accordance with different phases to intake of each tertiary unit.

2. Second Stage: The Irrigation Groups which are organized by farmers formulate distribution system programming . Steps as follows:

(1) In accordance with distance of location, divided area of tertiary unit into 3 or 4 groups. Based on experience, establish water supply multiple CH(I). Water Supply multiple of relatively distant irrigation group is relatively small.

(2) Upon deciding area of each group and multiple of water supply, calculate irrigation time of each group.

$$AW(I)=\frac{A(I)}{CH(I)}\qquad(6)$$

$$TT(I)=\frac{AW(I)}{\sum AW(I)}\times(Ped-TL)\qquad(7)$$

which I is group classification, AW(I) is time to be obtained by each group, A(I) is area for each group, TT(I) is distributed time for each group, Ped is interval of rotational irrigation, TL is time of waterways.

(3) Classify irrigation area of each small group into several rankings and compute distributed irrigation time based on above equation.

(4) With respect to hill mounds of each field, calculate distributed time of each hill mound in accordance with ranking irrigation time using area method.

(5) In accordance with irrigation sequence, accumulate irrigation time of each hill mound and arrange time schedule of irrigation of each hill mound within the rotational irrigation interval.

3. Third Stage: Implemented in accordance with above irrigation plan.

In accordance with the experience of the manager, determine critical values of each operational measures. Water distribution plan are still a part of the irrigation plan. It lacks a water distribution model that meets the requirement of a fair and reasonable principle and timely response to conditions of water sources. Below is a compilation of current method of implementation of each Irrigation Association.

(1) When quantity of actual diversion differs slightly with planned water supply: primary considerations include increase cost of operation and management, common measures taken as follows:

a. Regulate quantity of distributed water: When water quantity of water sources changes, distribute water in accordance with water distribution ratio of each cannel. With respect to supplementary water sources, distribute in coordination with quantity of incoming water from water sources. However, it should be limited to upper limit of planned water use for such region. If it exceed planned water use for said area, then it should not be included.

b. Record time of water-use: After water distribution to each waterway, commence recording time of water use to control the gross quantity of water-use for each group.

c. Trace water-use of each group: The inability of each group to timely regulate floodgate due to rapid changes in water volume of water sources would result to wastage in water. The manager, based on his experience, should observe the time of arrival of discharge of different water sources to each tributary and branches so that operators can regulate floodgate in a timely manner. In addition, in times where discharge is not adequate, the operator may actually trace improper water use to allow for a fair and reasonable distribution and utilization.

(2) When quantity of actual diversion differs greatly with planned water supply (water shortage): primary considerations include loss of profit due to reduced production, complete reliance on experience of manager. Common measures taken as follows:

a. Strengthen irrigation management: in a situation where water shortage is not too serious, strengthen conveyance management and tracing of water sources to minimize unwanted losses.

b. Minimize irrigation water depth method: in accordance with water use ratio of waterways, reduce quantity of supply to each system. Although this method is very simple and convenient, it cannot effectively reduce loss in water delivery. Moreover, it could lead to irrigation difficulties due to low head.

c. Rotational Irrigation By Area and By Sections: In addition to rotational irrigation to tributary and branches of large systems, each rotation value group can further be divided into areas and section rotational irrigation to respond to different water shortage condition of rotational irrigation.

d. Large Division Rotational Irrigation: Divide system into various large division, implement centralized irrigation, reduce conveyance loss, strengthen irrigation management. At the present stage, this is the method commonly used by the Irrigation Association. However, prior communication with farmers must first be undertaken to prevent difficulties in implementation.
e. Extend Rotation Interval Method: In conducting rotational irrigation, establish number of days for rotational irrigation based on the demands of each rotational irrigation group, alter interval of rotational irrigation to increase number of days for dry field to overcome problems of water shortage.
(3) In cases where there is a continuing shortage of water sources: support government policies, interrupt or stop providing irrigation to field areas which consume a large amount of water or which have poor benefits i.e. fallow.
In the past, Taiwan formulate the brought about inadequate head. Farmers do not know where to turn for help. A water shortage would result in scattered fallow farms and interruption of water delivery process, thereby affecting the production value and comprehensiveness of the entire irrigation system. At present, if changes for plans for irrigation water need can be established in advanced from the perspective of demands, (such as establishment of rotational irrigation, crop transfer area, etc.) and reduce farmer's losses to the minimum to maintain the reasonable production value of the field area. Also, alter irrigation water-use plan from time to time in accordance with changes in discharge of water sources to eliminate risk of water shortage and ensure the reasonable irrigation water distribution of the field area.

RATIONAL IRRIGATION OPERATION AND MANAGEMENT PLAN

Irrigation operation and management plan can be primarily divided into water supply plan and water distribution plan. Formulation of water supply plan is relatively simpler as it only needs to be based on irrigation water need and irrigation water loss to compute quantity of irrigation supply. Water distribution plans are primarily focused at formulation of different water supply plans to respond to changes in quantity of water sources so that water supply plan and quantity of actual irrigation water sources can be consistent.
1. Water Supply Plan
All irrigation water supply plan can be divided into amound of irrigation water supply (IWS : m^3), amound of irrigation water need (IWN : m^3) and amound of irrigation water loss (IWL : m^3) as shown in the equation below:

$$IWS = IWN + IWL \qquad (8)$$

(1) Amound of Irrigation Water Need (IWS)
The primary objective of irrigation is to provide water needed in the normal growth environment of crops. Basic condition of crop production is to satisfy amount of evapotranspiration needed by crops in the normal environment. When irrigation is larger than the quantity of evapotranspiration, under excellent drainage and percolation, it could maintain production quantity and production

environment of agricultural fields. When irrigation is smaller than quantity of evaportranspiration, it would rely on the irrigation supplement to maintain the scope of growth endurance of crops. The gradual exacerbation of the production environment would lead to water volume of irrigation to be far smaller than the amount of evaportranspiration. As a result, production and ecology will start to encounter destruction, agricultural fields start to worsen and difficult to recover. The formation of salty and alkaline soil is an example.

For paddy fields, irrigation water need refers to quantity of water used in land leveling to transform dry farmlands into wet farmlands (SAT) to satisfy the amount of evaportranspiration (ETrice) needed by crops for normal growth, prevent dryness of soil, water depth (WL) to maintain suitable for growth temperature of paddy rice and "Adequate Percolation"(Pad) to maintain sustained utilization of land. If effective rainfall (ER) and upstream percolation return water to supplement irrigation water need is considered, per Figure 1, then irrigation water need can be expressed in equation (9).

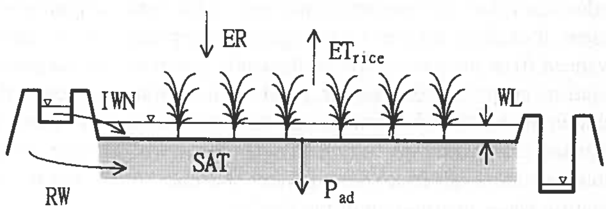


Figure 1 Illustrative Drawing of Irrigation Water Need for Paddy Field

$$IWN = (SAT + ET_{rice} + P_{ad} + WL - ER - RW) \times A = D \times A \quad \text{............(9)}$$

which A is irrigation area, D is depth of irrigation water.p

(2) Amound of Irrigation Water Loss

Reasons causing irrigation water loss can be divided into two categories: water loss caused by poor hardware and loss not caused by human error such as percolation of soil and waterway, damage to internal surface works and water surface evaporation volumn. The second is water loss due to poor software and losses caused by human error such as improper operational management, low irrigation efficiency between the fields, illegal water piracy and water for diluting and polluting use. Traditional paddy field irrigation mostly belong to Open Canal system. During water passage, each water branches have a stoplog to control the water level and flow capacity to maintain a fixed waterhead. When water level reaches needed irrigation waterhead, it could guide water into water intake outlet of tertiary unit to implement irrigation. Thus, loss of delivered water volume caused by poor hardware can be seen as fixed value. Losses caused by poor software would be aggravated with incidents of water shortages. Thus, methods should be devised through regulations, education and moral ethics to prevent losses.

In the past, Taiwan uses conveyance loss S to express irrigation water loss in conveyance system as shown in Equation 10, "Tertiary Area Irrigation Rate IR, "include irrigation water loss in distribution system.

$$S=\frac{Q_L}{Q_S}=\frac{Q'_L}{Q_a} \qquad (10)$$

In reservoir diversion, as quantity of actual diversion (Q_a:cms) is drawn based on quantity of planned water use (Q_N: cms), the application of the above equation will not create too big a problem. However, in a canal system diversion, to increase effective utilization of water resources, there is a need to regulate actual quantity of diversion in accordance with the abundance or shortage of river discharge. Thus, the application of S is not appropriate . Taking for example water shortage condition, as actual quantity of diversion (Q_a) is lower than quantity of planned water use in normal times ($Q_a<Q_S$), in applying S, there is an underestimated condition ($Q'_L < Q_l$, Q_l :cms) for quantity of loss for delivered water (Q'_L :cms). As a result, actual amount of water to water intake outlet of tertiary unit water intake outlet is inadequate and condition of water shortage in the field is more serious.

Form the logical perspective, the objective of water supply plans are to ensure that under the foundation of irrigation water need estimate irrigation water supply and not to seek the difference between irrigation water suplly and irrigation water loss. Therefore, quantity of water loss in water delivery should be recorded in Factor of Loss (L), as shown in Equations 11, 12 and 13.

$$L=\frac{V_L}{V_O} \qquad (11)$$

$$V_L = L \times V_O \qquad (12)$$

$$V_I=(1+L)\times V_O \qquad (13)$$

which L is factor of loss, V_L is of quantity of water loss in delivered water (m^3). V_O is quantity of water in water outake outlet (m^3). Vi is quantity of water of water intake outlet (m^3)

(3) Establishment of Water Supply Plan.

Utilizing above discussions, the following irrigation water supply can be arrived (Table 2).

From the perspective of balanced supply and demand.

$$IWS=\prod_{i=1}^{k}(1+L(i))\times IWN \qquad (14)$$

which IWS and IWN is function for time. If irrigation area (A), irrigation supply water time (Ts), irrigation water needed time (Tn, normally Tn is ten days or half month) and extension time of water flow ti, then relationship of irrigation water supply discharge Qs and irrigation water needed Qn is as shown in Figure 2.

Table 2 The Discharge of Each Dergree of Cannel

Degree of cannel	Distribution System	Conveyance System		
	field	Diversion (1)	Lateral (2)	Main (3)
Factor of Loss L(i)	L(0)	L(1)	L(2)	L(3)
Amount of outflow $V_o(i)$	IWN	(1+L(0))×IWN	$\prod_{i=0}^{1}(1+L(i))\times IWN$	$\prod_{i=0}^{2}(1+L(i))\times IWN$
Amount of loss $V_L(i)$	L(0)×IWN	L(1)×(1+L(0))×IWN	$L(2)\times\prod_{i=0}^{1}(1+L(i))\times IWN$	$L(3)\times\prod_{i=0}^{2}(1+L(i))\times IWN$
Amound of inflow $V_i(i)$	(1+L(0))×IWN	$\prod_{i=0}^{1}(1+L(i))\times IWN$	$\prod_{i=0}^{2}(1+L(i))\times IWN$	$\prod_{i=0}^{3}(1+L(i))\times IWN$

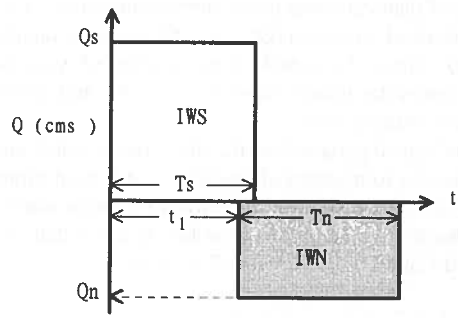


Figure 2 Illustrative Drawing on Relationship of IWS, IWN, Ts, Tn, ti

$$IWS = Q_s(t - t_I) \times T_s \quad (15)$$

$$IWN = Q_n(t) \times T_n \quad (16)$$

$$Q_s(t - t_I) = \frac{T_n}{T_s} \times \left(\prod_{i=0}^{3}(1 + L(i)) \times Q_n(t)\right) \quad (17)$$

(1)In conveyance system, as channels maintain long-term water passages, so Ts =Tn, i.e, i=1 to 3, Ts=Tn.

$$Q_s(t - t_I) = \prod_{i=1}^{3}(1 + L(i)) \times Q_n(t) \quad (18)$$

(2)In distribution system, during actual implementation, farmer will divert more water volume to increase irrigation efficiency and reduce irrigation time, thus, there is a need to centralize fixed flow capacity and implement group irrigation. There are many factors to be considered in group irrigation. Three primary impact equations are enumerated below to serve as examples:

a. $Qs <$ cannel capacity ....(19)

b. $\sum_{i=1}^{N} Ts(i) \le Tn$ ....(20)

c. $Ts(i) >$ irrigation time of farmers........(21)

of which Qs is flow capacity of water intake outlet of distribution system, Tn is appropriate irrigation interval for crops in distribution system, ti is waterway traveling time in distribution system, N is number of groupings, Ts(i) is distributed diversion time for each group. For example, when flow capacity of QS is too small, in addition to lowering irrigation efficiency, irrigation time of each set Ts(i) is extended and will cause $\sum_{i=1}^{N} Ts(i) \geq Tn$ thereby losing opportunity for appropriate irrigation. If grouping number N is extremely big, it will cause irrigation time distributed to each set to be shortened, Ts(i) < irrigation time of farmers. As a result, farmer will not be able to catch up with irrigation. Based on experience of the author.distribution system for an area of approximately 50 ha is approximately best at 3 to 4 groups.

Also, factor of loss of different area of each grouping will have a difference. Area of each group should be distributed to achieve a relatively reasonable irrigation distribution time. Assuming factor of loss of distribution system is L, then considering size of area A(i) is directly proportional to loss of factor, then factor of loss distributed to each set is adjusted as follows:

$$A = \sum A(i) \quad (22)$$

$$L_0 = \frac{L}{A} \quad (23)$$

$$L_1 = \frac{\sum A(i)}{N} \times L_0 \quad (24)$$

$$L_2 = \frac{\sum A^2(i)}{\sum A(i)} \times L_0 \quad (25)$$

$$K = \frac{L_1}{L_2} \quad (26)$$

$$L(i) = 1 + (A(i) \times L_0) \times K \quad (27)$$

A reasonable Ts(i) can be obtained from Equations (17), (19), (20), (21) and (27). However, to allow irrigation water to be send to root system of crops within a specific time and maintain downstream field area return to waterhead, irrigation should within permissible scope of channel capacity, divert water as much as possible to maintain adequate waterhead and increase irrigation efficiency.

(2)Water Distribution Plans

The objective of water distribution plans is to make prior plans to change water supply plan of irrigation water need. From combination of various water supply plan of different irrigation need water and water distribution plan to respond to critical discharge of different waterhead, Equation 9 showed the primary method used as shown in Table 3.

Table 3 Theoretical Foundation for Water Distribution Plans Under Different Water Supply Conditions

Actual Water Supply Condition	Theoretical Foundation	Water Distribution Plan
$Q_c > Q_a > 75\% \times Q_p$	Change Irrigation Depth D	Factor K
$75\% \times Q_p > Q_a$	Change Irrigation Area A	Gilinan (Rotolin)

Note 1 : Q_c:capacity of channel ,Q_p:discharge of planned ,Q_a : discharge of supply

1.Change Irrigation Water Depth D: When sources of water is not stable, distribute changing water quantity to each irrigation area in accordance with ratio and within level acceptable by farmers. as shown in Equation 26.

$$K=\frac{Q_s-Q_{loss}}{Q_p-Q_{loss}} \qquad (28)$$

which K is coefficient for ratio increase or decrease, Qloss is irrigation loss discharge. Just multiply K value with flow capacity of each water intake outlet to find new control flow capacity of each water intake outlet of each area. If it involves different water use of crops, this method can be used to adjust inflow of other water sources and movement of other subjects.

2.Change Irrigation Area A: In cases where water volume is decreased to a level not acceptable to farmers, primary irrigation area could be adjusted by dividing each irrigation area into groups and adopting rotational water supply methods. Focus on relatively large discharge and irrigate one of the group. Groupings and applicable scope are as shown in table 4.

Table 4 Applicable Scope of Rotational Water Supply Plan Grouping

Water Supply Condition	Water Distribution Measures
75% Qp > Q >50% Q	2 rotation groups
50% Q > Q> 33% Q	3 rotation groups
33% Q> Q > 25% Q	4 rotation groups

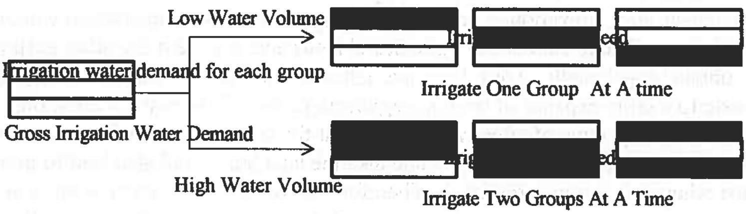
The next step is to consider the direct ratio of length of the waterways l1 and factor of loss. Thus, put more weight on length of waterways. Assuming that loss of factor of irrigation system is L3, area is A1, then, factor of loss of each group should be adjusted as follows:

$$\bar{l}=\frac{\sum(A_i\times l_i)}{\sum A_i} \qquad (29)$$

$$L=\frac{L_3}{\bar{l}} \qquad (30)$$

$$L(i)=L\times l_i \qquad (31$$

For example, with waterway as a unit, divide irrigation area into 3 groups, then, based on amount of water, decide whether to irrigate one group at a time or two groups at a time, as shown in Figure 3. This way, actual amount of diversion of waterway could be adjusted to 1/3 or 2/3 of originally planned irrigation water supply.



CONCLUSION

(1)A comparison between Equation (1) and Table 2 showed that although irrigation rate of tertiary area is similar to quantity of water intake outlet, irrigation rate includes regional return water-use rate and irrigation rate and represents the actual irrigation efficiency of the area. For first line operators, this is practical. In the past, value for said rate is dictated by experience. Now, it can be validated based on factor of irrigation water need, allowing such value to be precise and practical

(2)Maintaining the sustained utilization of agricultural fields is very important to areas where there are limited land resources. In the past, percolation is perceived as the most important aspect in irrigation. In reality, percolation of small field is closely related to soil productivity. Presently, there is the so-called "adequate percolation" which means that it is the best percolation condition for the cultivation of aquatic rice, approximately between 15~25mm/day. Thus,in forecasting irrigation water need,the concept of sustainable utilization of natural resources such as "adequate percolation" should be given much importance.

(3)In the past, planned water supply only takes into account the theoretical applicable irrigation time and condition of actual irrigation is neglected. This has resulted to inadequacy during the days and waste of water during the night, extremely small capacity for medium-sized water supply waterways and extremely large capacity for small-sized water supply waterways or weariness of farmers in an attempt to complete irrigation within distributed irrigation diversion time. Thus, the above should first be taken into consideration when deciding water supply plan for distribution system and capacity of small-sized and medium-sized water supply channel.

(4)If occurrence of water shortage can be known from hstorical data of river discharge, then in accordance with water shortage level adjust water supply plan, and plan a set of distribution plan including the implementation of rotational irrigation and fallow farms. If there is a need to save on irrigation water use during the dry season to support water-use for other areas, then, from the perspective of "beneficiary has to pay compensation", improvement of management, hardware facilities, regulations and moral ethics and strengthening of irrigation rate of fields should be perceived as preferred improvement subjects.

(5)In areas where government provide provisional subsidies to farmers and there is concentrated utilization of land, farmers hope to obtain compensation without working or change land use of agricultural lands and not use it for other purposes to obtain large benefit. Thus, improper fallowing will always lead to creation of waste to a large expanse of land in neighboring areas of the city. In addition, from the perspective of effective management for soil, the result of fallowing will not only result to creation of salty and alkaline land but would also lead to greater cost when cultivation is resumed. Therefore, fallowfarms should be seen as an emergency measure for water distribution plan and not an effective tool in the long term.

RECOMMENDATION

A reasonable irrigation operation and management plan should not only have a healthy and sound water distribution plan but should also consider the effective utilization of natural resources. It should also fully utilize space for flexible water use in field area, i.e., in times of drought, consider increasing effort and expenses in water-use management to upgrade irrigation management and achieve the objective of a reasonable water distribution; in times of abundant supply of water, the unique characteristics of "field is reservoir" should be considered, divert a large amount of water from the riverways to the field, coordinate with sustained utilization concepts of fields by planting crops on fallow fields and creating a water pond, as per Figures 4, 5 and 6. Store excess water in times where water supply is aboundant and adjust water distribution difficulties for mixed planting. Through movement of the soil, break into nonpermeable layer of field area and supplement underground water to promote soil oxidation and reduction and allow for sustained utilization of land. During the dry season, supplement irrigation water of the entire area from pond, conduct conditional transfer of irrigation water for upstream crops for use in other areas.

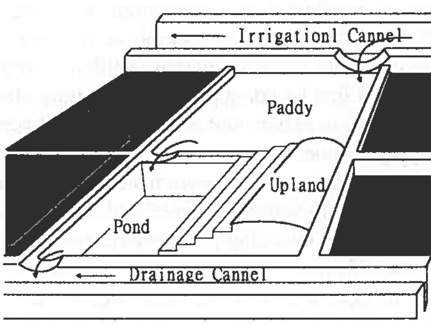


Figure 4 Illustrative Drawing of Sustained Utilization Structure of Fields

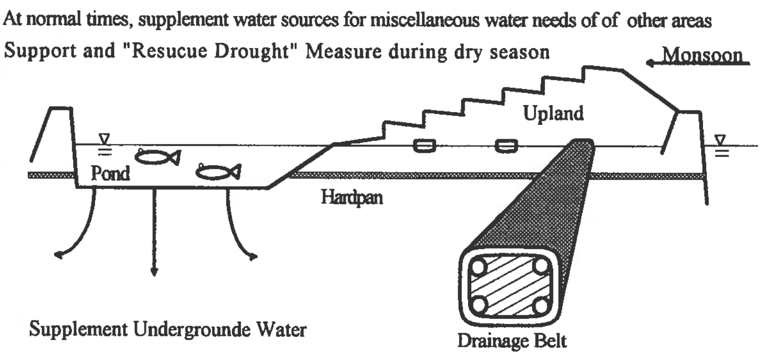


Figure 5 Illustrative Drawing of Sustained Utilization Operation of Fields

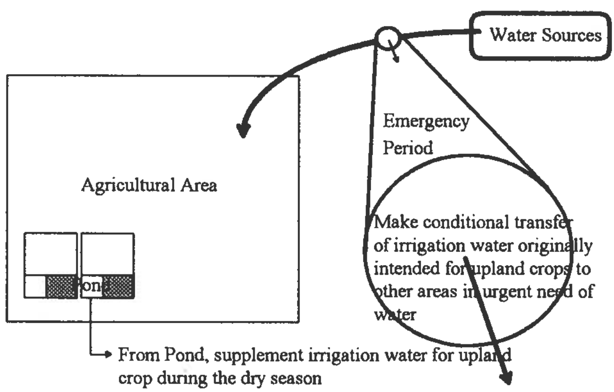


Figure 6 Illustrative Drawing of Field Sustained Utilization Supporting Water Need of Other Areas During the Dry Season

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