# Applying Warping for Improving Land Subsidence and On Farm Water Supply-A Case Study for Choshui

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## abstract

Due to groundwater over withdraw for satisfying the water demand of agriculture and fisheries that results imbalance of groundwater level and land subsidence in Yunlin city, south-central Taiwan. To improve land subsidence problems and to meet the needs of local vegetable farm irrigation water demand for sustainable use of agricultural land, the most importance is to reduce the agriculture and fisheries groundwater withdrawal that current status of water imbalance and the use of Choshui turbid water to improve the fallow paddy fields cultivation capability.This research proposes a conceptual system that storing turbid water into 30 cm high ridge fallow paddy field, called water cultivation, for sediment and recycle for irrigation.In order to build the model, the hydrometer test in the laboratory will be carried out to discuss the sediment concentration of Choshui turbid water at different flow rates and settling velocity distribution of suspended solids that the ratio of water and soil could be determined. Water and sediment will be separated due to gravity, the upper water will flow to the nearby vegetable field to satisfy its irrigation requirement instead of pumping water.In view of this, the current local multiplicity of the environment, policies, people's livelihood, one can take full advantage of fallow fields and in line with national policy that withdrawal groundwater is prohibited under the premise of solving the farmers irrigation water problems and improve the fallow fields cultivation capability, and indirect benefits groundwater that soil and resources to be used sustainably and efficiently.

*Keywords:*Warping Works, Ground Water Withdrawal, Water Logging Paddy Field

## 1.Introduction

Yunlin city, Taiwan has been facing aquifer water unbalance that is agriculture, fisheries of long-term groundwater pumping currently. Assessing pumping amounts and groundwater fluxes was indeed an essential support regional water resources toward good management, especially the Cho-Shui Alluvial Fan area, where rainfall is seasonal uneven extremely. Results indicate1995 has been accumulated pumping volume about 155.4 million cubic meter, the rainfall-recharge was 81.3 million cubic meter, and the constant head inflow was 18 million cubic meter[6].According to Leu - focuses on the relationship between different layers of groundwater levels and utilize spatiotemporal related interpolate value of settlement of each groundwater station to conclude the critical groundwater station and the critical changes of water level in an aquifer[15]. Stations close to the coast of Holung Chi and Taan Chi also exhibited a rapid rising trend of salinization and exceed the upper limit for irrigation criteria in recent years. Among six major rivers of Taiwan, only Tachia river and Choshui river to retain the suitability for the purpose of irrigation. In short, better water qualities for these six rivers are associated with high water flow stages of summer seasons and the low water periods are found in the low flow stages of late spring seasons[7]. As compared between field measurement data and simulation results to three models. Three models have indicated that the trend towards simulation results of the land subsidence corresponds to the filed measurement of land subsidence[14]. Because the unbalance of groundwater for aquifer water caused land subsidence. Taiwan region a

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total area of 2,403 square kilometers of land subsidence, which Yunlin region 880 square kilometers was the most widely largest cumulative amount of the maximum subsidence depth of 2.02 m by water and Statistics Bulletin in 2000[17]. In 2010, the maximum cumulative total subsidence depth increased dramatically to 2.43 m. The subsidence rate was 7.3 cm in 2009[18]. Yunlin region have been subsiding for 2000 to 2010 year.

The agriculture was the main part of Taiwan economy from the Dynasty Ming to Ching. It was the main pusher to change Taiwan history style and features, too. There were two foundation stones to lay the basis of agricultural development. They were the land reclamation and the water exploitation. Especially, the water conservancy was the lifeblood of agriculture. That could raise the great value of land and make the engagement on the perpetual agriculture management. Tao Kuan, water exploitationgot into the deserted villages step by step. Especially in the time of Kuan Hsu, they not only entered the east Taiwan, but also used the surplus water or the end water to open up a lot of small ponds[9]. Water for agriculture development is the most important factor. The use of storage to obtain water from ponds is one of these methods in Taiwan's agricultural. Yunlin region cultivable fallow area from 42% in 2002 year increased to 52% in 2009 year by AGRICULTURAL STATISTICS YEARBOOK in 2002 and 2009 year[19]. We use closed well to the purpose of prohibiting extraction of groundwater, land subsidence, but the problem still not resolved.

In Taiwan, steep erosional gradients, short transport distances, and short storage times have significantly increased the intensity of physical weathering. The sediments present only a moderate chemical weathering on the basis of major and trace element geochemistry[11]. Drainage area:2989km; Runoff : 1.2m/yr; Suspended sediment discharge: 54.1 Mt/yr[11]. In this article which a mathematical model for low-concentration sediment-laden flow was suggested based on the two-phase flow theory, and a solving scheme for the mathematical model in curvilinear grids was worked out. The observed data in the Zhang River in China was used for the verification of the model, and the calculated results of the water level, velocity and river bed deformation are in agreement with the observed ones[12]. Suspended solids entrained by the Choshui precipitation in the lower reaches of the formation of slate alluvial soils will affect crop production in Yunlin[13]. LIU know that low-flow and sediment entrainment is proportional to the relationship [12]. We know Yunlin region is alluvial plain, the river water will be entrained a lot of suspended solids to the Choshui Alluvial Plain. Farmers used to obtain water from Choshui River to irrigated vegetable fields, but sometimes turbidity high then farmers will not be used to irrigate vegetable fields.

This shows that the HCO3(superscript -) content in the soil solution of some of the soils in this experiment did reach the level to retard potassium uptake. The phosphorus content in the rice plant was also found negatively correlated with the pH values of the soil solution. Phosphorus absorption was retarded in some of the soils with higher pH values in this experiment. It is due to the fact that when pH values is above 7, the excess calcium may further hinder phosphorus absorption and utilization. In conclusion, the low yield of some slate alluvial soils in central Taiwan may be caused by the abnormally high concentrations of HCO3(superscript -), Ca(superscript 2+), and Mg(superscript 2+) produced during the course of rice growth[13]. Overdraft of groundwater in the Choshuichi Alluvial Fan has been the major mechanism for a negative impact of land subsidence. The elevation changes in the subsidence area are primarily affected by two factors: the current groundwater level variations and a long

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term trend caused by the past excessive extraction in aquifers. The two factors can be separated and estimated by a linear relationship and temporal functions. In addition, the correlation coefficient between the synthetic and observed elevation changes can be served as an effective and quantitative indicator in differentiating the normal and/or subsidence area and weighting factor for various aquifers[1]. The causes of land subsidence can be multiple and complex; consolidation of thick mud layer is the most important factor among them. However, extensive and costly observations are needed to obtain data for quantitative confirmation of consolidation in thick mud layers[1]. In this study, we examine the correlation between the land subsidence (deduced from GPS data) and the groundwater level variations of monitoring wells in the period between 1994 and 2006. Our aim is to quantitatively describe the relationship between vertical displacement on surface and groundwater level variation in identifying the distinctive effects among aquifers and derive the long-term trend for the land subsidence area. The behavior of aquifers is vital to the understanding of land subsidence process[1]. Choshui River ,excessive floods or suspended matter siltation then blocking water intake will cause diversion function imbalance. Without water problem will result in People's livelihood use water difficulties[2]. We discussed the groundwater characteristics of the apex of the Zhuoshui river Alluvial Fan. We found that there is two to three months of response delay between the river water level and groundwater level in the studied area and there is a prominent period of one year analyzed from the data[3].The time-varying soil moisture content in the study watershed was analyzed based on a current precipitation index (CPI). An exponential function was selected to describe the relationship between the CPI and the partial contributing area (PCA) during storm events[4]. The Changhua coastal area is located on the north Jhuoshuei River alluvial plain. The velocities of land subsidence during 2001, 2002, 2003 respectively were 17.6 cm/yr, 11.7 cm/yr and 10.4 cm/yr, based on the studies of the Ministry of Economic Affairs. Realizing this dire problem, we need to study the land subsidence in this area in order to prevent or mitigate the possible impact on local infrastructure. The achievement demonstrated that the Changhua coastal area has been still the serious land subsidence area. VR02 is the most serious land subsidence point which the displacement is nearly 80mm per year. The displacement of 1(superscript st) order benchmarks were nearly 17~56mm per year during the monitoring period[5]. We use fallow fields to storage Choshui River turbid water.On one hand, groundwater recharge using storage. On the other hand, use of natural sedimentation method take the upper water to irrigate vegetable fields.

## 2. Paddy Water Balance model

In this case the fields consist of independent plots, each plot being constructed with an independent irrigation inlet and drainage outlet. Thus, paddy field layouts are broadly classified as plot-to-plot and independent layouts. The primary objective of layout improvement is to control the field water balance condition in order to obtain optimal conditions for increasing productivity such as soil-water regime suitable for plant growth and yield, soil moisture allowing trafficability, higher water use efficiency and low harmful effects on the environment (e.g. waterlogging, salinity, pollution and soil erosion). In Japan, Korea and a few other countries, the recent trend of land readjustments are made in connection with mechanization in order to minimize the labor requirement for rice cultivation[16]. The water balance components considered in the model are shown in Fig. 2-1. The inflow to the field consists of the total water supplied through rainfall and irrigation, and the outflow consists of water leaving the field through evapotranspiration, seepage, percolation, and surface runoff. The field storage was assumed to be adequately represented by the ponded surface water since, in a properly irrigated paddy field, the plow layer exists under saturated condition and the soil moisture is constant during most of the crop growth period.A generalized water balance equation for a single paddy plot can be expressed as follows(Fig.1-1)

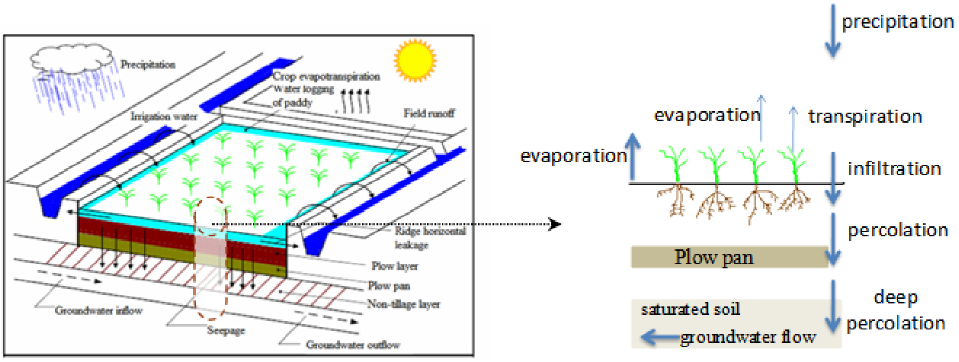


Fig. 2-1 Water balance of water logging paddy field

Important source of groundwater recharge areas are often irrigated irrigation water. Paddy's field water consumption, in addition to some of the crop evapotranspiration, about half of the Deep Percolation, this Deep Percolation for the Basin Recharge of groundwater recharge. we can use large quantities of irrigation water into paddy fields to promote groundwater recharge. Fallow land or in non-irrigated period, if any excess water, we should still continue to irrigate paddy field or dry land, in order to artificially recharge groundwater.

When in the fields of suspended solids sediment accumulated over time, farmers will be fully tillage once. This time Plow pan (7 ~ 25cm in depth under the surface) will be local damage. we use turbid water of Zhoushui River conduit diversion into the paddy fields. Implementation of water allocation strategies in the paddy fields. This strategy is 40 times the original leakage direct subsidies to groundwater. And consider the resumption of farming land in the impoundment of the function. The results showed that infiltration rate is 0.33 times the background value. After fully tillage once the field that can be quickly restored paddy fields of the impoundment features[17]. The components vary with climate, scale, and local/ regional geologic/ hydrogeo- -logic conditions. For the sake of reference, on a global annual basis, evaporation and evapotranspiration is 58% of precipitation, streamflow is 40% (direct runoff is 28% and baseflow 12%), and deep percolation is 2% by World Water Balance.

Return to the ocean through deep percolation is totally independent of the surface waters; therefore, it may be a potential candidate for capture by groundwater systems. Thus, on a global annual basis, up to 2% of precipitation may be potentially tapped by groundwater systems with minimum encroachment on established [surface water] rights. In practice, specific values of deep percolation would have to be established on a local, subregional, or regional basis. For groundwater basins lying in close proximity to the ocean, the capture of all or fractions of deep percolation should be examined carefully because of the possibility of salt-water intrusion.

## 3. Model Application

The first introduces the background information Huwei Township, Yunlin County. The second experimental method described is to use hydrometer test estimates the turbid water of the Zhoushui River conduit. Inside the flask(Units sedimentation height) and (water) ratio. Application of warping method in Fallow fields as (Water field), to achieve (land re-use) and (promote fertility) features.Other hand, we use surface water irrigate vegetable fields, to achieve low-cost irrigation purposes.

Further exploration, we use (Water field) method of access to clean water.Using the optimal operation of the various ancillary scenarios to achieve the maximum (water capacity) utilization.

### *3.1 Description of the study area*

The YunLin basin is located in the western part of central Taiwan, as depicted in Fig. 3-1 The Cho-Shui River and Pei-Kong River are the two major rivers flowing through the basin. The basin extends 48 km from east to west and 24 km from north to south and has a total area of approximately 1000 km2. Rainfall is concentrated in the wet season from May to October while the dry season is between November and April. The annual average rainfall and temperature are 1416.8 mm and 22.6 °C, respectively.

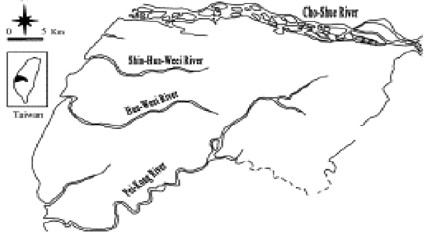


Fig. 3-1 Yun-Lin basin

### *3.2 Flow and Sand content data analysis*

We used CHI-CHOU 2000~2009 year (Table 3-2-1) of water flow, Sand content, Sediment discharge data, obtained scatter plot. By the scatter plot (Fig. 3-2-1) Flow and Sand content to see the distribution pattern, with physical exponential function relationships. During the period from 2000~ 2009 year, the average sand content of about 7500ppm, in addition to the highnumeric sand content in 2001 (23000ppm), 2002 year sand content is low (850ppm).

Table 3-2-1 CHICHOU,CHANGHUA (ex:2009 year)

| Date | Flow | Sand content | Sediment discharge |
|---|---|---|---|
| 2009/1/20 | 6.4 | 242 | 133.75 |
| 2009/2/9 | 5 | 141 | 60.86 |
| 2009/3/2 | 5.06 | 355 | 155.26 |
| 2009/3/9 | 43.56 | 1170 | 4403.6 |
| 2009/3/19 | 7.33 | 891 | 564.05 |
| 2009/4/8 | 6.97 | 185 | 111.46 |
| 2009/4/20 | 15.24 | 132 | 173.81 |
| 2009/4/23 | 171.06 | 1280 | 18918.2 |
| 2009/5/11 | 11.93 | 198 | 204.16 |
| 2009/5/21 | 4.26 | 226 | 83.24 |
| 2009/6/12 | 5.91 | 239 | 121.94 |
| 2009/6/19 | 59.73 | 484 | 2497.6 |
| 2009/6/30 | 30.86 | 224 | 597.23 |
| 2009/7/10 | 16.07 | 123 | 170.8 |
| 2009/7/29 | 30.16 | 373 | 971.88 |
| 2009/8/4 | 60.57 | 1760 | 9210.06 |
| 2009/8/8 | 4130.94 | 41600 | 14847604.16 |
| 2009/8/10 | 2789.91 | 55600 | 13402257.24 |
| 2009/8/14 | 726.56 | 18700 | 1173894.92 |
| 2009/8/21 | 375.29 | 13300 | 431252.1 |
| 2009/9/4 | 98.9 | 4430 | 37853.79 |
| 2009/9/14 | 38.33 | 1920 | 6357.99 |
| 2009/9/25 | 13.92 | 423 | 508.55 |
| 2009/10/16 | 55.48 | 4290 | 20564.37 |
| 2009/10/26 | 22.38 | 1330 | 2571.39 |
| 2009/11/9 | 11.22 | 365 | 353.71 |
| 2009/11/27 | 8.72 | 1580 | 1189.84 |
| 2009/12/10 | 5.52 | 157 | 74.89 |
| 2009/12/25 | 16.02 | 3020 | 4180.33 |

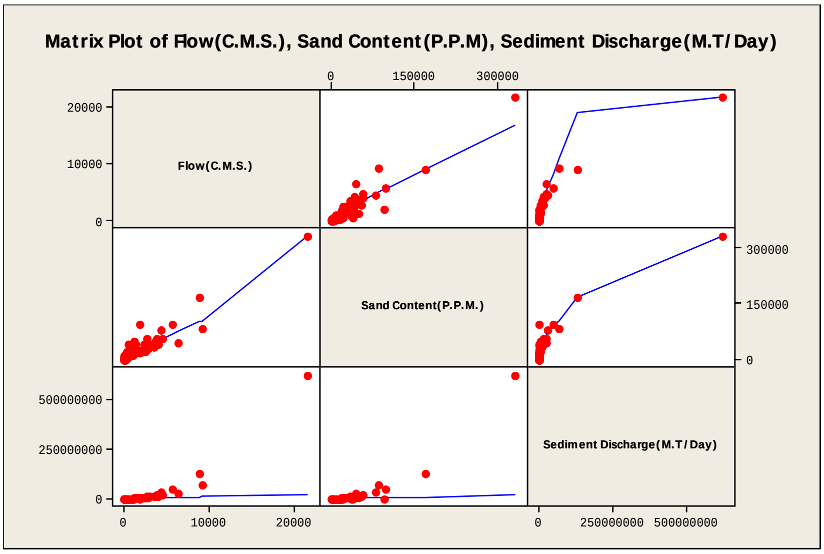


Fig. 3-2-1 Flow,Sand Content,Sediment Discharge scattergraph

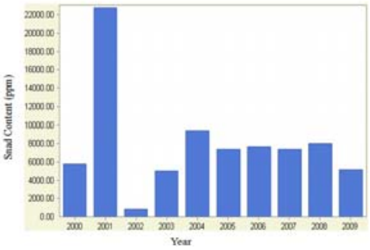


Fig. 3-2-2 Sand Content, year histogram

Fig. 3-2-3 Experimental paddy field and data Station

*3.3 Estimation of irrigation water consumption- crop irrigation during the each irrigation water consumption*

The vegetable crops (Bok Coy) using Open type and facility cultivation can be grown throughout the year. Growth number of days 30 to 45 days.The definition of growth days for 30 days. According to Agricultural Engineering Research Center (2002) of the Yunlin Irrigation common cultivated(crop irrigation during the each irrigation water consumption) of information. Planted cabbage spring and fall crop water requirement is estimated at Bok Coy water demand. The initial period from 1 to 2 days, irrigation 8~15mm;Peak period from 2 to 3 days, irrigation 15~20mm;Late period from 3 to 5 days, irrigation 20~25mm.

*3.4 Specific Gravity test*

Identified by the ASTM hydrometer analysis of the scope is the size of particles smaller than 0.075mm in diameter, so in this study used the screen to # 200 (0.074 mm) , and its stepsSummarized as follows:

(1) Take 40g of water multiplied by the factor (MF) of dry soil, add 100ml of distilled water and 50ml of 5% of the partial sodium, and dispersed by ultrasonic disperser for

10 minutes, if the texture of the soil recommendations smaller dispersion than 15 minutes.

(2) to prepare an aqueous solution of the control group and thus to practice (hydrometer) placement and reading. And measure (graduated cylinder) (1000ml) of the cross- sectional area (section A '). Fig. 3-4-1 shows the actual operation.

Fig. 3-4-1 CNS 11776 specific gravity test step

### *3.5 Hydrological balance (water logging paddy field) depth of highly derived*

### *3.5.1Basic assumptions：*

$H_1$ ： turbid water height
$H_2$ ：water height
$ER$ ：effective rainfall
$ET$ ：evaporation and evapotranspiration
$F$ ：infiltration
$D$ ：high ridge
$T$ ：rainfall delay
$F$ ：total infiltration
$f$ ：Any time ( $t$ ) of the infiltration rate
$f_0$ ： initial infiltration rate
$f_c$ ：final infiltration rate

$A_1$ ：Inflow fallow fields (trapezoidal opening sectional area)；$T_1$ ：upper bottom；$T_2$ ：lower bottom；$h_1$ ：high; $S_1$ ：sediment high; $\eta$ ：crop coefficient; $PET$ ：potential evapotranspiration; $PET = K \cdot F$ ; $F = t \cdot \sum p\%$ ; $K$ ： evapotranspiration correction factor

$t$ ：outflow times

$$f = f_0 + \left(f_0 - f_c\right)e^{-kt}$$

$$F = \int_0^T f dt = \int_0^T f_0 dt + \int_0^T \left(f_0 - f_c\right)e^{-kt} dt$$

$$F = f_0 T + \frac{\left(f_0 - f_c\right)}{k} e^{-kT}$$

$$H_1 = \frac{Qt}{A}$$

$$H_1 + ER - ET - F = H_2 + \Delta S$$

when $ER < D$ 或 $ER > D$ then

$$H_1 + ER \le D$$

### *3.5.2 Flow determined by the energy equation:*

$$gz = \frac{u^2}{2}$$

$$u = \sqrt{2gz}$$

Flow volume need consider about water surface $dz$ per unit time $dt$ changes:

$$uA_1 dt = -(L_1 \cdot L_2)dz$$

$$A_1 = (T_1 + T_2) \cdot h_1 / 2$$

Or $A_1$ ：pumping tube cross-sectional area

$$dt = -\frac{(L_1 \cdot L_2)}{A_1 \cdot \sqrt{2gz}} dz$$

$$t = \int_{z-s_1}^{z} \frac{L_1 \cdot L_2}{A_1 \cdot \sqrt{2gz}} dz$$

$$\eta \cdot V_{\text{vegetable field and irrigation water}} = PET - \sum R$$

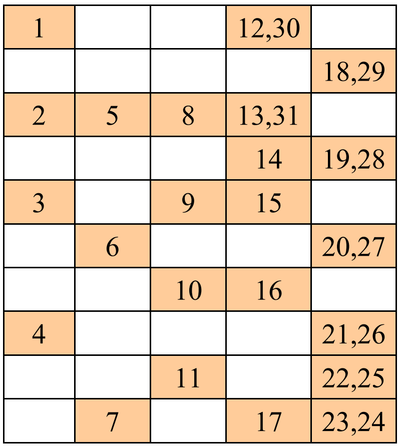
$$= K \cdot F - (\sum r_1 + \sum r_2)$$

$$h_{\text{vegetable field and irrigation water high}} = \frac{V_{\text{vegetable field and irrigation water}}}{A_{\text{vegetable field area}}}$$

$$3600 \cdot \int_{z-s_1}^{z} \frac{L_1 \cdot L_2}{A_1 \cdot \sqrt{2gz}} dz \cdot Q_{\text{inflow of field}} = A_{\text{vegetable field area}} \cdot h_{\text{vegetable field and irrigation water high}}$$

### *3.6 Fallow field test site configuration*

A fallow field in each area marked with a number of red flags.Pumping of dirty water, according to label and date, turns into the fallow fields.For example, February 1 water storage in the (No. 1 fallow fields). February 2 water storage in the (No. 2 fallow fields) as shown in Figure 3-6-1. For 24 hours after the extraction of surface water to irrigate crops.Diagram shown in Figure 3-6-2. This is the warping of its primary mechanism for the improvement of solid and liquid separation.



| | | | | |
|---|---|---|---|---|
| 1 | | | 12,30 | |
| | | | | 18,29 |
| 2 | 5 | 8 | 13,31 | |
| | | | 14 | 19,28 |
| 3 | | 9 | 15 | |
| | 6 | | | 20,27 |
| | | 10 | 16 | |
| 4 | | | | 21,26 |
| | | 11 | | 22,25 |
| | 7 | | 17 | 23,24 |

Fig. 3-6-1 50ha is expressed as one rotational irrigation, a grid of 1ha each field zone (dark grid for the (Species of paddy field), sequentially numbered, numbered to 31 said 31 days; white squares for the vegetable fields)

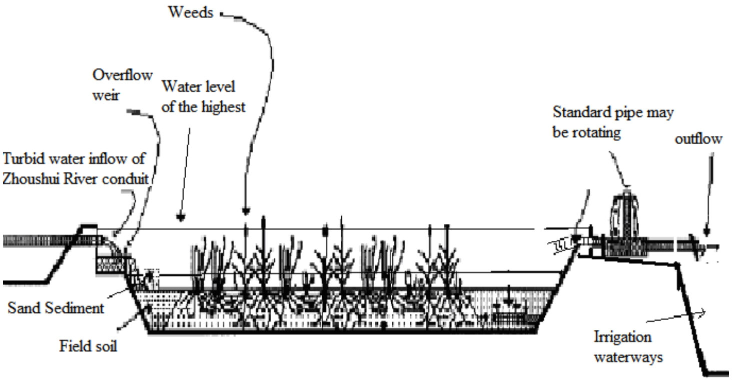


Fig. 3-6-2 warping the surface flow model modified profile

## *3.7 Optimal of the paddy field operations measures*

Basic assumptions：

$L_1$ :fallow field length(m), $L_2$ :fallow field width(m), $L_1 \cdot L_2 = A_1$ : fallow field area (m$^2$), $H$ :ridge height (m), $H_1$ :24 hours after the sediment Sediment height, $A \cdot H_1$ :storage turbid water volume, $A_1H - A_1H_1$ : 24 hours after storage turbid water volume.

$L_3$ : vegetable field length(m), $L_4$ : vegetable field width (m), $L_3 \cdot L_4 = A_2$ : vegetable field area(m$^2$), $D_{w1}$ : the initial water demand for vegetable field (mm), $D_{w2}$ : peak water demand for vegetable field (mm), $D_{w3}$ : later period water demand for vegetable field (mm).

Assumptions:

When standing 24 hours later, when the water depth 38cm (1000c.c.), can be pumped30cm depth (800c.c.), can be regarded as not disturb the bottom sediment.When standing for 30 minutes, 1, 12, 24 hours later, we can pump the water depth was 5cm, 9cm, 20cm, 30cm.

We assume that (eraly, peak, late period) of irrigation demand water growing vegetables (we use the median value to calculate), $D_{w1}$ = 12 (mm): early period vegetable irrigation demand, $D_{w2}$ = 18 (mm): peak period vegetable irrigation demand, $D_{w3}$ = 23 (mm): late period irrigation vegetables demand. By mass conservation law. we have to balance water supply and water demand is based. Estimating following formula:

$$P + I - O - E + R_g - R_f = \Delta S$$

Assumptions:

Where P is precipitation is constant (to simplify the model, not to consider); I (upper field ) inflow constant (due to continuous inflow fills the water, so the con stant ); O for the (down field) outflow (as vegetable field and water demand); E is the evaporation per unit time (for the simplified model, not to consider); is (from the field at the bottom) of groundwater inflow (To simplify the model, not to consider); to (the field at the bottom), theSeepage volume (for the simplified model, not to consider); ΔS is change in the amount of water per unit time (for the simplified model, storage capacity does not change).

1. When $A_2$ is constant, the estimated $A_1$:

early period: $A_1H - A_1H_1 = D_{w1} \cdot A_2$, $A_1(H - H_1) = D_{w1} \cdot A_2$, $A_1 = \frac{D_{w1} \cdot A_2}{H - H_1}$.

peak period: $A_1H - A_1H_1 = D_{w2} \cdot A_2$, $A_1(H - H_1) = D_{w2} \cdot A_2$, $A_1 = \frac{D_{w2} \cdot A_2}{H - H_1}$.

later period: $A_1H - A_1H_1 = D_{w3} \cdot A_2$, $A_1(H - H_1) = D_{w3} \cdot A_2$, $A_1 = \frac{D_{w3} \cdot A_2}{H - H_1}$.

2.When the $A_1$ set constant, according to the type anti-push, estimated $A_2$:

early period: $A_1H - A_1H_1 = D_{w1} \cdot A_2$, $A_1(H - H_1) = D_{w1} \cdot A_2$, $A_2 = \frac{A_1 \cdot (H - H_1)}{D_{w1}}$.

peak period: $A_1H - A_1H_1 = D_{w2} \cdot A_2$, $A_1(H - H_1) = D_{w2} \cdot A_2$, $A_2 = \frac{A_1 \cdot (H - H_1)}{D_{w2}}$.

later period: $A_1H - A_1H_1 = D_{w3} \cdot A_2$, $A_1(H - H_1) = D_{w3} \cdot A_2$, $A_2 = \frac{A_1 \cdot (H - H_1)}{D_{w3}}$.

## 4. Results and discussion

### *4.1 Estimating the sand content*

Zhoushui River conduit flow by month minus monthly varying degrees of sand content. The remaining amount of water is fresh water. Used to supply irrigation to meet the vegetable fields (50ha for the 1 unit rotational irrigation) monthly crops (cabbage) water demand.

| station name | CHI-CHOU Brigde station (2000~2009) | |
|---|---|---|
| N(data number) | 143 | 110 |
| period | Dry period | Wet period |
| POWER Regression Formula | $Y=3.985X^{0.806}$ | $Y=3.251X^{0.918}$ |
| Adjusted R Square | 0.607 | 0.837 |

Y:sand content ,X:flow

### *4.2 water logging paddy field depth height*

Test results such as (Fig. 3-4-2 specific gravity test) the effective depth curve that Maximum cylinder depth 18cm.Reached maximum at 24hr after the effective depth of precipitation quantities 16.0598cm.Upper layer of water volume is about 600c.c..4hr after the effective depth of 15.6982 cm. Did not reach maximum sediment volume. There are 6.21% suspended matter (diameter 0.002994485mm) in slightly turbid water, (Fig. 3-4-3 size distribution curve).

Because of slightly turbid water rich in trace elements and organic matter, suitable for irrigation of plants, so consider using the upper slightly dirty water about 650c.c.

Fig. 3-4-2 the effective depth curve of specific gravity test)

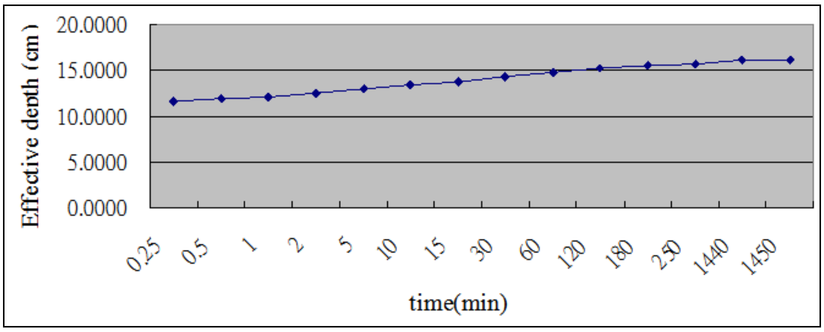
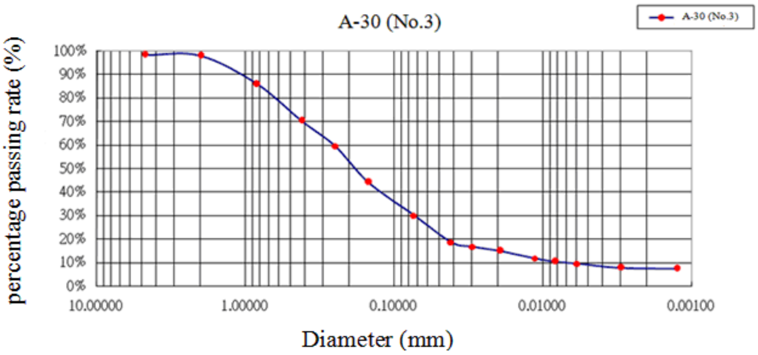


Fig. 3-4-3 size distribution curve



*4.3 Estimation of crop water demand scenarios*

By calculating the proportion of fallow land and (bok choy) early, peak, late water demand, we can estimate the required area of water logging paddy field.By calculating the proportion of fallow land and (bok choy) early, peak, late water demand, we can estimate the required area of paddy fields.Example One, if the ridge up to 80 cm depth, ie the early peak, the late water logging paddy field: vegetable fields= 1:80,1:43,1:32, as shown in Table 4-3-1.Example two, if the ridge up to 30 cm depth, ie the early peak, the late water logging paddy field: vegetable fields= 1:30; 1：16; 1:12, as shown in Table 4-3-2.

Table 4-3-1 1 ha of paddy field (design water depth of 80 cm) of about 8000 cubic meters of turbid volume, standing at different times. Irrigate the area of Bok choy.

| Water logging at different times | | 30min | 1hr | 12hr | 24hr |
|---|---|---|---|---|---|
| Irrigation area of bok choy (ha) | early period | 3 | 10 | 50 | 80 |
| | peak period | 1.6 | 5.33 | 26.67 | 42.67 |
| | late period | 1.2 | 4 | 20 | 32 |

Table 4-3-2 1 ha of paddy field (design water depth of 30 cm) of about 3000 cubic meters of turbid volume, standing at different times. Irrigate the area of Bok choy.

| Water logging at different times | | 30min | 1hr | 12hr | 24hr |
|---|---|---|---|---|---|
| Irrigation area of bok choy (ha) | early period | 1.125 | 3.75 | 18.75 | 30 |
| | peak period | 0.6 | 2.00 | 10.00 | 16.00 |
| | late period | 0.45 | 1.5 | 7.5 | 12 |

Table 4-3-1 shows the initial, peak, late species were 1ha paddy field can take care of 80ha, 42.67ha, 32ha vegetable fields. Particularly in the irrigated bok choy (late), the extreme demand for water.1ha 32ha of paddy field can only take care of the early vegetable fields about 2 / 5 Scale.Design considerations must be noted.

For example:

Situational one: A rotational irrigation area is 50ha. Design 1ha of the water logging paddy field in the early bok choy water demand is small, only the day before in the water and standing water is completed after 24hr.We intercept the upper water, and then can fully watered (about 80ha) of bok choy field.

Situational two:A rotational irrigation area is 50ha. We need to design 1.1718ha (about 1.2ha) of the water logging paddy field (0.1ha farm area can take care of 4.267ha bok choy field).In peak time, bok choy water demand is large. Only one day before the irrigation water has been completed and put it aside after 24hr.We intercept the upper water, and then can fully watered (about 50ha) of bok choy field.

Situational three:A rotational irrigation area is 50ha. We need to design 1.5625ha (about 1.6ha) of the water logging paddy field (0.1ha farm area can take care of 3.2ha bok choy field.)In late time, bok choy water demand is large. Only one day before the irrigation water has been completed and put it aside after 24hr.We intercept the upper water, and then can fully watered (about 50ha) of bok choy field.

Yunlin County farmland / fallow area ratio, we know that (fallow area) accounted for 52% of Yunlin County, so the estimate in (50ha area) in the area of fallow fields area of 26ha, 24ha for the farmland area.According to the above estimated results. We can according to different rotational irrigation region to design different types of paddy field area.

Situational four:A rotational irrigation area is 50ha. We need to design 0.75ha (about 0.8ha) of the water logging paddy field (0.1ha farm area can take care of 3.2ha bok choy field.)In peak time, bok choy water demand is large. Only one day before the irrigation water has been completed and put it aside after 24hr.We intercept the upper water, and then can fully watered (about 24ha) of bok choy field.

### *4.4 Estimate the cost of electricity savings*

The farmers each year (original using a pump groundwater pumping) electricity costs and maintenance of water pumps a total cost of $ 8760NTD in Yunlin County. We can immediately help farmers save money each year $ 6320NT. As shown in Table 4-4-1. This study used a pump horsepower: 1HP (power 750W), the water Diameter: 4 ", Voltage: 110V/220V.60HZ, the highest lift: 9m, pumping capacity of 60 tons per hour, with a total weight of 20 kg.

Table 4-4-1 irrigated 50ha (bok choy field), water pumps 1HP, 1hr 64 tons can be pumped

| estimate the cost of water logging paddy field | | original using a pump groundwater pumping cost | |
|---|---|---|---|
| project | cost(NTD) | project | cost(NTD) |
| pump horsepower 1HP-2" 0104 model | $3500 | Dug wells with water pumps | $150,000 |
| Each share (water pumps) maintenance costs (service life 5 years) | $1000 | Each share (water pumps) maintenance costs (service life 5 years) | $3000 |
| Cost of electricity per year (about $ 4NTD to 1 day) | $1440 | Cost of electricity per year (about $ 16NTD to 1 day) | $5760 |
| Total annual payments (excluding water pumps) | $2440 | Total annual payments (excluding water pumps) | $8760 |

## 5.Conclusions and suggestions

1. Reached maximum at 24hr after the effective depth of precipitation quantities 16.1cm.Upper layer of water volume is about 600c.c..4hr after the effective depth of 15.7 cm. There are 6.2% suspended matter in slightly turbid water. We can suitable for irrigation of plants, so consider using the upper slightly dirty water about 650c.c.
2. The sand content of Zhoushui River conduit to the by CHI-CHOU Brigde station data ( 2000 ~ 2009 year ) of experience formula to estimate：the sand content =3.865*

(Flow)0.824.

3. Design 1ha of the water logging paddy field in the early bok choy water demand is small, only one day before set water logging paddy field measure and standing water is completed after 24hr. We intercept the upper water, and then can fully watered (about 80ha) of bok choy field.In peak time, bok choy water demand is large. We need to design about 1.2ha of the water logging paddy field (0.1ha farm area can take care of 4.267ha bok choy field). We intercept the upper water and then can fully watered (about 50ha) of bok choy field.In late time, bok choy water demand is large too.We need to design 1.5625ha (about 1.6ha) of the water logging paddy field (0.1ha farm area can take care of 3.2ha bok choy field).

4. The farmers original total cost of $ 8760NTD per year per water pump unit in Yunlin County.We can immediately help farmers save money each year $ 6320NT.

5. Planning for the current study to an irrigation area 50ha vegetable area.Continued research can consider the proposed multi-regional distribution of irrigation water, irrigation water distribution pipeline optimization time.Future researchers can explore the use of multi-objective planning approach.Will make the study (water logging paddy field concept) can be widely applied to various types of vegetable area.

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功能變數代碼變更

格式化: 超連結

格式化: 不加底線