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# "Decision Support System for Irrigation Canals"

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**Abstract**— A Decision Support System (DSS) for irrigation of canals involve compilation of all relevant information and software tools for analyzing the information to reach for optimum utilization of supplied water in the system of canal. It is intended to enable decision making by compiling relevant information on historical canal flows, physical and hydraulic features of the canal network, computer models for analyzing the requirements and supplies for maximizing the food production. In this paper an effort is made to develop a typical framework of Decision Support System (DSS) for managing operations of water distribution in a system of irrigation canal. The paper presents a structure of a decision support system for more efficient and effective management of water supplies, and more timely delivery of irrigation water to agricultural users. The DSS may be linked with the SCADA (Supervisory Control and Data Acquisition) system for real-time monitoring of flow details and water level information and operation of canal gates to manage water deliveries. The use of decision support systems linked with SCADA and automated structures presents a very effective method for irrigation water distribution, which may ultimately result into conservation of precious water.

**Index Terms**—DSS, Irrigation, Models, Water Allocation etc.

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## 1.INTRODUCTION

AN increasing number of irrigation canals are implementing their modernization to improve their hydraulic efficiency, reduce any pilferage of water and improve their operational efficiency. The Decision Support System (DSS) comprises an information management system that performs data collection, its verification, management, its visualization, and calculates estimated crop water demand and water allocation for different levels of water units. The DSS solves semi- or un-structured canal water distribution problems by integration of optimization methods, modelling of physical processes, geographical information systems (GISs), remote sensing (RS), expert systems (ESs), and other technologies as per the requirement of the situation. DSS may integrates GIS, relational database, software engineering, and visualizationtechniques to provide a flexible, user-friendly, and applicable information system. The DSS may also incorporate models that are used to calculate the components related to solving water resource management problems.

## 2.OBJECTIVE OF STUDY

The objectives of this study are to study the development of framework for Decision Support System for irrigation and to prepare a preliminary framework of decision-making process related to water allocation scheme planning and implementation and to aid real-time responses to changes in water supply enabling a new water allocation scheme to be developed based on the actual relationship between the supply and demand for water.

The DSS is to allocate water to various water users units (e.g., sectors, agricultural fields) using mathematical models based on their respective water requirements with equity and to develop an information system for different water management sectors to manage and share data related to water. The models and the information system have been incorporated into a DSS – ID (Irrigation DSS). The water requirement is estimated by taking into account water rights, crop structure, canal hydraulics, and irrigation patterns.

## 3.SYSTEM DESIGN

A Decision Support System (DSS) is an integrated, interactive computer system, consisting of analytical tools and information management capabilities, designed to aid decision makers in solving relatively large, unstructured water resource management problems.

The Decision Support System (DSS) is a knowledge-based computer program that integrates and analyses data such as hydrologic, hydraulics of canal system, weather related data and the results of using an appropriate numerical models. The motivation of Decision Support System (DSS) is helping the decision-makers to understand the natural and causes of the canal water distribution problem that may occur in the field. A simple methodology adopted for composition of DSS integration of an (i) Information system including relational database and (ii) Mathematical models. The information system component provides for collecting, storing, retrieving and modifying required data. Mathematical models provide for analysing the behaviour of the canal system and hydraulic changes in its distribution system and prediction of the expected behaviour to give basic support to the decisions on the preferred options. The methodology in design of the DSS requires the following main phases:


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Phase 1: Analysis of the data information, knowledge and objectives needed by the decision makers and of the scenarios to be considered;

Phase 2: Selection of the appropriate procedures to be included in the DSS (such analysis of the behaviour of the system of canals for the assessment of the alternatives) by choosing and linking the suitable mathematical models.

Phase 3: Design of the DSS links (including the choice of the links to databases).

Phase 4: Determine the disciplines and actors that are represented within the DSS.

## 4. METHODOLOGY DEVELOPMENT

The general goal of the DSS is to support the understanding of how the irrigation and drainage network in the Irrigation Department's water service area would respond to a variety of water conservation alternatives.
The first step of the methodology of the given research is to study the working of Decision Support System. The next step is to study the preparation of the framework of the DSS. In this step, the different parameters which are needed to include in the DSS framework are to be found out. The third step is of identifying different models of DSS. In this step the working of the models which can be use for water allocation process are identified. The input and output parameters of each model has been studied. After that the linking of all these selected models has been carried out for the making of framework of DSS. The arrangement of all the parameters of this framework is such that the water allocation process can give the maximum efficiency with minimum water losses.

## 5. ID SYSTEM ARCHITECTURE

System architecture is very important for a successful implementation of DSS software system. Architecture to be applied in ID is to provide seamless communication mechanism between inner modules of the system to enhance their logical relationship, reduce the system development and maintenance cost, and improves the system flexibility. This may include five data transaction layers as indicated in Fig.-1, namely (i) the user interface layer, (ii)pre-process layer, (iii) transaction layer, (iv)post-process layer, and (v) database layer.

(1) The user interface layer is used to receive the requirements from the user. This layer may be composed of a GIS module, an input module, and an output module. The input module shall provide a user-friendly and simple interface for users with different computer technologies. All model results are visualized using texts, reports, and x-y charts in the output module.

(2) The pre-process layer is a bridge between the middle layer and the database layer. This layer plays an important role in providing the various interfaces to access the geo-information and non-spatial data in the layer.

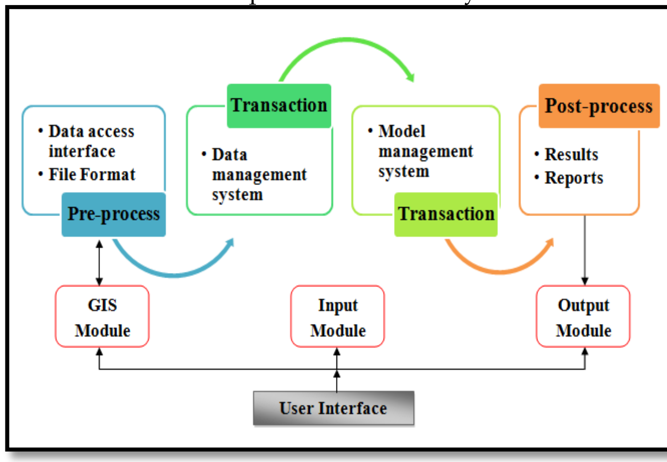


Fig 1. System Architecture of ID.

(3) The middle layer is the core of ID. The models are defined in the model library and managed by a model management system, which includes the Water Allocation Model (WAM), Irrigation Water Allocation Model (IWAM), and Crop Water Consumption (CWC).

(4) The objective of the post-process layer is to transform the results of the model by means of drawing 2-dimensional charts, making images based on a grid using GDAL (Geospatial Data Abstraction Library), opening a GIS component, and generating water allocation scheme reports.

(5) Geo-formation and non-spatial data saving processes are implemented in the database layer.

## 6. THE FRAMEWORK OF DECISION SUPPORT SYSTEM IN IRRIGATION CANAL AUTOMATION

Irrigation DSS is used to address decision-making problems regarding how to fairly allocate water to different levels of water use units to help improve water allocation schemes for water managers. The framework given in Fig.-2 illustrates two processes that contribute to developing an irrigation water allocation scheme and implementing water allocation. In the first process, the crop water consumption is calculated taking into account irrigation water quotas, water right areas, channel hydraulics and cropping patterns. And the second process gives the irrigation scheduling.
The objective is to prepare a basic framework of DSS which gives the crop water demand and irrigation schedule. Here, the daily crop water demand is calculated using the CWC model, integrating cropping pattern, climatic data, soil data and reference evapotranspiration. After that, the irrigation scheduling is calculated by using farmer's right, irrigation quota, canal hydraulics data and water allocation model. The water allocation process includes the two processes, i.e. calculation of crop water crop demand and irrigation scheduling. The detail processes are explained later. Combining these two processes, the final framework has been

prepared.

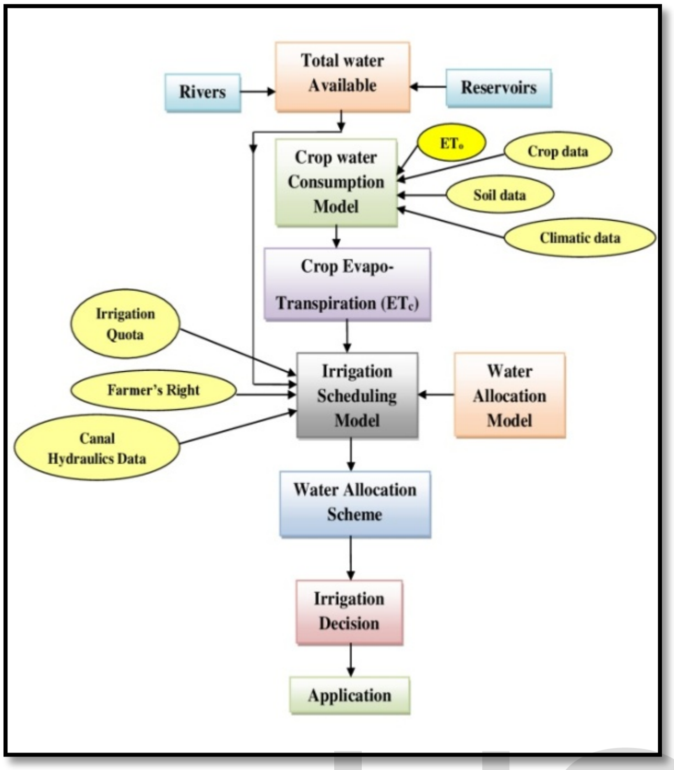


Fig. 2. Frame Work of DSS.

## 7.CALCULATION OF CROP WATER REQUIREMENT

## (CROP WATER CONSUMPTION MODEL)

The crop water requirements also called as the total amount of water used in evapotranspiration and it is defined as 'the depth of water needed to meet the water loss through evapotranspiration of a crop, being disease-free, growing in large fields under non restricting soil conditions, including soil water and fertility, and achieving full production potential under the given growing environment [9]'.

$$ETc = ETo \times Kc$$

Where:

ETc =Crop evapotranspiration (mm/day)
ETo= Reference crop evapotranspiration (mm/day)
Kc = Crop coefficient

The reference evapotranspiration can be estimated using different methods depending on the availability of climatic data. The most commonly used and internationally accepted ETc estimation methods are based on combination theory, solar radiation, temperature, and pan evaporation (FAO-56 Penman–Monteith, FAO-24 Penman, Kimberly–Penman, FAO-24 Radiation, Priestley– Taylor, Turc, Hargreaves, FAO-24 Blaney–Criddle, and FAO-24 Pan Evaporation). DSS can usually select any one of the previously mentioned methods based on the availability of data. Crop coefficients can be estimated by weighing lysimeters in research centers or estimated by RS images and normalized difference vegetation index (NDVI) calculation for the close relationship with crop green leaf area index (LAI) [9]. The basic principles of Crop Water Consumption Model are to estimate the reference crop evapotranspiration using the Hargreaves equation with minimal climatological data, or the Penmane-Monteith equation with detailed climatological data; to calculate the empirical coefficient (Kc) with the data contributed by the FAO and to estimate the crop water consumption according to crop structure, crop area, Kc, and the water use coefficient.This can be also be done by using CROPWAT software.

The CROPWAT software uses monthly climatic data (temperature, relative humidity, wind speed, sunshine hours, and rainfall) for the calculation of reference evapotranspiration. It has also four different methods to calculate effective rainfall but to be able to do this it requires dependable rainfall as input. Through the input of crop data (growth stages, Kc factors, root zone depth and allowable soil moisture depletion factor), the software calculates the crop water requirements on a decade (10-day) basis.

## 8.CALCULATION OF IRRIGATION SCHEDULING

## (IRRIGATION SCHEDULING MODEL)

Once the crop water and irrigation requirements have been calculated, the next step is the preparation of field irrigation schedules. The irrigation scheduling module prepares the schedule. Preparing irrigation schedule, the following parameters will be needed:

- Cropping pattern
- Daily water requirements of the different crops (ETc) at the different stages of their growth
- Root zone depth at the different growth stages of each crop (RZD)
- Total available soil moisture (SM)
- Allowable soil moisture depletion (P)
- On-site rainfall data

The cropping programme provides the different crops, their rotation and the time of planting and harvesting. The ET of each crop can be derived either by using CROPWAT or by using different methods. The RZD of each crop at the different stages of growth can be derived preferably from local information. The SM is usually determined through laboratory analysis during the soil surveys. The level of P depends on the crop and its stage of growth as well as on the soil type and irrigation system. A rain gauge would also be required on site to record the daily rainfall received. Irrigation frequency and duration have to be calculated for each crop of the existing cropping pattern and a sound irrigation schedule has to be put together in order to irrigate all crops at the time and for the duration they require the water.

Once the irrigation schedule is known, simplifications can be introduced in order to make the schedule practical and 'user-friendly' for the farmers, for example irrigation intervals and irrigation duration can be made uniform over a period of

14 days or a month. This is particularly important in smallholder irrigation schemes where a number of small farmers are involved, living at some distance away from the scheme. If they know the irrigation schedules for the rest of the month, they are in a better position to organize their work, household tasks and family life accordingly.

The rainfall can be taken into consideration at the time the irrigation schedule is applied. By using a rain gauge and by recording the amount of rainfall on a daily basis, this amount can be weighed against part of, or one or more irrigation applications. Therefore, the irrigation cycle is interrupted and a number of days are skipped, depending on the amount of rainfall, the daily water requirements and the moisture to be replenished in the root zone depth of the soil.

Irrigation frequency is defined as the frequency of applying water to a particular crop at a certain stage of growth and is expressed in days. In equation form it reads:

$$IF = \frac{SM_{ra}}{ET_C} \text{ OR } IF = \frac{SM_{ta} \times P \times RZD}{ET_C}$$

Where:
IF = Irrigation frequency (days)
SMra = Readily available soil moisture (SM x RZD x P) (mm)
SMta = Total available soil moisture (FC – PWP) (mm/m)
P = Allowable depletion (decimal)
RZD = Effective root zone depth (m)
Etc = Crop evapotranspiration or crop water requirement (CWR) (mm/day)

## 9.FUNCTIONING OF DSS IN ORDER SCHEDULING

Customer orders water online or over the phone. After order is made, software automatically checks if the customer has sufficient allocation and whether the order can be delivered within capacity constraints. Then order is sent to the customers turn out. Turn out automatically opens at requested time and continually adjust to deliver the ordered flow rate. Upstream flow gate anticipates the downstream demand using feed forward control. Along with real time level and flow information, upstream gate continuously adjust to maintain the water level immediately downstream. As each regulator adjusts to maintain the water level in the downstream pool, upstream regulator in turn adjusts right through to the reservoir. This ensures that, only the exact amount of water required is drawn from the reservoir. These eliminate the spills and wastage which occurs in traditional irrigation infrastructure. The following are the features of order irrigation scheduling:

- Farmers can order and manage their water delivery requests through the method of their choice.
- Define and manage pre-planned deliveries (rotations or rosters).
- Demand and service reporting by section or entire canal system.
- Logging of order history.
- Easy definition of planning areas.
- Generation of running sheets to provide operator instructions to field staff.

The following figure precisely describes the step by step functioning of Decision Support System in the process of order scheduling:

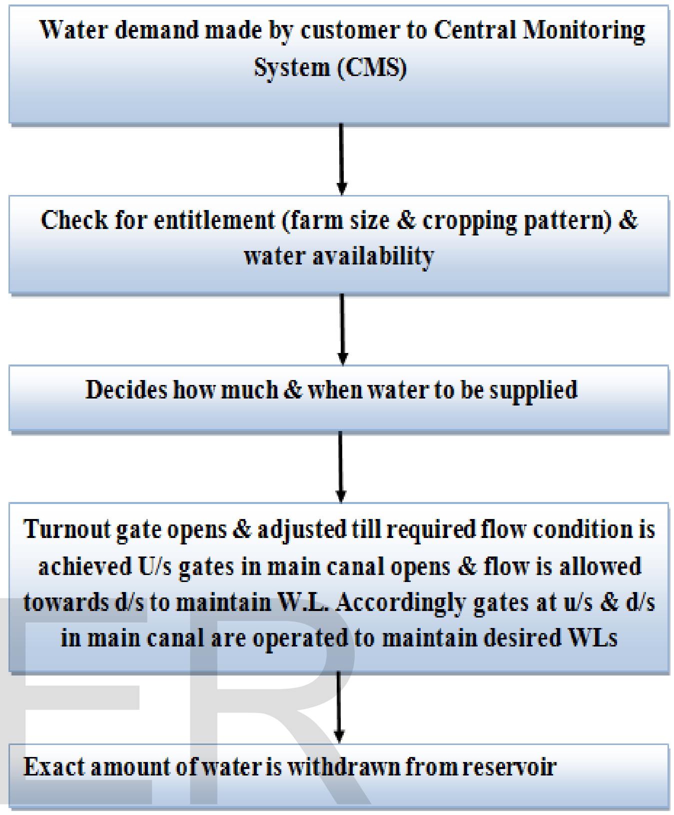


Fig. 3. Flowchart of Decision Support System in Order Scheduling

## 10. DISCUSSION AND CONCLUSION

A framework for DSS has been prepared to help water resource management decision makers in addressing water resources distribution problems. The DSS emphasizes the impacts of human activities on water resource management, which includes crop water requirements at various stages, hydraulics of system of canals and sequencing of operation of gates and above all data management. The DSS is a very effective tool for water allocation in agricultural regions. DSS is an integrated environment to share and manage data and to facilitate cooperation among different levels of users.

The models utilized in the DSS system are carefully chosen according to practical water resource management problems. These models focus on calculating quantifiably key parameters, e.g., crop water consumption, agricultural water demand, and water use efficiency, for decision processes. These parameters can aid decision makers in making effective decisions. The spatial distribution of agricultural water demand is one of the main elements used by decision makers to allocate water to different regions.

The DSS, SCADA, and scheduled water delivery also have the potential of meeting future agricultural demands in developing regions throughout the world. As the world population continues to grow there will be an increased demand for food production and in many cases water resources available for agriculture are already fully utilized. Utilizing a DSS linked to SCADA would allow water users in developing countries with surface application systems to conserve water from their current practices and apply the saved water to increased food production.

The DSS could also be used to refine water delivery scheduling. Many arid regions have been dealing with water shortages for decades and have already implemented scheduled water delivery. In most cases, water delivery schedules are based on a set interval of time and do not coincide with crop demand. In areas where this type of scheduling is practiced the DSS could be used to refine scheduling protocols to include crop demand. Scheduling water deliveries based on crop demands would provide additional saving in areas where scheduled water delivery is already implemented.

The DSS could be utilized in any irrigation system worldwide that practices surface irrigation techniques. Through scheduling based on crop water demand, overall diversions could be significantly reduced. Reduced diversions could help irrigators deal with drought, and climate change by allowing for increased utilization of stored water. Additionally, reduced diversions could be utilized to grow supplementary crops to supply the needs of a growing population in the future.

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