Application of Irrigation Management Performance Assessment Model (IMPAM) to the Lower Seyhan Irrigation Project

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1. Introduction

This study is aiming to develop a water balance model (Irrigation Management Performance Model, IMPAM) as a tool for assessment of management performance of irrigation areas. Today, saving water is one of the most important concerns for irrigation areas in the world, and several trials to improve irrigation performance through modification of water management (both physical and operational sides) are being continued. However, an alternation of water management should cause change in water balance and often brings unintended side effects. For example, a modification of canal system to decrease seepage from the system should cause fall of groundwater level, and it may hit farmers who depend on groundwater (Roost, 2002). Hence it is important to predict change in water balance caused by a change of irrigation management. In addition, it should be meaningful to grasp the present water balance of an irrigated area to examine what problems are in the area and how they can be modified.

2. Development of IMPAM

2.1 Scope of IMPAM

For an assessment of water management, farm-block to irrigation district should be the best as a scope, since difference of water management should appear most significantly in water balance of this level. And IMPAM deals with water balance of this scale. Though there are several existing water balance models, their scopes may be too wide or too narrow to describe water balance changed by alternations of management. The former ones (PODIUM, SIMIS) simulate balance of demand and supply at regional to country level considering socio-economical factors as well as agriculture. As their scope may be too large and detailed hydrological processes are ignored, they may not be suited for assessment of irrigation managements. On the other hand, the latter ones (especially SWAP and HYDRUS) calculate one-dimensional water balance in a farm plot precisely considering physical aspects of soil water movement. Water balance of an irrigation district often depends more on physical characteristics of irrigation system, operation, cropping pattern, distribution of landuse pattern than water balance in farm plots. For example, water balances of irrigation districts in Ningxia Autonomous Region (Weining and Qingtongxia IDs) and Hetao ID (Inner-Mongolia Autonomous Region) in the Yellow Rover basin, China, are quite different (Figure 1 (a) and (b)). Such difference should be mainly due to differences in characteristics of these irrigation districts such as operation, physical structures, etc., which cannot be described by one-dimensional water balance models. In the scope of IMPAM, these important components of water balance of irrigated areas are included.

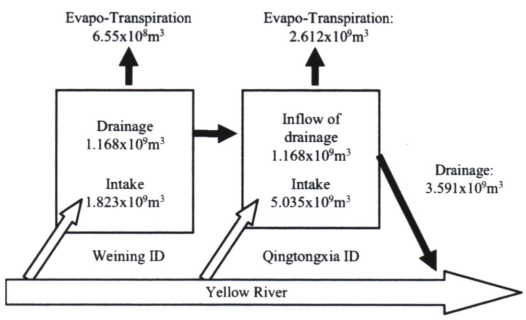

Figure 1 (a): Water balance of IDs in Ningxia

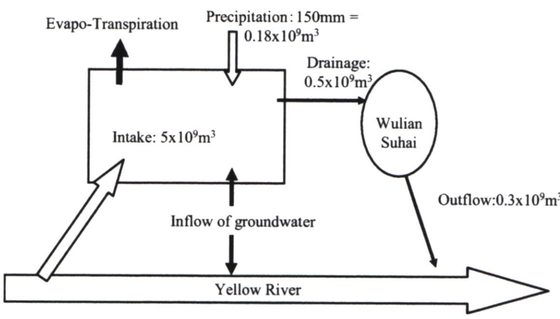

Figure 1 (b): Water balance of Hetao ID

2.2 Structure of IMPAM

For simulations of water balance, including the above-mentioned components, several kinds of datasets are required for IMPAM as indicated in Figure 2. And combining four modules (Water Distribution Module, Drainage Reuse Module, Spatial Water Balance Module, and Farm Water Balance Module) (Figure 3), IMPAM simulates complicated water dynamics in irrigated areas.

Functions of the four modules are as followings (A to D).

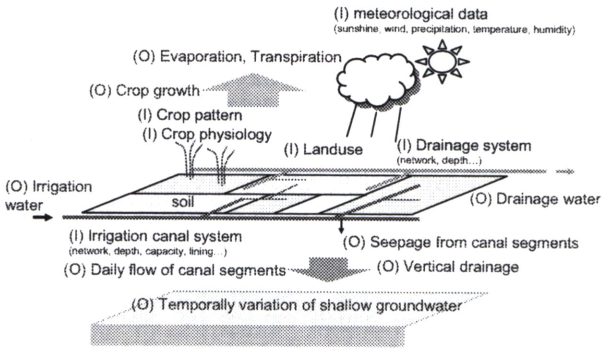

Figure 2: Input (I) and output (O) of IMPAM

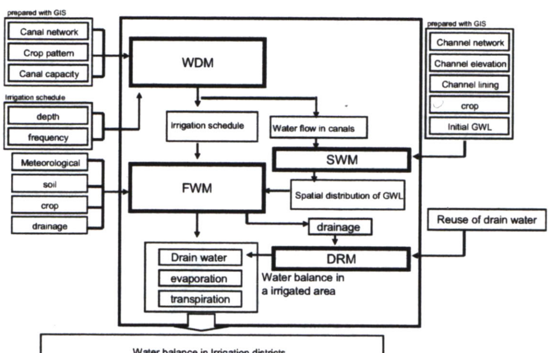

Figure 3: Framework of IMPAM

A. Water Distribution Module

WDM calculates daily discharge (m^3/sec.) of each irrigation canal segment, taking into account amount of seepage loss. Topological structure of irrigation canal network, capacity and loss rate of each canal segment, date and amount of irrigation for each farm plot, crop pattern, and dates of sowing and harvest are main input items of this module. Date and amount of irrigation is made based on reference tables prepared by local government, or can be calculated by the FWM. If the calculated daily discharge is not proper (for example, calculated discharge excesses canal capacity), canal daily discharge is calculated again after these irrigation schedules are adjusted.

B. Drain Reuse Module

DRM calculates total amount of drainage-water from an irrigated area. Drainage channel network, amount of drainage and amount of reuse of drainage-water of each plot are main input items of this module.

C. Farm Water balance Module

FWM calculates water balance of each plot (including bare or fallow) with data input such as irrigation schedule, meteorology, crop calendar, soil character parameters, etc. As this module, existing vertical one-dimensional water balance is used. In a test application mentioned below, SWAP (Soil Water Atmosphere Plant) was used. Other models also can be used as to required simulation precision and data availability.

D. Spatial Water balance Module

SWM calculate temporal and spatial variation of groundwater level. Meteorology, irrigation schedule, landuse-crop spatial distribution, irrigation-drainage channel spatial distribution database are main input items of this module. This module takes into account evapo- transpiration from land without crop (such as saline land) and seepage loss from irrigation canals as factors that affect water balance of irrigation areas. Spatial distribution of amount of seepage from canals is calculated based on canal daily discharge calculated by WDM. Temporary and spatial variation of groundwater level is used by FWM as a bottom boundary condition.

3. Result of test-run

A prototype of IMPAM was applied to Yongji Irrigation Area, Hetao Irrigation District, in the Yellow River basin, China, which consists of a main canal (Yongji Main Canal), six secondary canals, more than 700 tertiary canals, and about 1,300 km^2 of command area. Data for irrigation and drainage channel are based on an irrigation-drainage system map and Yongji Irrigation Area Management Office (2002). Landuse and crop pattern (sunflower, corn, wheat and fallow) were supposed as Figure 4 based on a field observation.

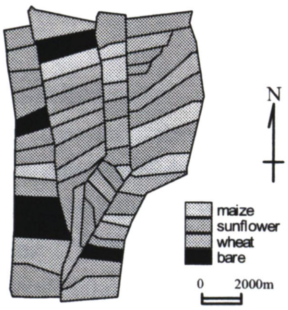

Figure 4: Supposed crop distribution

Figure 5 and 6 show results of this test-run, transpiration on 1st August and annual water balance in 1990 of a command area of Xile tertiary canal in Yongji Irrigation Area. As autumn irrigation that applied after harvest (September) for planting in the next year was not included in this test-run, deficit occurred at the end of the simulated period (Figure 6).

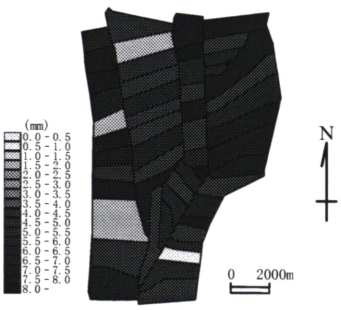

Figure 5: Transpiration at 1 August 1990

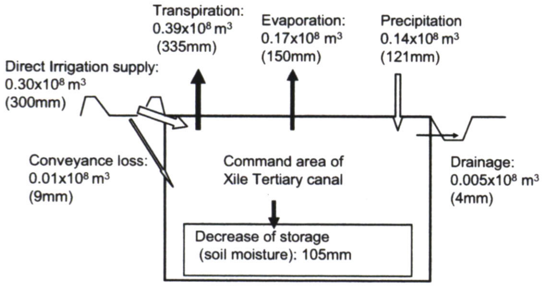

Figure 6: Water balance of Xile Tertiary canal

4. Application of IMPAM to LSP

Actual irrigated area of the Lower Seyhan Irrigation Project (LSP) (Figure 7) is about 133,000ha at a completion of construction stage III in 1987 (Donma, et al., 2004). Now we are planning to apply IMPAM to LSP and simulate water balances under some scenarios that may occur in the future. Since LSP is facing to some drastic changes, this simulation should provide important and useful information.

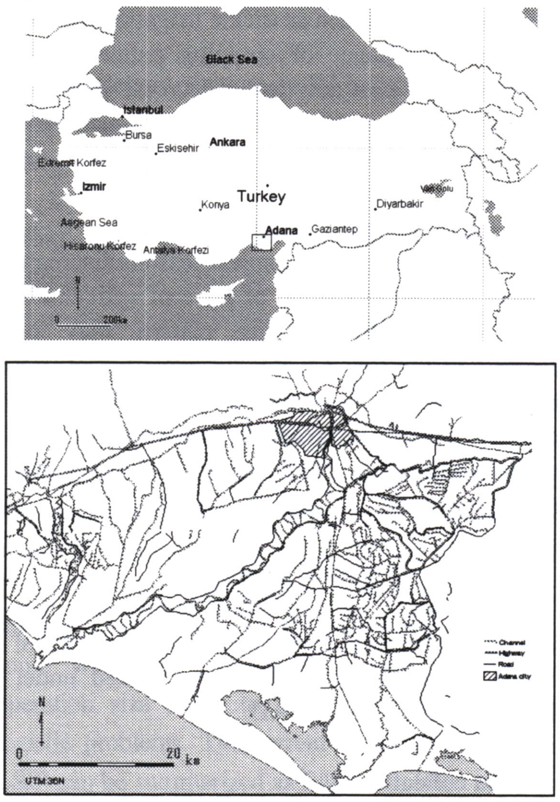

Figure 7: Lower Seyhan Irrigation Project

4.1 Scenarios to be assumed

Here, four scenarios (A to D) are suggested as examples. As simulations under these scenarios require special knowledge in several fields, it will be conducted cooperating with specialists of the fields in a framework of ICCAP.

A. Enlargement of irrigated area

This scenario will occur with fairly high probability. Construction stage IV of LSP is now being carried out, and some parts of irrigation canals have been already constructed. After completion of this stage, 40,657 ha of farmland in the lowest part of the project area will be newly irrigated (*loc. cit.*). Enlargement of irrigated area will definitely increase water demand. Farmers in the existing irrigated area are now allowed to use water abundantly however enlargement of irrigated area will force them to save water.

B. Adoption of water saving irrigation management

Another irrigation area that takes water from the Seyhan River may be constructed in the future. In this case, farmers will be forced to save water more strongly. In addition, adoption of new irrigation methods such as trickle irrigation that are adopted with change of cropping pattern or to decrease labor cost may bring decrease of water for irrigation. Under these scenarios, groundwater level may fall.

C. Change of cropping pattern

Because of socio-economical reasons (increase of labor cost and variation of price of agricultural products), present cropping pattern may be changed drastically. Change of crop brings not only change in evapo-transpiration in farmland, but also change in irrigation management. For example, citrus is often irrigated with trickle irrigation system.

D. Global warming

Global warming will affect hydrology, crop growth, salinity, and may cause socio-economical change. Water balance will be simulated under climate scenarios in 2070 AD.

4.2 Data collection

Datasets about irrigation/drainage system, meteorology, groundwater level, cropping pattern, soil character are necessary for accurate simulation. Fortunately, some data such as a detailed soil map (Figure 8), an irrigation / drainage system map have been already prepared as GIS datasets.

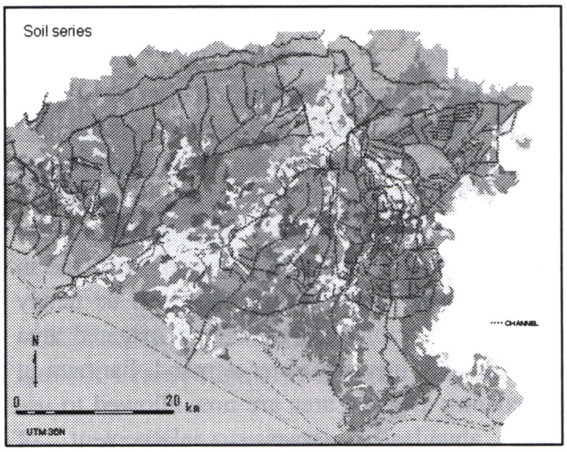

Figure 8: Soil series and canal system in LSP

Acknowledgement

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