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

Keisuke HOSHIKAWA[1], Takanori NAGANO[1], Sevgi DONMA[2] and Tsugihiro Watanabe[1]

[1] *Research Institute for Humanity and Nature (RIHN)*
335 Takashima-cho, Kamigyo-ku, Kyoto, 602-0878, Japan
[2]*6th Regional directorate of State Hydraulic Works, Adana, TURKEY*
e-mail: hoshi@chikyu.ac.jp

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. These factors cannot be included by one-dimensional water balance models. In the scope of IMPAM, these important components of water balance of irrigated areas are included.

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 1. And combining four modules (Water Distribution Module, Drainage Reuse Module, Spatial Water Balance Module, and Farm Water Balance Module) (Figure 2), IMPAM simulates complicated water dynamics in irrigated areas.

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

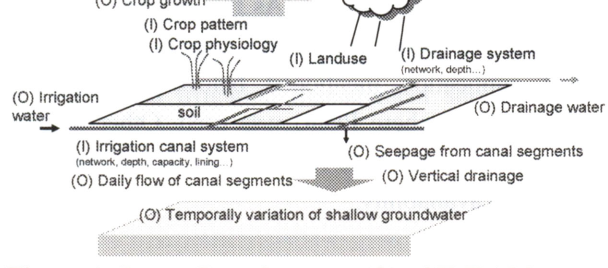


Figure 1: Input (I) and output (O) of IMPAM

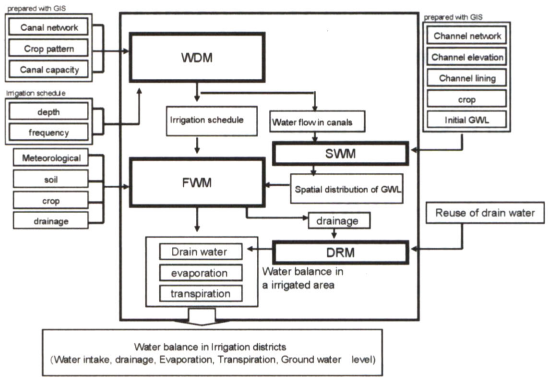


Figure 2: Framework of IMPAM

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. Application of IMPAM to LSP

Actual irrigated area of the Lower Seyhan Irrigation Project (LSP) (Figure 3) 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.

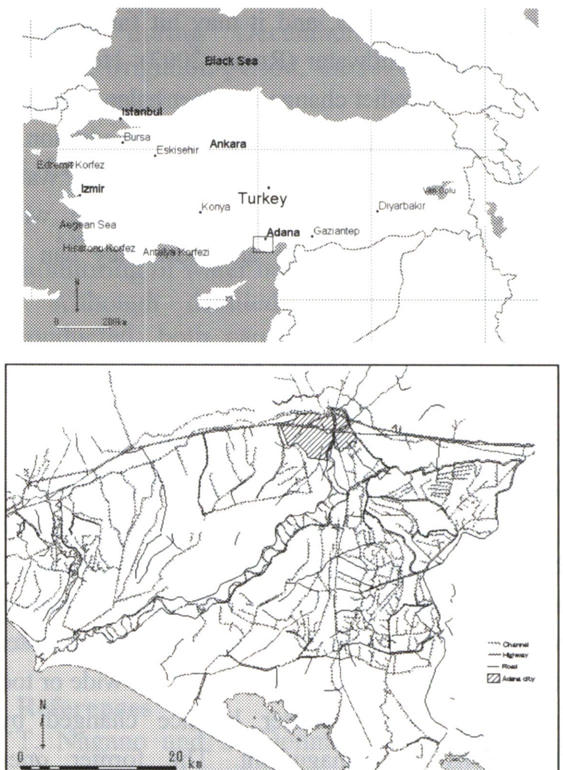


Figure 3: Lower Seyhan Irrigation Project

3.1 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. Climate data of 2070 (pseudo warming data) were prepared by Kimura (2005).

3.2 Simulation results in Gazi area, LSP

Gazi is a command area of YS7-1-1 (80.6ha in area) on the left bank of the Seyhan River. IMPAM ran with four climate and irrigation management data (Table 1) (Scenario B and D). Source of other data were listed in Table 2. Nagano et al. (2005) found that only 33% of intake water infiltrates is used for irrigation at farm and 66% should be lost in transmissions. In Run 1 to 3, leakage rate that estimated from the observed ratio of transmission loss (2.79m^3/m/day) was used, and the half (1.4 m^3/m/day) was given to Run 4 as a water saving scenario.

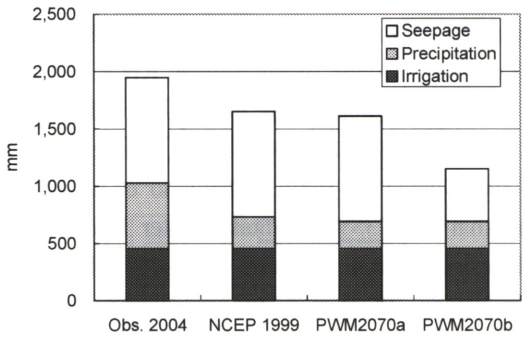
Table 1: Climate and irrigation management data used in the simulation in Gazi

	Run 1 (Obs. 2004)	Run 2 (NCEP 1999)	Run 3 (PWM 2070a)	Run 4 (PWM 2070b)
Climate	2004 observed	1999 NCEP/ NCAR	2070 Pseudo warming	2070 Pseudo warming
Manage ment	Observed	Observed	Observed	Assumed

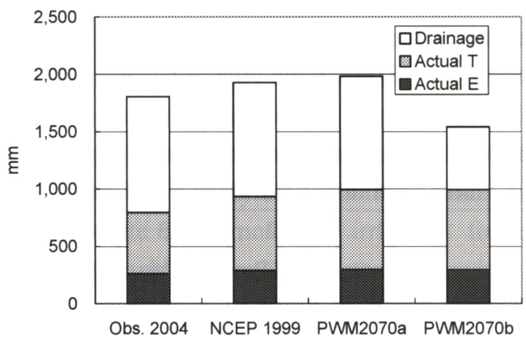
Table 2: Data source of the simulations

Data	source
Crop parameters	Van Dam et al. 1997
Soil parameters Layout drains	Cukurova University Estimated
Land use Crop pattern Irrigation scheme	Observed (Nagano et al., 2005)

Results of the four runs suggested that changes in climate should bring water balance change in agricultural areas (**Figure 4** and **5**). And in addition, it indicated that crop pattern (crop calendar and kind of crops) and irrigation management should also significantly affect it (**Figure 4** and **5**).



(a) Details of annual inflows



(b) Details of annual outflows

Figure 4: Water balances of the four simulations (average of the objective area) Differentials between the total inflow and total outflow resulted from changes in soil moisture and accumulation of errors in calculation.

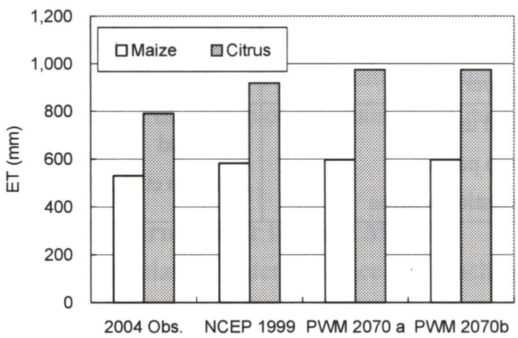


Figure 5: Simulated actual evapo-transpiration at citrus and maize fields (two sampling points)

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