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OPERATION MODELING FOR ZARIMA MAY DAY DAM RESERVOIR

MSc THESIS

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OPERATION MODELING

FOR ZARIMA MAY DAY RESERVOIR

BY

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Of

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Certification

I, the undersigned, certify that I read and hereby recommend for acceptance by Addis Ababa University a dissertation entitled "OPERATIONAL MODELING FOR ZARIMA MAYDAY DAM RESERVOIR” in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering.

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(Supervisor)

Augest 2021

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I, BIRUK W/TSADIK, declare that this is my original work and that it has not been presented and will not be presented to any other University for a similar or any degree award.

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ABSTRACT

The Ethiopian government is involved in the development of massive irrigation projects for sugar production in different parts of the country. One of these schemes is the Wolkayite sugar development project, located in the western zone of the Tigray region. It is planned to utilize the runoff of the Zarema River, which is a major tributary of the Tekeze river basin. To achieve this objective, a dam has been built across river Zarema, which would enable irrigation of more than 40,000 ha of land. The Sugar cane which is estimated to be cultivated around 40,000 ha of land is to be utilized as raw material for Welkit sugar factory which has a capacity of 24,000 TCD.

The objective of the study is to develop operation modeling for the Zarema May Day Dam reservoir. The input data consider for the model are daily inflow, monthly irrigation, and monthly reservoir surface evaporation, and Zarema May Day Dam physical data.

The reservoir operation modeling was done using Zarema river inflow source options. The high Simien mountain range ensures relatively high runoff in the river Zarema at the dam sit. The annual average runoff is around 1300Mm^3.

The seasonal flow regime is characterized by an important average monthly flow, particularly in July (169 m3/s) and August (225 m3/s), whereas the period from October to May exhibits a monthly average lower than the annual mean.

The reservoir operation modeling has been developed using two cases of inflow and three different scenarios, which has the same operation zone but differ irrigation area in Ha. And also reservoir operation guide curve and each year reservoir pool level were established.

DEDICATION

I dedicated this thesis to

My father, Ato W/tsadik W/senbet.

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Chapter 1 INTRODUCTION

1.1 General

Building a dam over a stream creates a reservoir. Reservoirs, such as irrigation, urban and industrial water storage, hydropower generation, and flood control, are typically built for many different purposes. The main function of a reservoir is to control the natural streamflow by storing excess water in the rainy season and releasing the accumulated water to supplement the reduction in river flow in the future dry season. In short, the goal of a reservoir is to equalize the flow of the natural stream and to adjust the water's temporal and spatial availability. Water contained in a reservoir may be transported to distant locations through pipes or channels, resulting in spatial changes, or it may be stored in the reservoir and subsequently released for beneficial purposes, resulting in temporal changes.

Water is either collected in the reservoir or supplied from storage, depending on the extent of natural inflows and demands at a given time. As a consequence of water storage, a reservoir provides water heads that can be used for electrical power generation or irrigation. A reservoir also includes a navigation tool to navigate rapids, a refuge for aqua life, and recreation and sports facilities. It increases the beauty of the landscape, encourages forests and wildlife.

In most arid and semi-arid regions, water shortage and fragility, uneven distribution of space and time, and its mismanagement are regarded as the main serious problems. Since agriculture is the key user of water resource availability, the efficient use of water for irrigation addresses many subtle considerations, such as the natural and time of irrigation of the crop, its growth stage, the switching between different crops to the available water, and the impact of the deficit of water supply on the supply of water.

Different models have been proposed for optimum reservoir operations in the past decade. The study formulated by Vedula and Mujumdar indicates an optimal reservoir operating strategy for irrigation of multiple crops with stochastic inflow using dynamic programming (DP) to optimally distribute the water available to all crops over the given span.

Depending on the condition of the reservoir, the extent of conditions, and any information about the likely inflow into the reservoir, a reservoir operating policy determines the amount of water to be released from the storage at any time. For a single-use reservoir, the operational issue is to settle on the releases to be made from the reservoir to optimize the benefits for that purpose. In addition to the above, it is also required for a multipurpose reservoir to distribute the release optimally.

This study focuses on evaluating the irrigation system's reservoir activity management as expected in Zarima. The goal of the study is to define reservoir operation strategies to achieve a sustainable balance between irrigation requirements, diverted flow, and compliance with river ecological flow released from the reservoir to achieve a parameterized reservoir operation process. To account for long-term climate variability, long-term (43 years) metro series data is used.

This thesis mainly describes how to use activity modeling using HEC-ResSim software for the Zarema May Day irrigation reservoir.

1.2 Statement of Problem

The main water source for Zarima reservoir is the flood coming from Zarima and Duduko River during the rainy season of June, July, and August. The height of Zarima May Day Dam is 152m (EL.954m.AMSL), the minimum operation level is (EL.937.78m. AMSL) and the maximum operating level at the crest level of the spillway is (EL.946.4m. AMSL) total reservoir capacity is 3.6 Bm^3 but only 785 Mm^3 of water is available for irrigation due to the topography nature of dam location.

The watershed of Zarema and Dukuko is a poor indirect measurement of runoff and rainfall. Based on the precipitation data and metrological information hydrological study was conducted based on the information the year 1968E.C to 2010 E.C. The missing data in the historical series were filled. Using the rainfall correlation model the missing year of the ungagged station rainfall recorded were extended and they develop monthly average inflow at the site is developwd and the runoff coefficient they used was 0.45. But in hydrological studies, the use of correlation is in some way an unsatisfactory substitute for actual rainfall.

Zarima May Day Dam was constructed and the project is proposed for a 40,000Ha irrigation project. Due to the reasons mentioned above developing reservoir rules and determine reliable irrigation land is necessary. New reservoir Operational modeling for Zarima reservoir regarding for two cases, case one for the WWDSE study of monthly average inflow and case two if 75% of WWDSE study monthly average inflows.

1.3 The objective of the Study

The main objective of this research work is to model a new reservoir operation rule for the proposed irrigation system at the Zarima May Day Dam reservoir.

1.3.1 Specific objective

- Developing possible irrigation deficit months.
- Developing Reservoir Rule Curves for Zarima May Day Dam reservoir.

1.4 Structure of the thesis

This thesis consists of five chapters including the introductory section. General overviews of each chapter are summarized as follows.

Chapter One, The introduction portion consists of the problem statement and the study's goals.

Chapter Two, The literature review briefly addresses the previous project analysis and methods of water resource management and general simulation and service techniques of the reservoir operation and brifely discusses the differnt simulation models available and explains the HEC-ResSim model, its features, and its applications.

Chapter Three, A summary of the study area, including the key features of the position of the Zarima river basin, rainfall characteristics, land use, and topography.

Chapter Four, The technique used to achieve the objectives of the thesis is defined. Hydrological, meteorological, organizational, and physical data collection and interpretation is the subject of the chapter. also deals with how the Zarima reservoir HEC-ResSim model was developed and the number of alternatives and scenarios used. finaly deals with the outcome; appropriate discussions must be made to interpret the outcomes of each case and situation.

Chapter Five, The final section of the report; findings and recommendations are included in the chapter.

Chapter 2 LITERATURE REVIEW

2.1 Reservoir operating policies

Determining optimum reservoir operating policies has been a major focus of the relatively new discipline of water supply systems (irrigation, hydropower, municipal) analysis. Extensive research has been conducted, and a tremendously large number of references on applying systems analysis techniques to reservoir operation problems have appeared in the literature during the past years. Many university research reports sponsored by the various state water resources research institutes have addressed the subject.

Ther is multi references are available in the literature, the following books are suggested to a general overview of the application of systems analysis techniques to reservoir operation problems. The textbook by Daniel P.Loucks (2005) explains the fundamentals of water Resources systems planning and analysis, including mathematical modeling techniques, which can be applied to reservoir operation problems. A simple and earlier technique for analyzing the relationship between reservoir inflows, desired draft rate, and the storage capacity is a mass curve technique, known as Ripple's mass diagram discussed in Rippl, W (1883).

2.1.1 Simulation Model

Simulation is the process of duplicating the behavior of an existing or proposed system. It is a highly powerful tool than optimization or mathematical model, which can address any problem in any field.

It consists of designing a model of the system and conducting experiments with this model either for a better understanding of the functioning of the system or for evaluating various strategies for its management. The advantages of the simulation model are (i) The model can be made as 'realistic and accurate' as available data, (ii) Large quantities of input data can be analyzed 'very rapidly' on a digital computer, (iii) A properly calibrated simulation model can be 'used to predict the effectiveness of a wide range of operating policies. The primary disadvantage is that it does not directly find the best operating policies.

Optimal coordination of the many facets of reservoir systems requires the assistance of computer modeling tools to provide information for rational operational decisions. Computer simulation models have been applied Many models are customized for the particular system, but there is also substantial usage of public domain, a general-purpose model such as HEC 5 (Hydrologic Engineering Center 1989), which was updated as HecRes Sim to include a Windows-based graphical user interface. Spreadsheets and generalized dynamic simulation models such as STELLA High-Performance System, Inc. are also popular (Stein et al 2001). Other similar system dynamics simulation models include POWER SIM (Powersim, Inc.)

2.1.2 Irrigation Scheduling

Good irrigation management is required for efficient and profitable use of water for irrigating. Irrigation scheduling is dependent on the design, maintenance, and operation of irrigation systems and the availability of water. A major part of any irrigation management program is the decision-making process for determining irrigation dates and/or how much water should be applied to the field for each irrigation turn. This decision-making process is referred to as irrigation scheduling. Efficient scheduling of irrigation maximizes the production and prevents under and/or overwatering of the crop.

2.1.3 Water balance and Crop management

The management of water resources in irrigation is a fundamental aspect of their sustainability. The current situation of irrigation throughout the world is characterized by a decrease in available water resources, especially in arid and semiarid zones. This trend, which will probably become more aggravated in the future, is due to the reduction in available water. Since water values are progressively increasing, it is necessary to analyze the factors that affect water uses to improve water management for sustainable agriculture. Worldwide, irrigated agriculture is responsible for more than 80% of water consumption in arid and semiarid zones. Thus, the improvement of water management in agriculture should deal with different aspects in a coordinated and integrated way.

2.1.4 Mathematical Optimization Technique

Linear programming

The most important optimization techniques used in reservoir operation are linear and dynamic programming. Linear programming is an operation research technique that has been widely used in water resource planning and management. Its popularity is due to the following considerations. Linear programming applies to a wide variety of problems; efficient solution algorithms and computer software packages are available for applying the solution algorithm. Various generalized optimization programs are commercially available for solving linear equations with constraints.

Dynamic programming

Dynamic programming, developed by Bellman (1957) for dealing with sequential decision processes, is not restricted by any requirement of linearity, convexity, or even continuity. Nevertheless, it is restricted to specific forms of the objective function. Dynamic programming theory and its applications in various fields are covered in depth in books by Cooper and Cooper (1981), and Denardo (1982). Mays and Tung (1992), describe the fundamentals of dynamic programming from the perspective of water resources planning and management.

Unlike linear programming, for which many general-purpose software packages are available, the availability of general dynamic programming codes is limited. Most dynamic programming computer programs have been developed for specific applications.

Dynamic programming is not a precisely structured algorithm like linear programming, but rather a general approach to solving optimization problems. Dynamic programming involves decomposing a complex problem into a series of simple sub-problems which are solved sequentially while transmitting essential information from one stage of the computations to the next using state concepts. Several dynamic programming models have been developed in the field of reservoir operation.

2.1.5 Rule Curve

For individual reservoirs, the performance of specified operating policies using associated operating rule curves can be simulated. Rule curves define the desired storage volumes, Water Levels, and releases at any time as a function of existing water level, the time of the year, water demand, and The Possible expected inflows.

For periods of drought, release from reservoirs can be reduced by a certain factor for each of several critical (also termed reduction) water levels. Any number of reduction factors and levels can be specified for each downstream user as part of the rule curves. Evaporation from the reservoir, precipitation into it, and leakage losses from it are accounted for given the height - volume - area table. Seasonal rule curve operation may be a viable alternative to a permanent storage reallocation under certain circumstances. Many factors affecting reservoir operation are seasonal.

Standard Operating Policy (SOP) (Stedinger et al 1984) is the policy that releases in each period only the target release, if possible. If sufficient water is not available, the reservoir empties. If too much water is available, the reservoir will fill and then spill any excess water.

The effectiveness of the standard operating policy is compared with policies derived from deterministic optimization by Mejia et al (1974). It can be observed that the Standard Operating Policy is the optimal operating policy to minimize the total deficit over the time horizon.

The draw-down-refill cycle begins when reservoirs are full and ends when they have been refilled by inflows after withdrawals. The inefficient condition created by inappropriate operations leading to some reservoirs being full and spilling while others remain unfilled can be avoided by apportioning required releases among parallel reservoirs in such a way that, after the water has been withdrawn.

The ratio of space available in each reservoir equals, as far as possible, the ratio of the draw down-refill cycle to that into all reservoirs. This is called as Space Rule (Maass et al 1962). As this Space Rule controls the spill, it is better suited for flood-prone areas or flood control reservoir operations.

The Pack Rule (Maass et al 1962) makes the reservoir space free for predicted inflows that would otherwise spill. The sum of the available reservoir space and the amount of water that can usefully be utilized during the entire period must be determined, assuming no further releases during the month. If the storage in the reservoir is already full and then if there is any further inflow into the reservoir, there will be a spill. To avoid spill and utilize it usefully, the release has to be distributed in such a way that there will be the additional release of water to be usefully utilized and make space in the reservoir to receive the predicted inflows into the reservoir.

Linear decision rule offers a release commitment based on previous time step storage. According to this policy, release Rt in any time step t, is given by Rt = St-1 + bt. Where St-1 is the storage at the start of the period t and bt is a decision parameter. Re Velle et al (1969) first proposed this rule; to simplify the chance-constrained LP formulation. The graphical representation of this rule, with the release on the Y-axis and storage on the X-axis, will have a slope of 450 and the intercept on the release axis is at bt. An operating rule that places more penalties on large deficits than small ones is called a Hedging Rule (Maass et al 1962). The idea behind the rule is that if the reservoir system managers try to always meet the demand during the early months of the critical period, they may incur severe deficits in later periods.

The simulation model was run for various combinations of Vbuffer and alpha values and from the results, the total deficit was calculated and the best one was selected which gives the lowest deficit. When the storage falls below the trigger value or buffer storage, rationing is introduced. In the simple hedging rule, whatever may be the storage level below the buffer storage, a constant reduction in demand is made and a water draft can be made based on the Standard Operating Policy.

In the Continuous Linear Hedging Rule, instead of a constant reduction in demand, a linear variation of demand reduction is assumed for storage between dead storage and storage at buffer storage. A continuous linear hedging rule has been applied for a drinking water supply system (Shih and Re Velle 1994). Finally, the continuous hedging was converted into a discrete rule (multiple hedging rule), probably to overcome the linearity assumption made initially.

2.1.6 Optimal Reservoir Rule curve

Optimal rule curves are necessary guidelines in the reservoir operation that has been used to assess the performance of any reservoir to satisfy water supply, irrigation, industrial, hydropower, and environmental conservation requirements. (Hindawi 2018). The terms rule curve or guide curve are typically used to denote operating rules which define ideal or target storage levels and provide a mechanism for release rules to be specified as a function of storage. Rule curves are usually expressed as water surface elevation or storage volume versus time of the year. Although the term rule curve denotes various other types of storage volume designations as well, the top of the conservation pool is a common form of rule curve designation. Operating plans may be expressed in various formats.

A water control diagram represents a compilation of regulating criteria, guidelines, rule curves, and specifications that govern the storage and release functions of a reservoir. A water control diagram or set of rule curves specify Release rules as a function of storage levels, season of the year, and related factors. The format and type of rules reflected in water control diagrams vary greatly for different reservoir projects.

2.2 Reservoir Operation Simulation Model HEC-ResSim

The successor to the well-known HEC-5, HEC-ResSim is a frequently used public domain simulation program developed by the U.S. Hydrological Engineering Center. Army of Engineers Corps. HEC-ResSim is a huge advance in the decision-making support tools available to water managers. It is planned to model flood control reservoir operations as well as flow augmentation.

HEC-ResSim uses an original rule-based approach to replicate the actual decision-making mechanism that reservoir managers need to use to meet flood control, power generation, water supply, and environmental quality operational requirements. Time of year, hydrological conditions, water temperature, and simultaneous operations by other reservoirs in a system are parameters that may affect flow requirements at a reservoir. There may be numerous and/or overlapping limitations on the functioning of the reservoirs assigned to meet the flow requirements. These flow specifications and constraints for the reservoir operating zones are defined by HEC-ResSim using a separate set of prioritized rules for each region. Flexible at-site and downstream control functions and multi-reservoir system constraints are specified by simple reservoir operating objectives As HEC-ResSim has progressed; it has made it possible to model more complex structures and organizational specifications with advanced features such as outlet prioritization, scripted state variables, and conditional logic.

The graphical user interface allows HEC-ResSim quick to use and performance analysis is supported by the customizable plotting and reporting tools. Among reservoir simulation models, HEC-ResSim is special because it seeks to replicate the decision-making mechanism that human reservoir operators would use to set releases. With a combination of hydraulic computations for flows through control structures and hydrological routing to describe the lag and attenuation of flows through segments of streams, the software reflects the physical actions of reservoir systems. Among reservoir simulation models, HEC-ResSim is special because it seeks to replicate the decision-making mechanism that human reservoir operators would use to set releases. With a combination of hydraulic computations for flows through control structures and hydrological routing to describe the lag and attenuation of flows through segments of streams, the software reflects the physical actions of reservoir systems.

2.2.1 HEC-ResSim Module Concepts

HEC-ResSim provides three different sets of functions called Modules, which provide access within a watershed to unique types of data. Watershed Configuration, Reservoir Network, and Simulation are such modules. Each module is accessible through means, toolbars, and schematic elements for a particular purpose and an associated collection of functions.

2.2.2 System of Storage Reservoir in HEC-ResSim

This module aims to provide a shared structure for the formation and description of watersheds. A watershed is connected with a geographic region for which it is possible to configure several models and area coverage. Both streams, programs, e.g. reservoirs, levees, gage locations, impact areas, time series locations, and hydrological and hydraulic data for a particular region can be included in the Watershed. Together, all of these specifics form a watershed structure once configured.

2.2.3 Reservoir operation rule in HEC-ResSim

The Reservoir Network module aims to isolate from the output analysis the growth of the reservoir model. The river schematic is defined in the Reservoir Network module, the physical and operational components of the reservoir model are identified, and the alternatives to be studied are created.

The basis of a reservoir network is built using configurations that are created as a blueprint in the Watershed Setup module. Routing paths and probably other network elements can be added to complete the network schematic connectivity.

Once the schematic is complete, physical and operational information is specified for each aspect of the network. Alternatives that define the reservoir network, operation set, initial conditions, and DSS pathname assignment (time-series mapping) are also developed.

2.3 Previous studies

2.3.1 Tekeze Basin master plan Study

This study's purpose was to provide data and information for the general planning of the Development of a Master Plan for integrated resources and land suitability evaluation for various future land uses that would support the people living in the basin and the country in general. The general environmental features of the Tekeze River Basin were reviewed in the study. Significant environmental issues and problems and major disputes have been reported in this study.

2.3.2 Tigray Water Works Study, Design & Supervision Enterprise

The main objective of this study was to carry out the engineering design of a net irrigation scheme for 50,000 ha to fit the requirements for sugarcane irrigated agricultural production. The analysis considered that the Dukuko River as the project area's source of irrigation water.

2.3.3 Water Works Design and Supervision Enterprise

WWDSE's first study was to create a dam on the Dukoko River and to suggest the production of 10,000 ha of sugar cane and 17,000 ha of other crops. The engineered system consisted of a 45 m high embankment dam and an approximately 11 km tunnel to conduct the flow to the command area regulator.

However, the land resource available at the Dukoko dam site, which is about 40,000 ha of land and the water resource capacity, was evaluated and found not to be adequate to produce 25,000 ha of sugar cane. Therefore other possible options were searched including the dam site location revision.

The second study configuration consists of a 144 m high dam across the Zarema River, a left abutment side-channel spillway, a temporary right abutment diversion conduit, a permanent middle-level outlet on the left abutment, and a 6.2 km long intake and approach channel located upstream of the dam and parallel to the reservoir on the left side.

2.3.4 SGI Studio and SC

The main objective of the study was to carry out a thorough review of both the WWDSE 2011 and the WWDSE and ELC project 2013 of the previous design paper.

Chapter 3 DESCRIPTION OF THE STUDY AREA

3.1 Location of Study Area

The Zarema May-Day Dam project is administratively located at the border of the Wolkayites and Tselemti weredas (according to the regional administrative hierarchy) in the Tigray region of the Western zone. The project area (the Dam axis, reservoir, and command area) is located between 1451548 m N-1562033 m N and 321244 m E-394095 m E in the UTM Zone 37N geographic coordinates.

The Zarema May-Day Dam project profits from the Zarema River water resources and the project's dam axis is situated downstream of the Zarima and Dukuko river drainage areas. The basin catchment area at the site of the Dam is 2,133 km2.

The Zarema River, which originates from the hill slopes of the Semien Mountains between the towns of Debark and Zarima, is perhaps one of the country's highest rainfall areas. Accumulated annual precipitation of more than 2,000 mm has already been recorded.

The Dukuko River originates more or less from the Zarema River at an altitude equivalent to that of the western portion of the Semien Mountains. The area of the Dukuko watershed up to the confluence with Zarema is approximately 1,200 km2. Both the Dukuko and Zarema are called Zarema River after the confluence. The Zarema River is the affluent left bank of the River Tekeze.Location Map of the the zarima may day dam is shown below, refer Figure 3-1 May Day Dam, project location .

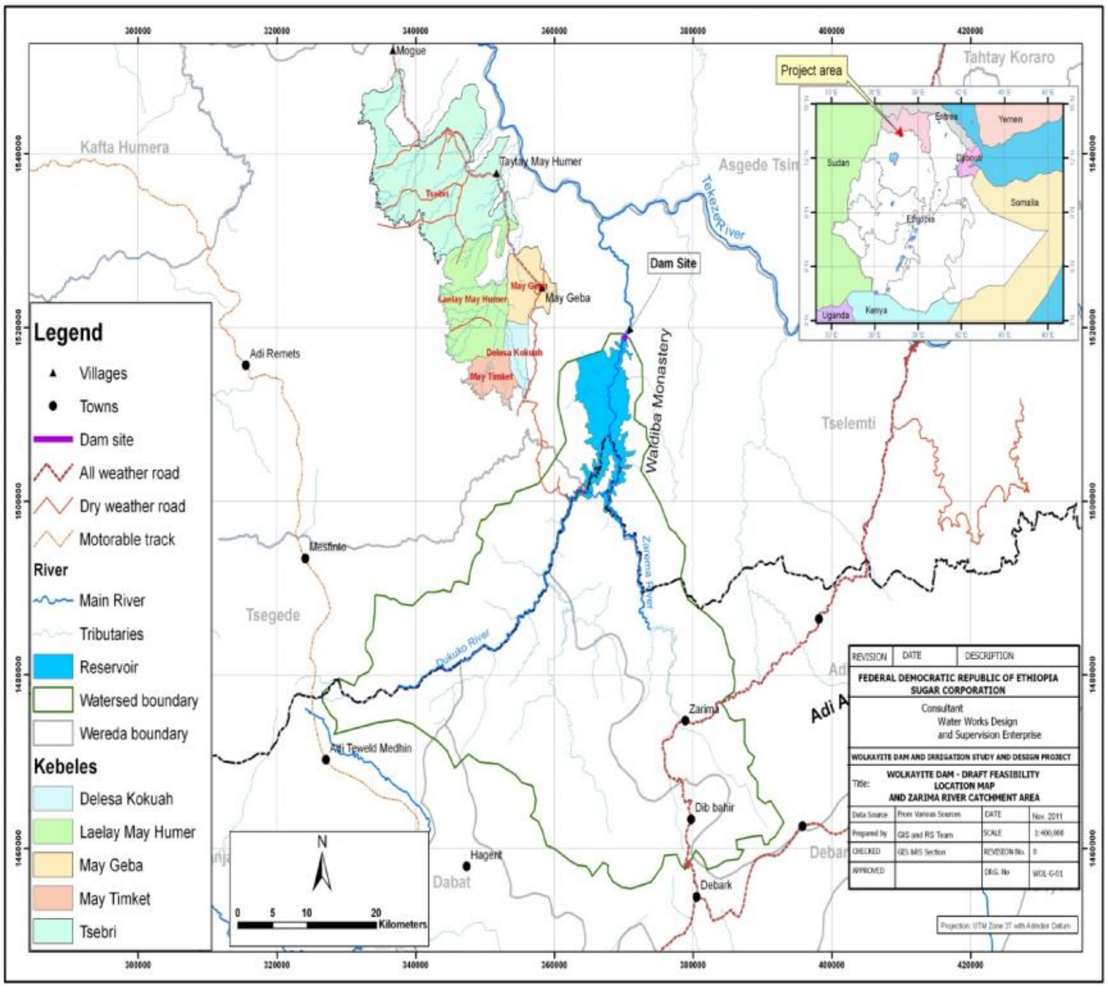

Figure 3-1 May Day Dam, project location (WWDSE, Final Feasibility Main Report, 2012 G.C.).

3.2 Catchment Characteristic

The watershed area of the upstream basin of Dam is 2,133 km2 (SRTM DTM.) The topography is mainly steep, and the rivers descend from about 3,000 m at the highest point of the lowest drainage boundary to 820 m at the dam site at a distance of 87 km (Zarema River distance). The basin is partially covered by forests and bushes, especially in the upper portions of the basin, while most of the lower portions are arid and semi-arid, owing to the increased demand for agricultural and pasture land. The differences between precipitation and evaporation are the main characteristics of the project region, particularly where the latter is much greater. The average annual precipitation in the watershed is 1,100 mm, with rains falling mainly during the June-September and late October rainy seasons. During these times, regular storms occur and rainfall depths of 76mm to 120 mm can drop in less than twenty hours. Such storms are largely orographic. (TWWDSE, 2011 G.C.)

During the rainy season, high flash floods are typical, which is to be expected due to the steep topography and heavy rainfall. The concentration-time is roughly 18 to 20 hours. The average annual discharge of the Zarema River at the dam site is approximately 16 m3 / s and a mean monthly discharge value of 200 m3 / s is possible in the rainy season. The Zarima River does not have the full historical flood details. (TWWDSE, 2011 G.C.)

The mean monthly sunshine hours vary from 6.5 to 8.5hrs / day for the various stations. During the dry phase, the maximum monthly values, up to 10hrs / day, occur. During the rainy season, and particularly in July and August, low values, to below 4hrs / day, occur. The highest monthly average wind runs, up to 300 km/day, occur during the rainy season (June-September) for all stations. During the dry season, low values occur, often below 100 km per day. (TWWDSE, 2011 G.C.)

3.2.1 Topography

Strong topographical variability characterizes the area. The area's drainage system is dominated by steep and undulating terrain comprising part of Semien Mountain. On a relatively narrow gorge with steep slopes, especially along the top part of the abutments, is the selected dam site corridor. The reservoir area contains both river channels and low-slope gradient areas (even flat plains) that are prevesouly used as farmland, grazing, and settlement areas. Generally, there is sufficient vegetation cover for the catchment and reservoir areas and the downside. The side of the heavily struck river parts was densely vegetated, while farm fields, grazing areas, and partial settlement were the flute plains. (TWWDSE, 2011 G.C.)

3.2.2 Soil Type of the Water-shed Area

From the soil map, the soil types of the catchment area are from GIS data. The type of soil in the drainage areas has a different infiltration rate. The Soil Conservation Service (SCS) has split the soil into four hydrological soil classes based on infiltration rates.

Group A: Soil with a low runoff potential due to high infiltration rates.

Group B: Soil with moderately low runoff potential due to moderate infiltration rates.

Group C: Soil with moderately high runoff potential due to slow infiltration rates.

Group D: Soils with a high runoff potential due to very slow infiltration rates.

It defines the soil types of the watershed areas which are crossed by the proposed alignment and prepares a map. **B** Hydrologic Soil (HSG) Community, i.e. Due to moderate infiltration rates, soil with relatively low runoff capacity. (TWWDSE, 2011 G.C.).

3.2.3 Land use Land corver

Land use and land cover are often used interchangeably, but a distinction exists between them. Land use refers to the economic activity for which land, such as agriculture, grazing, and forestry, is used. Land cover refers to the surface cover, the vegetation of the earth without regard to how that cover is used. In many cases, land use and land cover are directly linked, especially in areas where highly used and settlements have existed for a long time.

Types of Zarima watershed land use/ land cover have been established, defined and mapped. This section also identified agricultural land-use practices in the area; the percentage of land cover was calculated and estimated; the potential and constraints of each land use/cover were evaluated and discussed; the proposed sustainable land use plan for the watershed area was proposed. (TWWDSE, 2011 G.C.).

Land use/ **Land** cover Types

The Zarima watershed's main land use/land cover forms have been defined and mapped. The key forms of land use include agricultural land, grassland, timberland, shrubland, and bare land. The definition is provided as follows of these forms of land use/cover. (TWWDSE, 2011 G.C.).

Cultivated Land

This is a substantial land use that covers approximately 48,974 ha (23 percent) of the total watershed area. Every year, this unit is fully placed under cultivation for field crops. Sorghum (intercropped with sesame), finger millet, and barley (at a higher elevation) are the crops grown. The principal causes of erosion are known to be cultivated fields. After harvesting and first plowing, such fields are still bare and are exposed to extreme erosion during torrential rains. (TWWDSE, 2011 G.C.).

Grassland

This class includes regions in which grass vegetation is the dominant ground cover. Commonly, the mapping unit is used in the watershed. Grasslands interspersed with some trees were common and on the drier areas were common patches of shrubs. In areas with physical limitations, grasslands generally exist. The limitations include low rainfall, steep slopes, shallow soils, rock crop-outs, waterways, and waterlogging. The unit occupied about 38,784 ha (18%) of the total area of the watershed. Grazing is the major land using the activity of the unit. (TWWDSE, 2011 G.C.).

Woodland

The Woodland is classified as a separate 7 m or higher non-interlaced upper layer and exists in areas where the key limiting factor restricting forest growth as well as crop production is moisture stress. In addition, steep slopes and shallow depth of the soil could restrict man's activities to transform this class into other coverings it occurs in combination with vegetation of shrubs and grass, exposed rock, and soil surface. (TWWDSE, 2011 G.C.).

Around 3,213 ha (1.5 percent) of the total area of the watershed was occupied by the unit. The mainland use activities were livestock grazing and browsing, rain-fed crop cultivation, and in some areas, fuelwood collection and wood harvesting for charcoal. (TWWDSE, 2011 G.C.).

Shrub land

In areas with extensive physical limits, this unit existed. The disadvantages include very steep slopes, shallow soils, rock crop-outs, deeply dissected gorges, dry and rough areas, etc. In the watershed, the unit occupies relatively large areas. The broad coverage of this unit means less land in the watershed that is appropriate for agricultural purposes. Shrublands are significant of firewood and farm implementing sources. In most situations, they are used as open land for grazing and browsing. Shrublands are synonymous with grass plants, sparse trees, or forest patches. Around 107,002 (50 percent) of the total area of the watershed was occupied by the unit. The main land-use activities of this unit were considered to be livestock grazing and browsing (more for goats) and gathering wood. (TWWDSE, 2011 G.C.).

Bare land

This class contains areas where exposed rocks and exposed soil surfaces were the dominant covers. Around 13,400 ha (6 percent) of the total area of the watershed was occupied by the unit. This unit exists in the higher lands of wored Adi Arkay, Debark, and Tsegede. (TWWDSE, 2011 G.C.).

Cover	**Area (ha)**	**%**
Cultivated lands	48,974	23.0
Grass lands	38,784	18.2
Natural forest	134	0.1
Plantation	388	0.2
Wood land	3,213	1.5
Shrub land	107,002	50.2
Bare land	13,400	6.3
Water body	1,253	0.6
Total	**213,800**	

Table 3-1 Major land use/Cover. (TWWDSE, 2011 G.C.).

3.3 Climate

The country's climatic situation is divided into the following zones according to the National Atlas of Ethiopia.

1) **“Kur”;** 3300m a.s.l. and above (annual mean temp. of <10 oC.)
2) **“Dega”;** 2300 – 3300 meters .a.s.l. (annual mean temp. of 10 to 15 oC.)
3) **“Weina Dega”;** 1500 – 2300 meters a.s.l. (annual mean temp. of 15 to 20 oC.)
4) **“Kola” ,** 500 – 1500m a.s.l. (annual mean temp of about 30 oC)
5) **“Berha”,** below 500-m. a.s.l. (with annual mean temperature of 30-40C.)

From the above classification, the project channel falls within **“Kola”** climatic zones because the altitude of the route alignment lies between 810 and 957meters a.s.l. (TWWDSE, 2011 G.C.).

3.3.1 Rainfall Regimes

A useful uniform definition of the rainfall regimes was prepared by the NMA. Based on this definition, the country's rainfall regimes are divided into four types of rainfall regimes.

Mono-modal: A single peak rainfall pattern is described. The period of this single precipitation varies from 3-8 months. In general, in this rainfall area, the length of the wet period declines from south to north. This rainfall regime is further divided into three sub-divisions based on the length of the wet season.

Bi-modal Type I: A quasi-dual peak rainfall pattern is characterized by a small peak in April and a maximum peak in August. Therefore, this area is characterized by a semi-bi-modal pattern of precipitation.

Bi-modal Type II: During April and October, the area in this rainfall region was dominated by a double peak rainfall trend with similar peaks.

Generally, in this rainy zone, the annual rainfall decreases from west to east. Diffuse pattern: An irregular rainfall pattern characterizes the area. The pattern is diffused and not well established, while irregular rainfall occurs during the period from August / September to January / February. With this general overview of the country's rainfall regimes, the project region of Wolkayet is divided into mono-modal rainfall regimes. Therefore, it has a distinctive season of rainfall that gives July a peak rainfall of 218 mm. (TWWDSE, 2011 G.C.).

3.3.2 Precipitation

The rainfall records data of the Zarima and Adi Remets stations (51 years extended series) for the annual precipitation in the project area has been established by TWWDS. In the river basin, the rainfall pattern varies between 1746 mm/yr and 1268 mm / yr in the command area. The maximum annual precipitation was estimated in 1988 at a substantial 3336 mm / yr (Zarima station), whereas the minimum precipitation was recorded in 1986 (Zarima station) at a low 291 mm / yr (Zarima station). These findings indicate a great variability in the total rainfall over the years, as some unusually long rainy seasons with high rainfall are soon followed, on the other hand, by prolonged dry seasons with vital rainfall shortages (up to seven months of drought).

The highest rainfall is usually recorded in July and August, where the total is approximately equivalent to 52% of the annual average. Conversely, December and January are the driest months and frequently show little to no rain. (TWWDSE, 2011 G.C.).

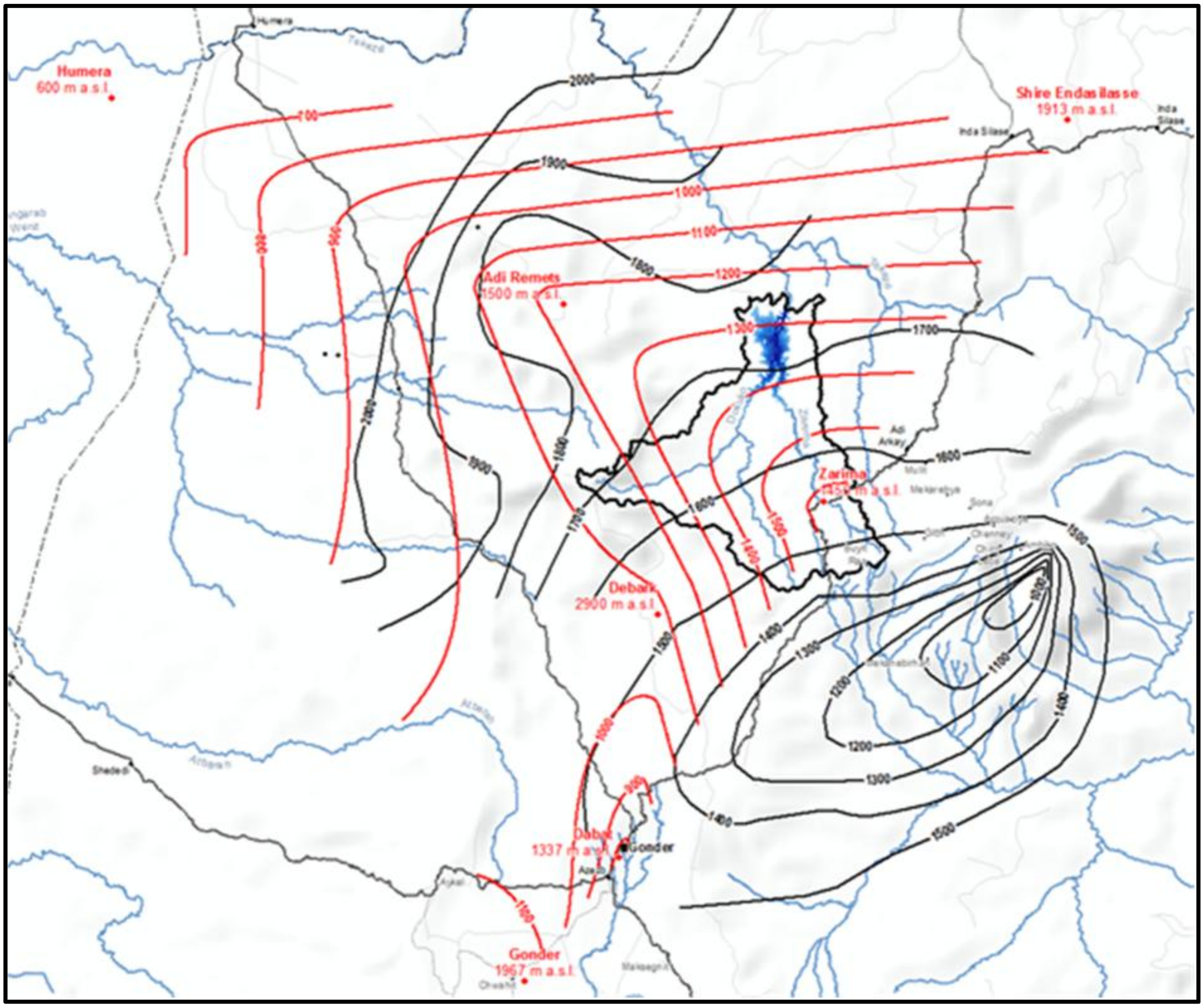

Figure 3-2 Meteorological stations with precipitation contours (red) and potential evapotranspiration (black) (WWDSE, Final Feasibility Main Report, 2012 G.C.).

3.3.3 Temperature

Mainly, the temperature is determined by altitude. Average annual temperatures in the lowlands (600 m asl) are above 26 ° C, while average temperatures in the Simien mountains are below 10 ° C. The average maximum temperature in the largest portion of the highlands is around 22 ° C. Minimum monthly temperatures are between 3 and 21 ° C in December-February, while maximum monthly mean temperatures are between 19 and 21 ° C in March-April, and maximum monthly mean values are between 19 and 43 ° C in March-April (TWWDSE, 2011 G.C.).

3.4 Water source

Within the Tekeze Basin is the Zarima watershed. Two sub-watershed areas are included in this watershed, which is fed by seven major rivers, namely Zarima, Ambera, Chilo, Dekuko, Mnjiro, May Timket, and Kota wonz, and other small perennial and seasonal rivers. At the center of the lower altitude, where there is a risk of irregular rainfall, the watershed sits. Based on its magnitude of flow, the main river for the watershed is the Zarima River which emerges from the mountain chains of Semen in Adarkay, Debark, and Tsegede woredas. This river is supplemented by its tributaries, Ambera, Chilo, Dikok, Mnjiro, May Timket, and Kota wonz Rivers, which emerge within the mountain chains of Simen. (TWWDSE, 2011 G.C.).

3.5 Zarima Dam and Reservoir

Zarema May Day Dam has a height of 144.00m, crest length of 730m, and the reservoir inundates about 9815 ha of land at the normal flood level. Assessment of availability of various construction materials for different types of dams has been carried out for embankment and gravity dams. Materials explored include impervious material for core, rock fill, rock for embankment, aggregate, and riprap, and filter and transition materials. (WWDSE, Final Feasibility Main Report, 2012 G.C.).

Chapter 4 METHODOLOGY

This portion of the technique presents different analysis techniques used to collect data, the form of data collected, how it was processed or treated. It also describes the construction and components of the computer model for the two cases and scenarios used to evaluate the model and analyze the operation of reservoirs under the various scenarios of water demand.

The development of a model to analyze the potential development of the yield and demand of water supplies and the associated modifications to the reservoir infrastructure is closely related to the available input data. Any input information has to be given to start a simulation.

4.1 Data Collection and Analyses

In order to run the model and find specific results for the simulations, data collection and interpretation of the available data is a major part of the thesis. Most of the operational part of the model result was determined by available data such as information on the demand for irrigation water and specifics, releases of spillways by variations in elevations, inflow, precipitation, evapotranspiration, and so on.

For data processing, the following items are considered.

- Establishing the river networks, catchment shape files by using GIS software river shapefiles for the Water-Shade module part.
- Inserting all necessary Reservoir physical Reservoir data and defining an alternative

- Simulate the reservoir system analysis by the HEC-ResSim hydrologic model software.

- Estimate the maximum irrigable land with different scenario, reservoir elevation and releases that can be utilized by existing water resources in the future.

Specific activities and approaches include:

1. Gather and analyze data required for reservoir modeling. This data includes:

WWDSE feasibility study (inflow and reservoir pool elevations and releases and the corresponding computed reservoir inflows, etc.) collected time series data. Physical and operational reservoir data including description of reservoir pool (elevation storage-area tables), outlet capacity curves, irrigation diversion data, operational zones, minimum and maximum release criteria, etc.

2. Create a model schematic that describes the watershed's main locations. Reservoirs, control points, diversion locations, and any other locations that are needed for the description of key locations and will be used as information for the analysis of performance. Form files of the selective part of Zarima Basin, including a file of the shape of rivers and streams, pool shapefile describing the positions of the reservoir. The entire necessary shapefile was created using GIS software.

3. For each major reservoir in the basin, define the physical and operational data. Physical reservoir information includes the concept of reservoir pool storage, dam elevation and length, outlets and their release capacities, and details on irrigation demand.

Defining operational data requires defining the zones or levels of the activity, the rules that limit releases for each zone, and a plan for release allocation that shows how releases will be distributed to the outlets available. The requisite physical information from the feasibility study was gathered.

4. Simulation of the reservoirs using different scenarios.

5. Compare and Analysis of simulation results using Microsoft excel.

4.1.1 Hydrological Data

As a direct input to the model, the HEC-ResSim model utilizes regular river inflows to the reservoir. Historical inflows were used for HecRes Sim as data imputation. This historical inflow dataset was created using a separate source. Monthly Zarima and Duduko dataset: In the hydrological feasibility study, an inflow dataset was acquired at WWDSE that centered on monthly inflows in Zarima and covered variable periods of history.

4.1.2 Evaporation from the Reservoir

The water that is lost to the air from the surface of the pond is called evaporation. The amount of water lost by evaporation depends largely on local climate conditions. High air temperatures, low humidity, strong winds and sunshine will increase evaporation. Low air temperatures, high humidity, rainfall and cloud cover will decrease evaporation. Evaporation will also depend on the water surface area. The larger the reservoir, the more water will evaporate from its surface.

One of the most common methods to find the evaporation rate is accurately to measure daily water losses from a standard-size container called a Class A Pan. Wind speed, minimum and maximum temperature, radition, relative humidity and Class A pan Evaporation Ep values were taken from the Agronomy and Agriculture Planning report for general sunshine hours.

Times (dayes)	daily total net radiation(MJ m-2 day-1)	Air Tamprater(0c)			Relative humidity(%)	wind speed (m/s)	Pressure (kPa)	Class A pan Evporation(mm/month)	Adjuest Ep (Ep*0.75)(mm/month)
		max	min	mean					
Jan	18	29.4	11	20.2	35	1.61	90.40	163.06	122.30
Feb	18	28.9	12.8	20.85	34.4	1.94	90.40	164.08	123.06
Mar	18	30.5	14.8	22.65	32.2	1.98	90.40	191.58	143.69
Apr	18	31.6	15.7	23.65	35.7	2.16	90.40	186	139.50
May	18	30.7	15.4	23.05	46.3	2.53	90.40	180.6	135.45
Jun	18	27.6	15.3	21.45	57.5	3.00	90.40	150.6	112.95
Jul	18	24.3	14	19.15	73.6	2.55	90.40	109.43	82.07
Aug	18	23.8	14.4	19.1	77.8	2.33	90.40	106.02	79.52
Sept	18	25.6	13.9	19.75	69.4	1.94	90.40	127.8	95.85
Oct	18	27.4	13.7	20.55	57.3	1.47	90.40	142.91	107.18
Nov	18	28.1	12.8	20.45	41.4	1.35	90.40	125.74	94.31
Dec	18	27.7	11.8	19.75	40	1.33	90.40	144.46	108.35

Figure 4-1 Evaporation Data for Zarima reservoir (TWWDSE, 2011 G.C.)

4.2 Simulation

We simulate two separate cases and their scenario after we have entered all the necessary data and generated alternatives. The applicable inputs to the model in our study case are:

1. Daily inflow series for Case $_1$ and Case $_{2.}$
2. Monthly irrigation demand (for 40,000ha, 30,000ha, 25,000ha).

3. Evaporation losses (mm).
4. Ecological flow release ($2.5m^3/s$).
5. Reservoir volume and area-elevation relationship.

4.3 Water balance

For the next alternatives regarding the operation of the reservoir, the calculation of water balance and irrigation water demand at Zarema May-Day Reservoir was carried out:

- Alternative R, water release from Zarema May-Day Reservoir is defined following the daily average discharge in the Zarema Basin in the period 1968-2010E.C.
- Alternative A, water release from the reservoir is defined by irrigation water demand (40,000 Ha) and ecological discharge of $2.5m^3/s$, constant along the operation period.
- Alternative B, water release from the reservoir is defined by irrigation water demand (30,000 Ha) and ecological discharge of $2.5m^3/s$, constant along the operation period.
- Alternative C, water release from the reservoir is defined by irrigation water demand (25,000 Ha) and ecological discharge of $2.5m^3/s$, constant along the operation period.

Combinations of the listed alternatives lead to the following realistic operations of the May-Day reservoir:

1) Scenario "R-A": water release from the reservoir is defined according to alternative "A".

2) Scenario "R-B": water release from the reservoir is defined according to alternative "B".

3) Scenario "R-C": water release from the reservoir is defined according to alternative "C".

4.4 Development of HEC-ResSim For ZARIMA Reservoir

The U.S. Army Corp of Engineers-Hydrologic Engineering Center developed the HEC-5 software for flood control and conservation systems simulation in 1973. It was originally written for the application of single flood events for flood control. The system was later extended to multi-event floods and provided basic capabilities for water supply and hydropower research. Finally, in 1977, pumped-storage hydropower analysis capacity was added. All versions were developed in FORTRAN and interfaced with the HEC-DSS data storage system.

With the implementation of a graphical user interface (GUI), HEC-5 has recently developed into HEC-ResSim software. Its simulation capabilities for hydropower include run-of-river generation study, peak power generation, pumped storage, and operation of system power. The reservoir releases are calculated to meet power production targets that may differ on a weekly, regular, or hourly basis to simulate hydropower activity. Additionally, the hydropower component takes into account the penstock capacity and losses, as well as leakage parameters.

The model makes it possible for the user to identify alternatives and run simulations to compare outcomes simultaneously. The HEC-ResSim schematic elements allow watershed, reservoir network, and simulation data to be visually represented in a geo-referenced context that interacts with associated data. HEC-ResSim is also compatible with ArcGIS shapefiles, which can be used as a background layer to allow the physical system to be better represented. Watershed boundaries, reservoirs, channel networks, diversions, etc. can be superimposed over the shapefile.figure 4.2 describes the graphical illustration of HEC-ResSim.

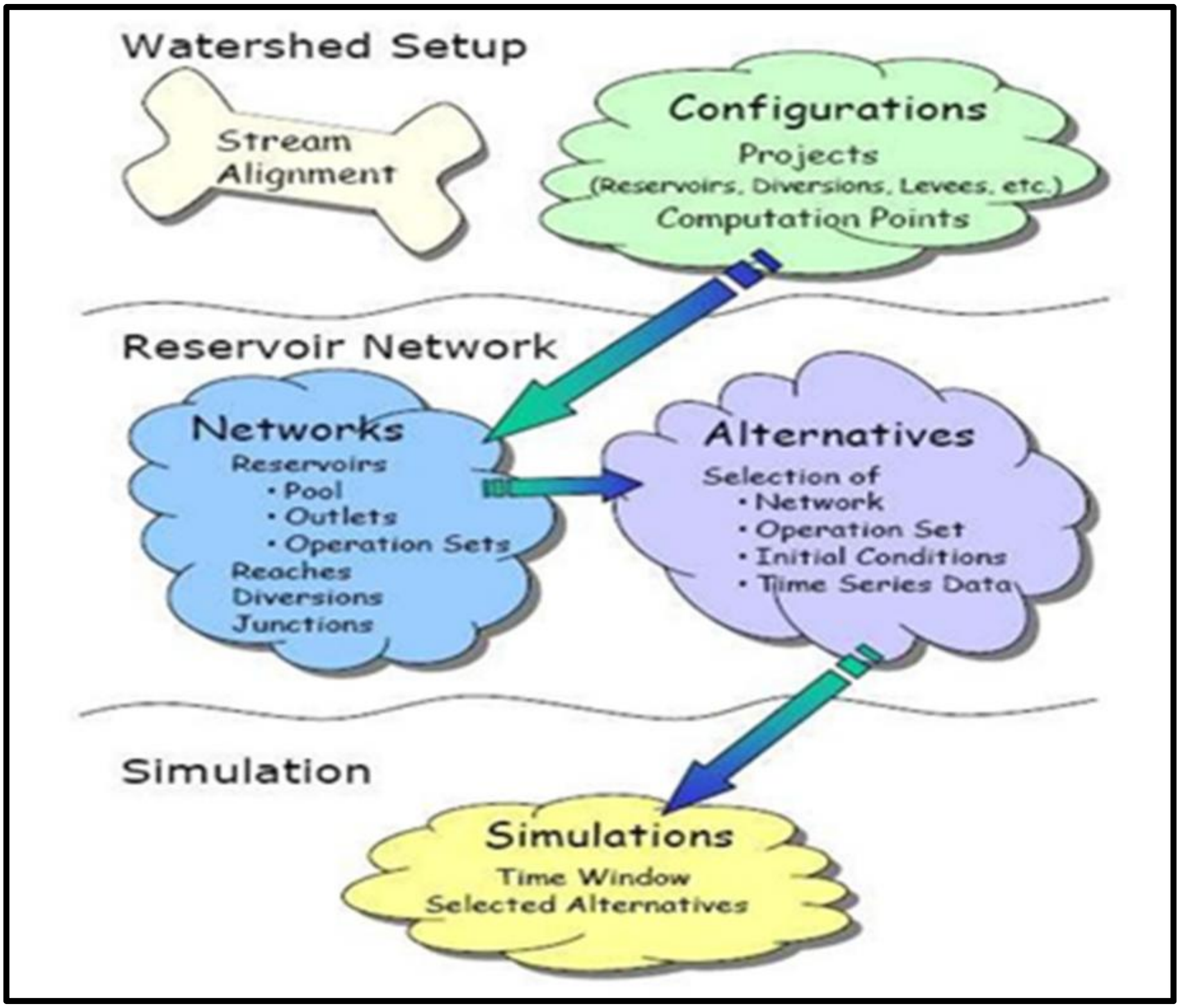

Figure 4.2 Graphical Ilustration of the HEC-ResSim modules.

The HEC-ResSim program is divided into three modules which are the watershed setup, the reservoir network definition, and the simulation scenario management.

4.4.1 WaterShed Setup

Zarima Watershed is one of the Tekezi Basin sub-basins. Major streams, projects (e.g. reservoirs), computing points, time-series positions, and hydrological and hydraulic data points for a particular region can be included in the watershed.

Adding the map layers into the HEC-ResSim model, Schematization & configuration of stream alignment & configurations of the projects were done. Arc-View GIS files (Shapefiles) of the basin were used as the background layer for the model schematic and delineation of the stream alignment. Map/shape/ file includes rivers, streams, the existing and the proposed dam sites (projects), hydrological and metrological gage locations, and a watershed boundary. Using the necessary drawing tools from the HEC-ResSim drawing toolbar, these projects and computation points are developed. Reservoir inflow and outflow points, operational location, and confluences are included in computation points (modeling points. Refer Figure 4-2 Zarima reservoir watershed setup (HEC-ResSim).

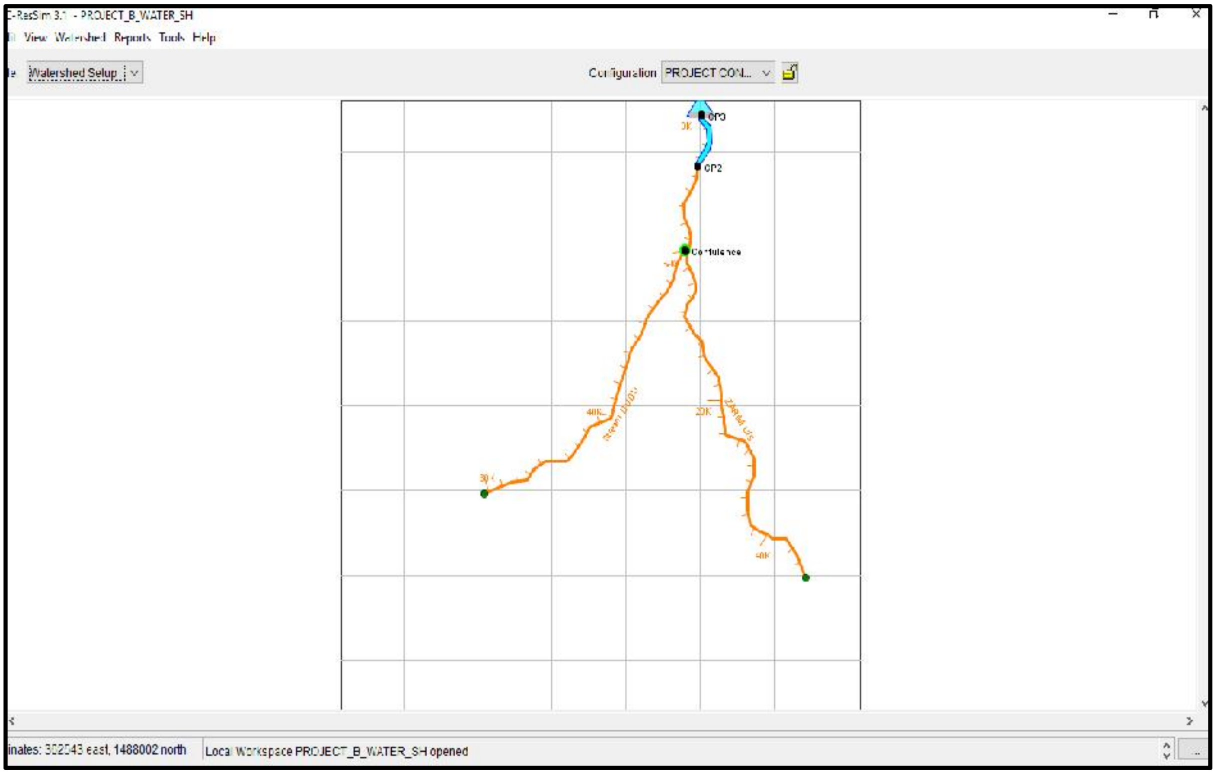

Figure 4-2 Zarima reservoir watershed setup (HEC-ResSim)

4.4.2 Reservoir Network Setup

The physical and operational elements of the reservoir are identified and the alternatives that need to be evaluated are developed in the Reservoir Network module network schematic. The basis of a reservoir network will be built using configurations that are created as a blueprint in the watershed setup module. Then, to complete the connectivity of the network schematic, routing reaches and even other network elements would be added. Once the schematic is complete, physical and operational information is specified for each aspect of the network.

Alternatives that define the reservoir network, operation set(s), initial conditions, and pathname assignment (time-series mapping) are also developed. refer the figure 4.4 below Zarima reservoir Network setup (HEC-ResSim) .

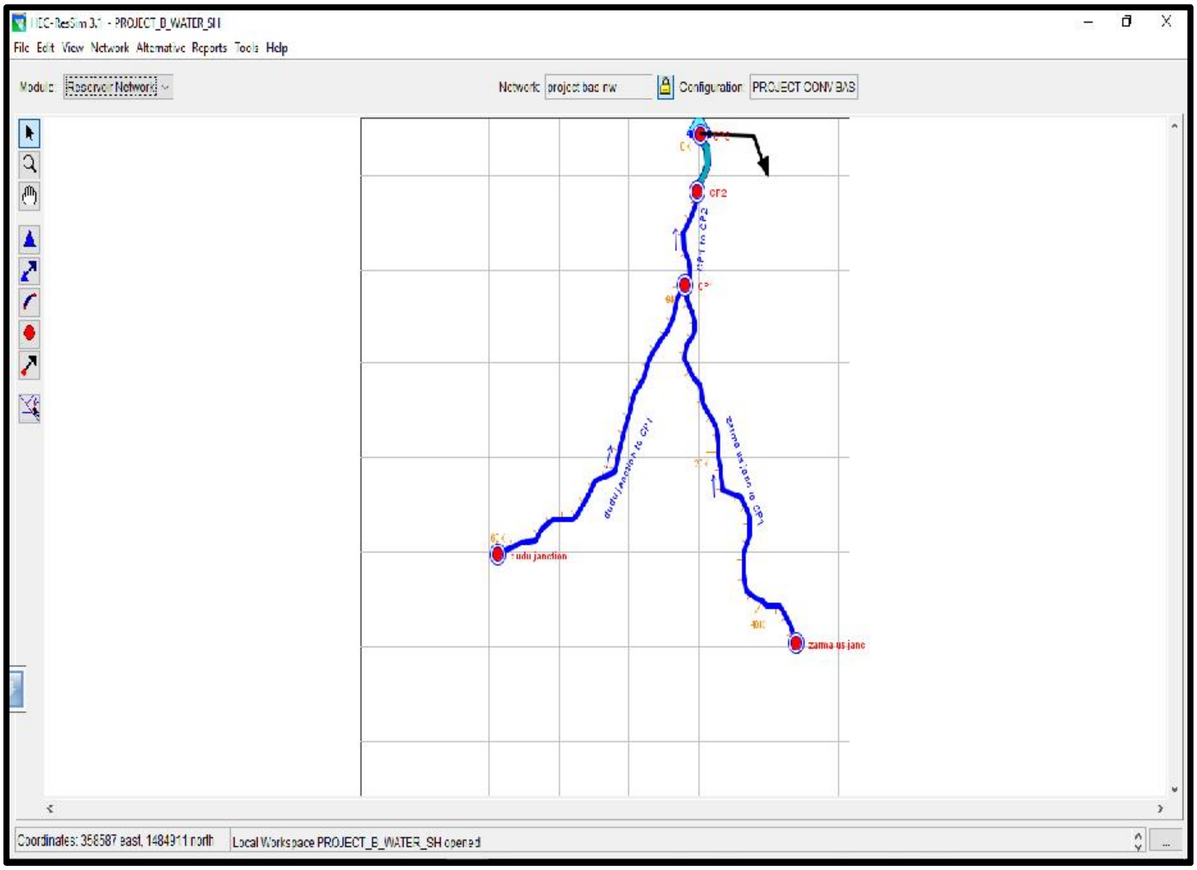

Figure 4-3 Zarima reservoir Network setup (HEC-ResSim)

4.4.3 Simulation Module

The Simulation module allows the model to test different river flow hypotheses once the reservoir model is complete and the alternatives have been identified.

A computing period and the alternatives to be evaluated must be defined when a simulation time window is formed. Then, ResSim creates a directory structure that represents the simulation within the RSS folder of the watershed. There will be a copy of the watershed inside this simulation tree, including only those files required by the selected alternatives.

A DSS file called simulations, which will eventually contain all the DSS records that represent the input and output for the chosen alternatives, is also generated in the simulation. Additionally, elements for subsequent simulations can be modified and saved.refer Figure 4-4 Zarima reservoir Simulation setup (HEC-ResSim)

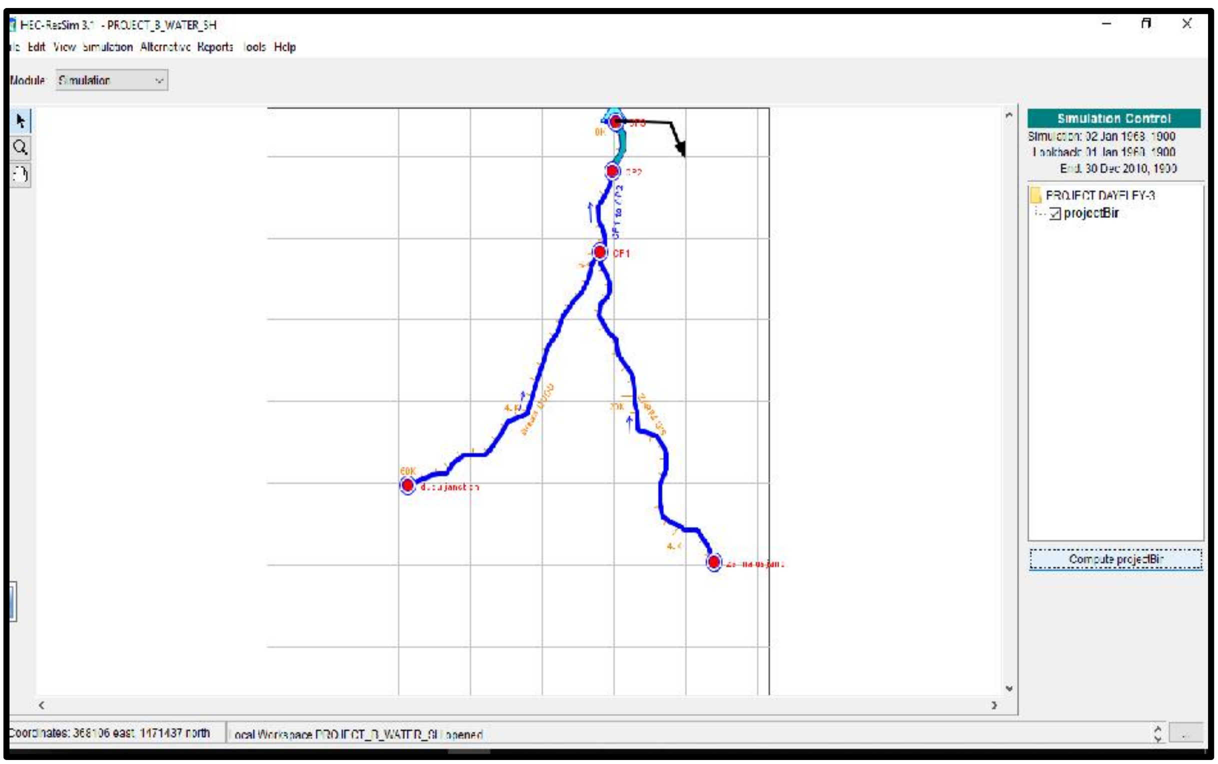

Figure 4-4 Zarima reservoir Simulation setup (HEC-ResSim)

4.4.4 Junction

Four functions serve the junction elements: 1) they connect model elements, 2) they are how flow (headwater or incremental) enters the network, 3) they combine flow, the outflow of a junction is the sum of the inflows to the junction, and d 4) they measure stage using the measured junction outflow when supplied with an optional rating curve. The focus area has 5 junctions in this analysis of the Zarima river basin. There are 2 junctions in the reservoir. One is water for inflow and the other is water for outflow or release.The relation between network elements is taken for granted once a reservoir network is assembled, but a good model design requires junctions at key locations to efficiently identify and manage inflow data through various alternatives.

Junctions can fall into two groups, depending on the inflow locations: boundary junctions and interior junctions. Boundary junctions in the network have no reaches or reservoirs above them and usually consider a single upstream metric or inflow reflecting the cumulative inflow of headwater. Until passing the total flow onto the downstream portion, interior junctions combine inflow routed from upstream with incremental local flow.

4.4.5 Reach

Routing reaches represent the natural streams of the system which route water from one junction to another in the network. Routing is done in HEC-ResSim using one of a handful of hydrologic routing methods. The lag and attenuation of flow within a range are determined by one of a variety of available standard hydrological routing methods, such as Muskingum, Modified Puls, Coefficient, or Muskingum-Cunge. For each routing array, losses via seepage can be listed. For this, the Muskingum technique is used.

For the Muskingum routing scheme, three parameters, Muskingum K, Muskingum X, and the number of sub-reaches, are required. The K parameter is the travel time of the flood wave through the reach, the X parameter is used because of the channel and overbank storage to model the flood wave attenuation, and an additional parameter is the number of sub reaches that affect the amount of attenuation through the reach.

The X parameter is dimensionless and can vary from 0.0– 0.5. A value of 0.0 maximizes attenuation of the flood wave and a value of 0.5 does not attenuate the flood wave, indicates a “direct translation” of the hydrograph through the reach. K is approximated using the kirpich’s formula: $K=0.0078L^{0.77}\ S^{-0.385}$. Where K=travel time for a drop of water to travel from the remotest point outlet (minute). L= Length of channel/ditch from headwater to the outlet in ft and S= average watershed slope, ft/ft.The computed (K) in hr, X and the number of sub-reach values have been entered as an input to reach the editor of the reservoir network model.In this analysis, the flow from Duduko junction to CP 1 (Reach Duduko), from Zarima junction to CP1 (Zarima Reach), and CP1 to CP 3 (Reach Confluence) is routed to three routing points.refer Figure Figure 4-5 Zarima reservoir reach editor (HEC-ResSim) .

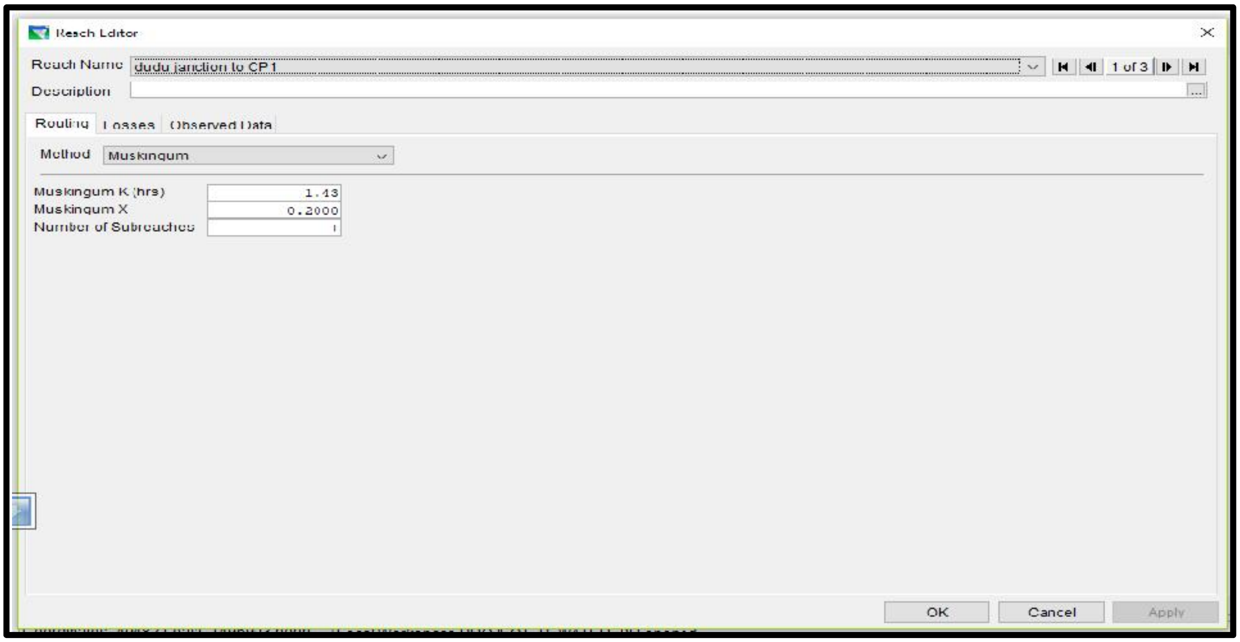

Figure 4-5 Zarima reservoir reach editor (HEC-ResSim) .

4.4.6 Reservoir

The Reservoir Network is the next development phase after the creation of the watershed. The Reservoir Network Module has the purpose of separating the production of the reservoir model from the analysis of the output. One will create the river system schematic in the Reservoir Network module, identify the physical and operational elements of the reservoir model, and establish the alternatives to be studied. The foundation of a reservoir network has been built using configurations that are created as a blueprint in the Watershed Setup Module. The routing ranges were then introduced and other network elements were also added to complete the network scheme's connectivity when the schematic is complete, it integrates physical and operational data for each aspect of the network.

Alternatives have also been developed to define the reservoir network, operation set(s), initial conditions, and DSS pathname assignment (time-series mapping). There may be four types of network components represented by HEC-ResSim: junctions, routing routes, diversions, and reservoirs.

4.4.7 Physical Components

The definition of physical components is one of the most significant aspects of the HEC model. Tiny modifications also have a significant influence on the system's behavior and the results in the simulation section deteriorate or improve the result. The feedback that should be taken into account for the physical part consists of the reservoir pool characteristics that are characterized by the storage-elevation-area curve and the dam properties consisting of unregulated and controlled outlets along with tailwater elevation and downstream power.refer

Figure 4-6 Zarima reservoir editor (HEC-ResSim)

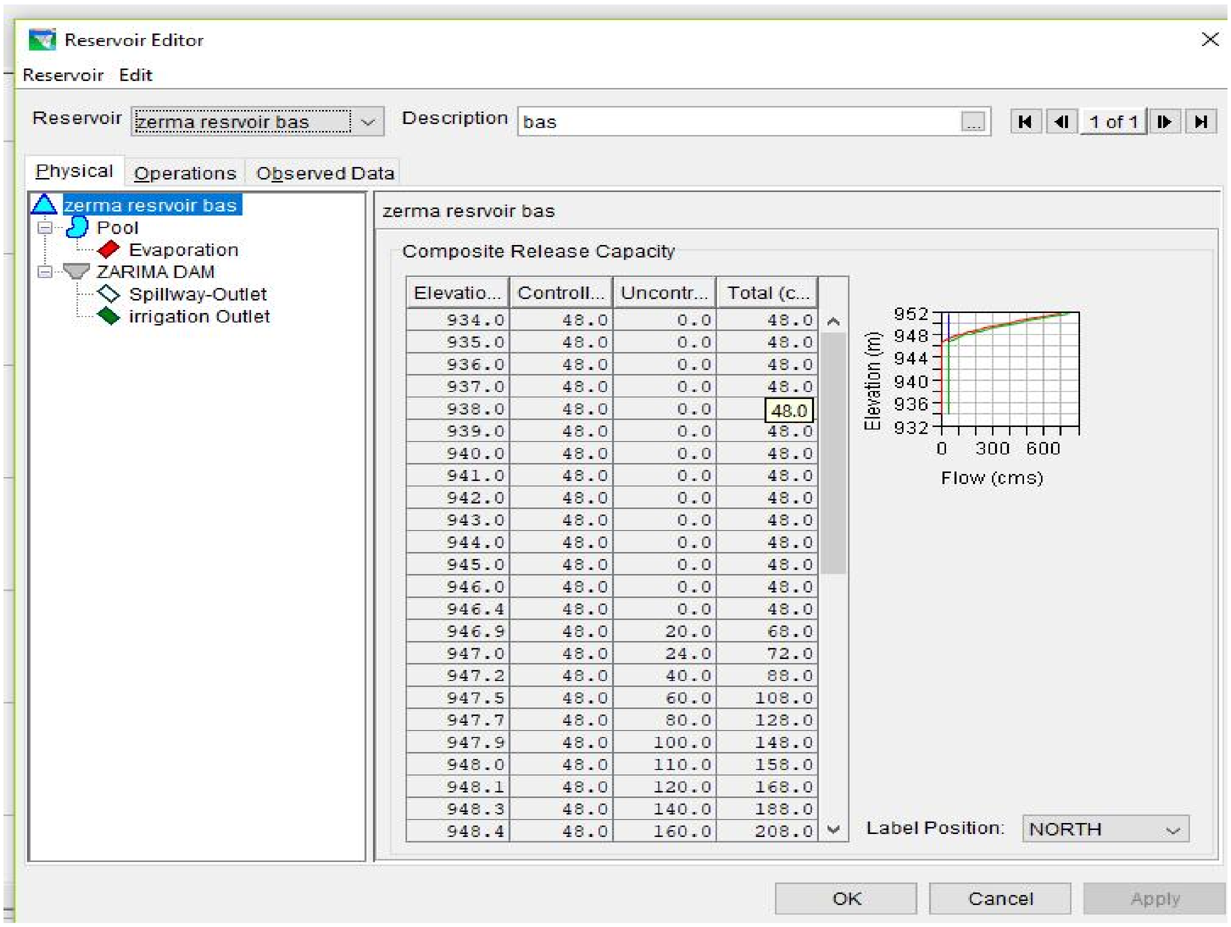

Figure 4-6 Zarima reservoir editor (HEC-ResSim).

4.4.8 Storage Elevation Area

WWDSE, performed the volume-elevation curve and region-elevation curve of the Zarima reservoir. as an input i use for the Zarima Dam reservoir modeling.Based mainly on the DEM images, the physical characteristics of the reservoir have been computed by five meter elevation differnce.

Through the DTM survey, corrections were implemented in the dam area.refer Table 4-1 Zarima reservoir Volume-Elevation relationship and reservoir surface. and Figure 4-7 Volume-Elevation relationship (storage curve) of Zarema reservoir..

Elevation (m asl)	Area (sq km)	Storage (M m3)	H	Area (hectares)	Storage (m3)
820.00	0.00	0.00	0.00	0.01	100.00
825.00	0.01	0.00	5.00	1.30	250.00
830.00	0.26	1.00	10.00	25.50	1,000,000.00
835.00	0.52	3.00	15.00	52.20	3,000,000.00
840.00	0.84	6.00	20.00	83.70	6,000,000.00
845.00	1.20	11.00	25.00	120.10	11,000,000.00
850.00	1.87	19.00	30.00	187.00	19,000,000.00
855.00	2.40	30.00	35.00	240.40	30,000,000.00
860.00	3.11	43.00	40.00	311.20	43,000,000.00
865.00	3.97	61.00	45.00	396.80	61,000,000.00
870.00	6.01	86.00	50.00	601.10	86,000,000.00
875.00	11.74	130.00	55.00	1,173.60	130,000,000.00
880.00	14.59	196.00	60.00	1,458.60	196,000,000.00
885.00	18.08	278.00	65.00	1,807.80	278,000,000.00
890.00	21.74	377.00	70.00	2,174.40	377,000,000.00
895.00	28.18	502.00	75.00	2,817.60	502,000,000.00
900.00	34.25	658.00	80.00	3,425.00	658,000,000.00
905.00	40.00	844.00	85.00	3,999.50	844,000,000.00
910.00	46.54	1060.00	90.00	4,654.40	1,060,000,000.00
915.00	52.08	1307.00	95.00	5,208.00	1,307,000,000.00
920.00	58.87	1584.00	100.00	5,886.60	1,584,000,000.00
925.00	65.58	1895.00	105.00	6,558.40	1,895,000,000.00
930.00	72.60	2241.00	110.00	7,260.30	2,241,000,000.00
935.00	80.58	2624.00	115.00	8,058.30	2,624,000,000.00
937.75	84.14	2834.00	117.75	8,413.55	2,834,000,000.00
940.00	87.69	3044.00	120.00	8,768.80	3,044,000,000.00
945.00	96.12	3504.00	125.00	9,612.40	3,504,000,000.00
646.40	98.31	3644.00	126.40	9,830.52	3,644,000,000.00
950.00	103.91	4004.00	130.00	10,391.40	4,004,000,000.00
955.00	112.64	4545.00	135.00	11,264.20	4,545,000,000.00

Table 4-1 Zarima reservoir Volume-Elevation relationship and reservoir surface. (WWDSE, Final Feasibility Main Report, 2012 G.C.)

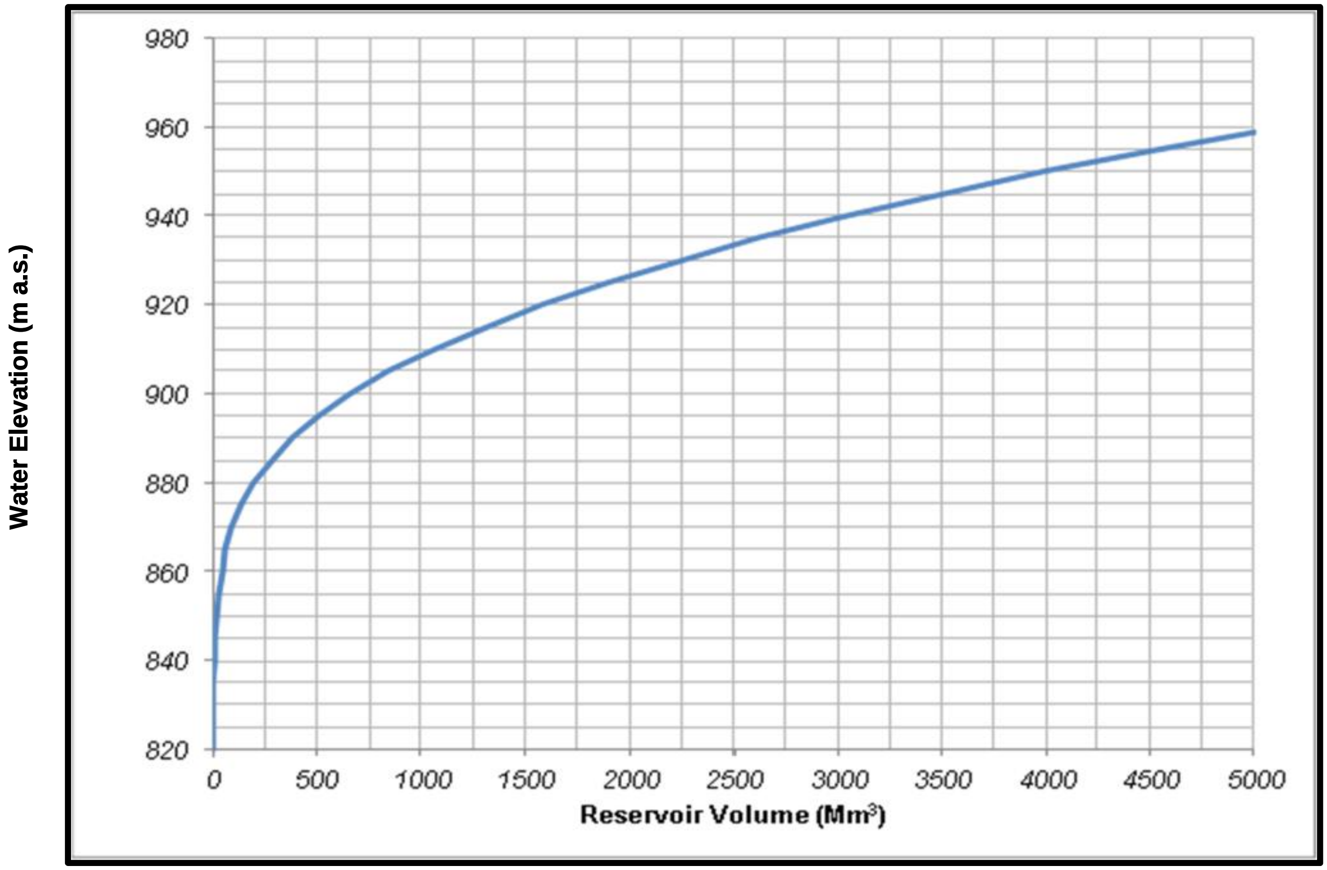

Figure 4-7 Volume-Elevation relationship (storage curve) of Zarema reservoir. (WWDSE, Final Feasibility Main Report, 2012 G.C.)

4.4.9 Reservoir Capacity

The physical features of the Zarema reservoir were obtained from the topographical characteristics available. Increases of 5 m were determined for the volume-elevation relationship, also known as the storage curve.Table 4-1 Zarima reservoir Volume-Elevation relationship and reservoir surface.

4.4.10 Spillway (uncontrolled)

The spillway consists of a 30 m wide shallow approach flow overflow crest, an approximately250 m long, 23 m deep, concrete-lined, slightly sloping channel with a head of 130 m, 360 m long, almost 50 m wide, and almost fully unlined, stepped chute.

At the end of the spillway channel, the design comprises a nearly 65 ° bend, which is intended to direct the flow into the stepped chute. The curve consists of three vanes and associated deflecting walls, a collection of diagonal sills at the bottom of the channel, and at the end of the curve, two rows of buffer blocks.

The ogee crest consists of two 14.5 m bays, each divided by a 1 m wide pier (30 m total) supporting the spillway bridge. The pier frame reaches into the spillway channel for around 15 m; the length of the total pier is about 26 m. The training walls of the spillway stretch almost 19 m into the approach channel, with a 10 m curved radius shape.

The bottom grade of the spillway channel is 0.5%, the cross-section is rectangular, with a width ranging from 30 to 23 m and a constant height of 6 m.

Using convergent sidewalls, the transformation is realized and starts some 12 m downstream from the crest pier. With a convergence angle of about 4.5 degrees and a general length of 45 m, the transition is straight-lined.

The channel segment at the terminal bend is divided into 3 curved vanes, each 7 m high, separated by an approximately 1.5 m thick deflection wall that stretches over the entire bend. Near the end of the bend, the bottom of the channel is indicated by 2 diagonal steps.

Each phase has a height of about 1.8 m and stretches across the entire vane concerning the channel axis, the steps indicate an angle of 30 degrees. 2 rows of baffle blocks are mounted immediately downstream from the end of the bend, spanning across the entire channel width, with a staggering pattern for a total of 29 blocks. Every block is 1.5 meters wide, 1.8 meters long, and 1.8 meters high. Around 4 m downstream from the end of the deflecting walls is the first row, followed by the second row after 2 m.

The stepped chute is built for the full spectrum of discharges to function in a nappy flow regime. The height of the steps ranges between 3.2 and 3.4 m. The lining of concrete stretches downstream to near El. 915.60m MASL. (WWDSE, Final Feasibility Main Report, 2012 G.C.)

4.4.11 Irrigation intake (controlled)

Dam irrigation outlet systems are primarily located at the dam body and/or at the dam abutment. Zarema May-Day Dam outlet's special nature is its position at the edge of the reservoir, 6.5 km from the left side of the edge of the dam. (WWDSE, Final Feasibility Main Report, 2012 G.C.).

4.5 Operation Component

Each reservoir in the ResSim network must decide the amount of water to be released at each point of a simulation run in a manner comparable to the methods an operator would use. For this to occur, it is possible to make scheme decisions on the release or to define an active schedule.

This strategy is referred to as Operation Package. (2013 HEC) An operation set consists of three basic features: Zones, Rules, and the identification of the Guide curve. Refer Figure 4-8 operational component of Zarima reservoir (HecRes Sim).

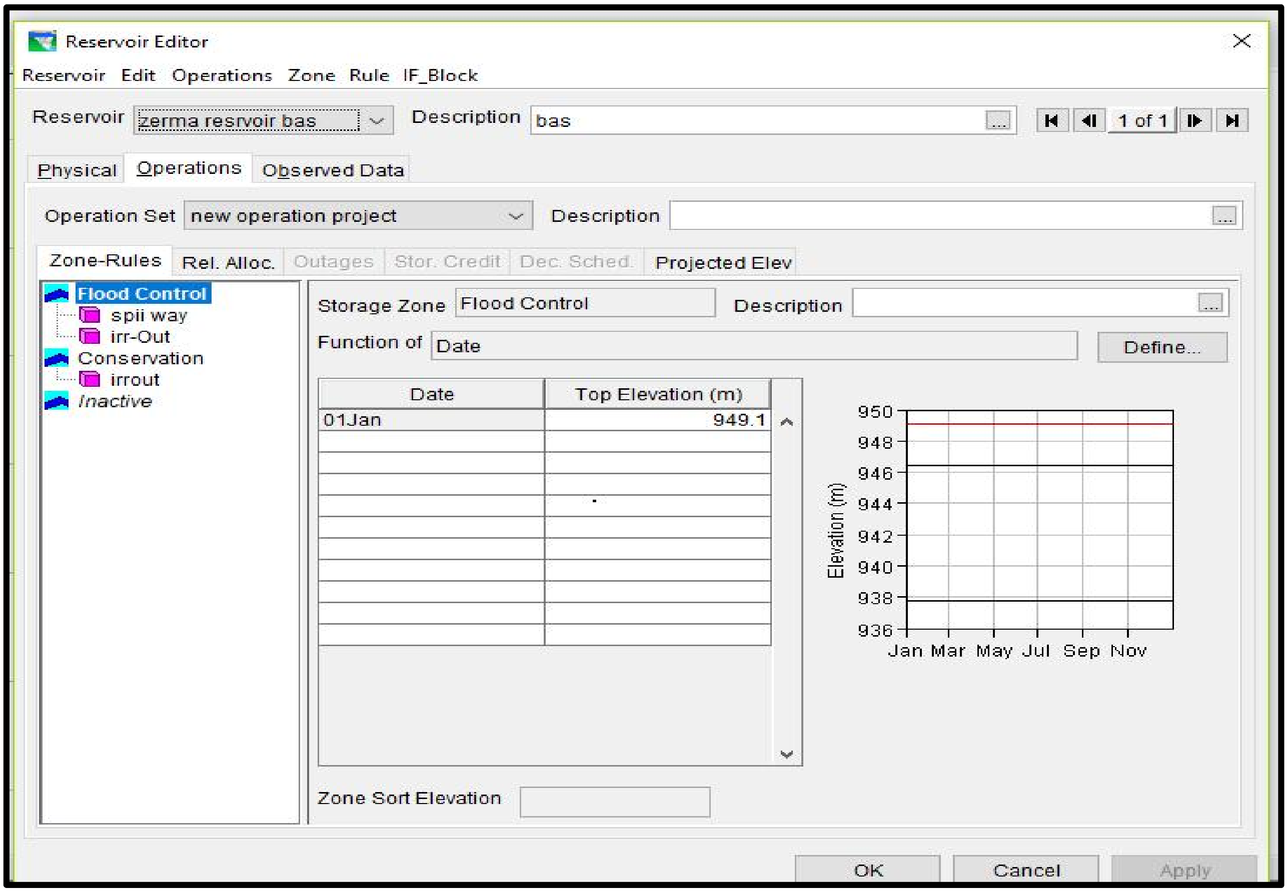

Figure 4-8 operational component of Zarima reservoir (HecRes Sim).

4.5.1 Zone

Storage for reservoirs is divided into four zones, or ponds. That includes the flood-control zone, conservation zone, buffer zone, and inactive zone, from top to bottom. The conservation and buffer ponds, combined, constitute the active storage of the reservoir.

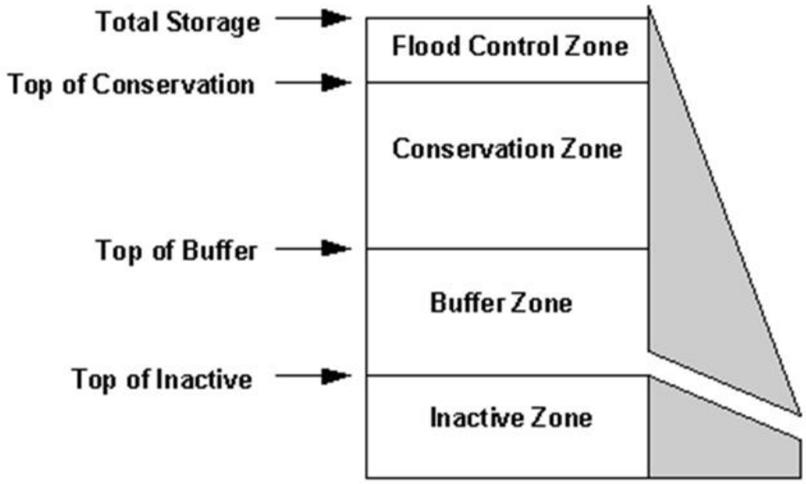

Figure 4-9 Reservoir storage zone.

4.5.2 Rule

Operation rules describe the logic used to make decisions on the reservoir to releasing water or not. Refer Figure 4-10 operational rule of Zarima dam (HecRes Sim).

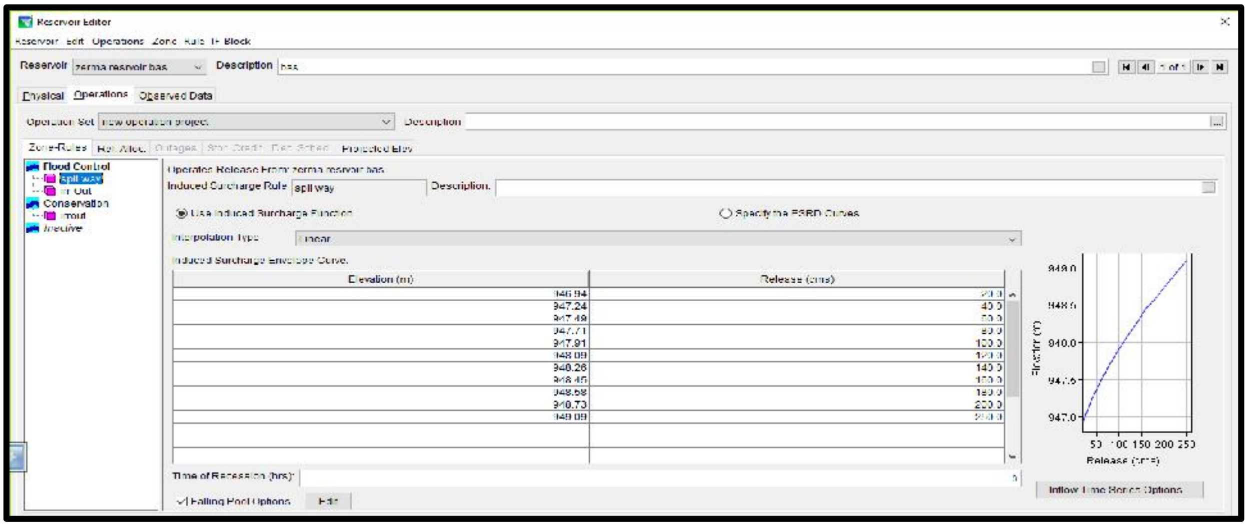

Figure 4-10 operational rule of Zarima dam (HecRes Sim).

4.5.3 Guide Curve

A reservoir has to have a goal elevation in HEC-ResSim. The target elevation of a reservoir, depicted as a function of time, is called its Guide Curve. It is the dividing line between the reservoir's upper zones (usually called the flood-control pool) and the lower zones (usually referred to as the conservation pool). Guide Curve specifies the reservoir level between the flood and reservoir pools. Guide curve operation oversees releases to maintain that storage level.

The general release activity is to release water as rapidly as possible when high inflows enter the flood pool and increase storage above the guide curve, or minimize releases to the minimum amounts needed to fulfill the requirements of buffer, conservation, or hydropower when inflows are low and storage level is drawn down below the guide curve.

As inflows decrease (after flood pool invasion) or inflows increase (after draw-down into the hydropower or conservation pools), operations of the guide curve begin to guide the level of storage back to the Guide Curve.

In HEC-ResSim, the release decision logic begins and ends with the curve of the guide. When the elevation of the reservoir is above the guide curve, the reservoir wants to release more water than enters the pool; when the guide curve is below, the reservoir wants to release less water than enters the pool. Both operational laws and physical restrictions serve as limits on the capacity of the reservoir to achieve the objective of returning the pool to the elevation of its guide curve. Without rules, the reservoir is limited only by the physical ability of the outlets to get to and remain at the elevation of the guide curve.

4.5.4 System Balance Storage

According to the inflow outflow equation, the water balance was determined based on mean monthly flows. The key input components are inflow into the reservoir (1968-2010) for each case; rainfall throughout the water surface of the reservoir, inflow across the reservoir and the dam body, sewage, and evaporation across the ranges (negligible and not included in the calculation). The key components of production are controlled reservoir release (irrigation and environmental flow) losses due to evaporation from the water surface of the reservoir overflow (spillover).

4.6 RESULT AND DISCUSSION

In this thesis, we conducted the simulation of the Zarima May Day dam reservoir operation for different Cases and scenarios using HecRes Sim module software.

The general objective of the thesis was to conduct a reservoir operation system of the planned irrigation scheme at Zarima May Day reservoir using Hec_ResSim (Hydrological Engineering center reservoir system simulation) modeling.

The simulation was made for 1968-2010 (43) years using the daily inflow data at the dam site, monthly irrigation diversion data (CWR), monthly evaporation data, and the minimum monthly ecological release for downstream of Zarima reservoir as inputs to the HEC-ResSim model.

The maximum reservoir level of Zarima reservoir is 946.4 m a.s.l. while the minimum water operation level is 937.75 m a.s.l. live storage capacity is 786,480,000 m^3. Basic characteristics are presented in the following scheme.

4.6.1 The initial condition and simulation constraints for all scenarios were:

a) Initial water level, 946.40 m a.s.l., corresponding to the spillway crest (normal water level);

b) Minimum water level, 936.4 m a.s.l., defined by the intake operative level;

c) Reservoir live storage, 786,480,000 m^3. Mm3.

4.6.2 Irrigation demand

The flowing table describe the irrigation water requirement for welkite sugar cane for differt irrigation area. rfer

Table 4-2 crop water requirement (Sugar cane).

Irrigation water demand and Envaromental discharge				
month	**Irrigation water demand 40,000ha (m3/s)**	**Irrigation water demand 30,000ha (m3/s)**	**Irrigation water demand 25,000ha (m3/s)**	**Environmental discharge (m3/s)**
January	27.37	20.53	17.11	2.50
February	36.92	27.69	23.07	2.50
March	43.78	32.83	27.36	2.50
April	36.73	27.55	22.96	2.50
May	32.36	24.27	20.22	2.50
June	14.92	11.19	9.32	2.50
July	3.26	2.44	2.04	2.50
August	2.09	1.57	1.31	2.50
September	12.73	9.55	7.96	2.50
October	27.94	20.96	17.46	2.50
November	31.71	23.78	19.82	2.50
December	25.98	19.48	16.24	2.50

Table 4-2 crop water requirement (Sugar cane) (TWWDSE, 2011 G.C.).

4.6.3 Monthly irrigation Deficit

The irrigation deficit, described as the number of months with a release of water lower than the defined demand, over the 43 years long simulation, is approximate 50% (260 months over 516) for the production of sugarcane (40, 000 ha), and 17% (90 months over 516) for the production of sugarcane (30, 000 ha) and 13% (65 months over 516) for the production of sugarcane (25, 000 ha).

The deficit is expected in March to July for Scenario “A”, May to June for scenario “B” and only June and July for scenario “C”, for exceptionally dry seasons, starting from April. Refer Table 4-3 Surmised average monthly irrigation deficit .

Summarized average monthly irrigation deficit for case 1 and case 2. for 43 year time serious (1968-2010) .												
In case average inflow is 41 m^3/s												
Area	January	February	March	April	May	June	July	August	September	October	November	December
40,000 Ha	-	-	4.41	3.14	10.53	5.82	0.52	-	-	-	2.77	-
30,000 Ha	-	-	-	-	2.98	2.78	-	-	-	-	-	-
25,000 Ha	-	-	-	-	-	0.60	-	-	-	-	-	-
In case average inflow is 31 m^3/s												
Area	January	February	March	April	May	June	July	August	September	October	November	December
40,000 Ha	-	-	8.97	11.33	18.59	8.17	0.60	-	-	-	2.91	-
30,000 Ha	-	-	-	-	2.91	4.29	1.79	-	-	-	-	-
25,000 Ha	-	-	-	-	-	2.93	1.74	-	-	-	-	-

Table 4-3 Surmised average monthly irrigation deficit .

4.6.4 Case 1

When WWDSE study of monthly average inflow is concedering. The sumrize table below show the possible irrigation defficet monthes,for three differ irrigable land ther is adeficit monthes.pleas refer Table 4-4 Reservoir operation model for case one.

Reservoir operation, model simulation (1968-2010) 41 m3/s			
	40,000Ha	30,000Ha	25,000Ha
N° months with irrigation deficit	260(516)	90(516)	65 (516)
Irrigation deficit (% months)	50%	17%	13%
N° years with at least 1 month deficit	43(43)	43(43)	43(43)
Maximum monthly deficit (m3)	(123,949,333.00)	(94,635,999.75)	(29,820,010.88)
Maximum annual deficit (Mm3)	(389,370,916.77)	(271,387,250.88)	(31,811,012.48)
Max. monthly spillway release (m3/s)	700.00	700	700

Table 4-4 Reservoir operation model for case one .

4.6.5 Case2

if 75% of WWDSE study monthly average inflows is cocedering.also for those three monthes there is adefecite monthes but the pesent of those defecate monthes there asmall incremental. Pleas refer

Table 4-5 Reservoir operation model for case two.

Reservoir operation, model simulation (1968-2010)			
	40,000Ha	30,000Ha	25,000Ha
N° months with irrigation deficit	258(516)	96 (516)	68
Irrigation deficit (% months)	50%	19%	13%
N° years with at least 1 month deficit	43 (43)	43 (43)	43 (43)
Maximum monthly deficit (m3)	(123,949,333.00)	(11,126,432.25)	(988,329.60)
Maximum annual deficit (Mm3)	(527,882,486.00)	(23,709,888.75)	(22,766,400.00)
Max. monthly spillway release (m3/s)	80.54	592.97	468.09

Table 4-5 Reservoir operation model for case two.

4.6.6 Zarima Reservoir rule curve

Developing of reservoir rule curve is one of the objectives of this thesis, after accomplishing the simulation of HEC-ResSim the data we found in tabular form is export to exile and we develop reservoir rule curve for each year of the time serious. As the figure shown below the rule curve of 41 years is almost in a similar manner but the year 2010 and 1994 show as maximum release rule due to excess rainfall. Refer Figure 4-11 each year reservoir pool level of Zarima reservoir (1968-2010).

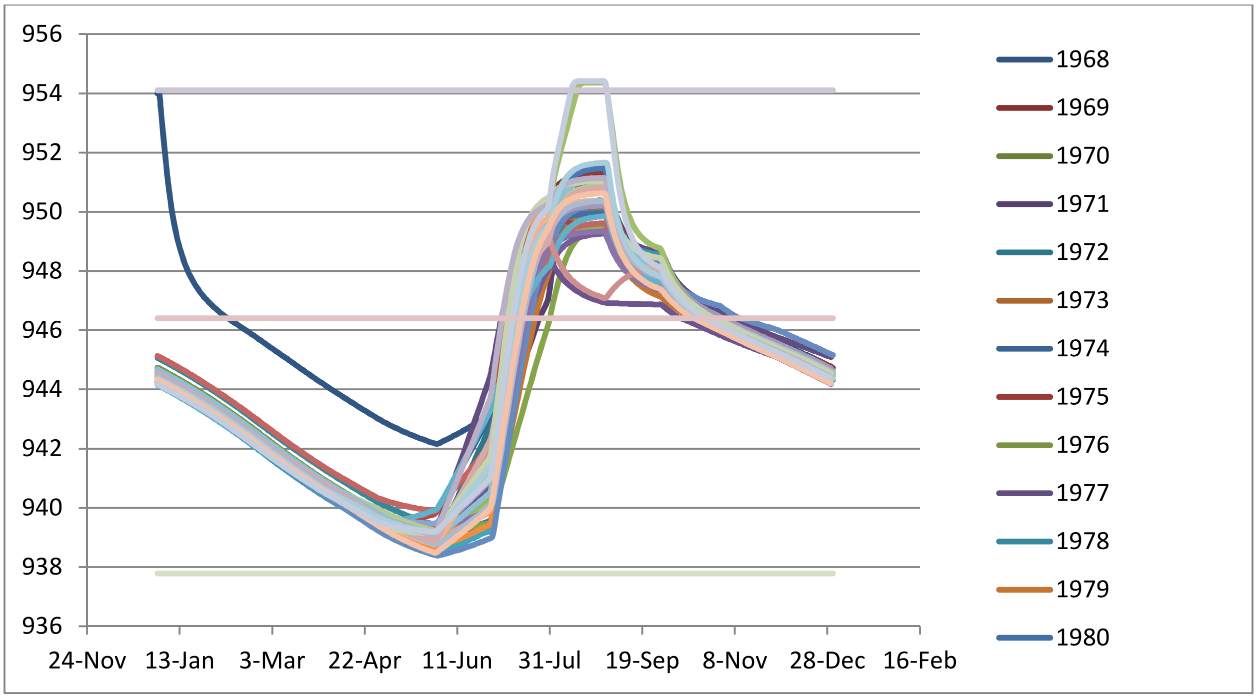

Figure 4-11 each year reservoir pool level of Zarima reservoir (1968-2010).

As we discussed before the release decision logic in HEC-ResSim starts and ends with the guide curve. When the reservoir's pool elevation is above the guide curve in our case maximum operation level 946.4m MASL, the reservoir wants to release more water than is entering the pool.

When below guide curve in this case when the reservoir is at minimum operating level is 937.78m and the reservoir wants to release less water than is entering the pool. As the table below shows the reservoir maximum and minimum operating rule depend on the daily available inflow and the monthly required irrigation demand. Refer

Figure 4-12 Operational guide curve of Zarima reservoir.

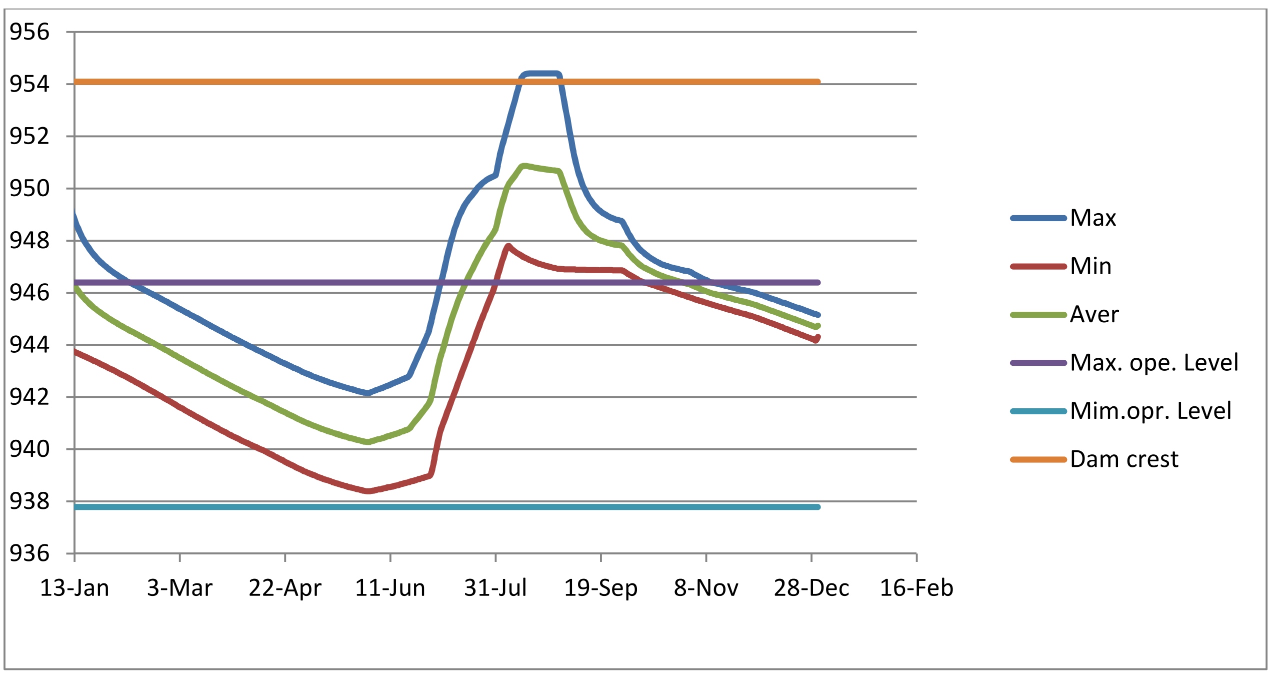

Figure 4-12 Operational guide curve of Zarima reservoir.

Chapter 5 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The objective of the thesis is to develop reservoir operation modeling for Zarima May Day reservoir using HEC-ResSim 3.1 model software considering 43 years of daily inflow, monthly irrigation, monthly evaporation data, and the minimum monthly ecological release demand downstream of Zarima reservoir as inputs to HEC-ResSim model.

The study commenced with gathering all the available metrological and hydrological data from WWDSE hydrological feasibility study. The dam was constructed downstream of the confluence of Zarima and duduk river therefore the flood during the rainy season is the main source of water.

The necessary physical characteristics of the dam are inserted into the software, the data was gathered from the final SGI dam study. The maximum and the minimum operating level is 946.4m and 937.78m m.a.s.l respectively.

The reservoir operation modeling has been performed for two cases. In case one, the average inflow is 41m3/s (as per WWDSE hydrological feasibility study), and Case two, the average inflow is 31m3/s (75% WWDSE hydrological feasibility study for the safety reliability) and different alternatives regarding the operation of reservoir, alternative “R” water release from the reservoir, “A” water release for 40,000 Ha environmental discharge, and “B” water release for 30,000 Ha environmental discharge and “C” water release for 25,000 Ha and environmental discharge 2.5 m3/constant along the operation period.

Regareding to the above works I conclude that for bothe cases inflow onley Scenario 3,water releas for 25,000Ha is low dficet monthes therfor the project shall be concederde thes and have to use the reserviore rull curve for effective operation.

5.2 Recommendation

The irrigation deficit can be successfully mitigated if adopting the following strategies: for the two Cases

1. By constructing a control gate the release of water in the river through the spillway. The excess inflow may be temporarily stored in suitable check reservoirs along with the irrigation network;
2. Due to the limit of water source and for efficient use, the irrigation system of welkit sugar can project shall be drip irrigation or sprinkler irrigation.best example Tana Beles suger Factory and Wenje Shewa Factorey.
3. To be modeling the system more accurately, a measured inflow outflow hydrograph is necessary therefore gaging station shall be installed upstream and downstream of the dam.
4. While the project starts to grow sugar can there must follow the guide cure developed above for the safety of the project.
5. For both cases scenario ‘R-B’ and ‘R-C’ the deficit can be reduced totally by stop releasing water for downstream, special ‘R-C’ for two cases.
6. Since the irrigation water requirement of sugarcane varies throughout its routine reservoir operation rule cure shall be produced for each sequence year.

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ANNEX I

Result of Zarrim Reservoir operation

and

Irrigation deficit

Case one

Total inflow

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min	**0,0**	**0,0**	**0,0**	**0,0**	**0,4**	**9,6**	**88,7**	**131,7**	**23,9**	**1,2**	**0,0**	**0,0**
Avg	**0,1**	**0,1**	**0,2**	**1,1**	**4,8**	**34,2**	**169,4**	**225,3**	**58,8**	**5,4**	**0,7**	**0,3**
Max	**1,9**	**0,9**	**1,3**	**5,4**	**18,7**	**85,2**	**236,1**	**452,7**	**98,4**	**20,3**	**4,8**	**2,6**
Max-Min	**1,9**	**0,9**	**1,3**	**5,4**	**18,3**	**75,6**	**147,4**	**321,0**	**74,5**	**19,1**	**4,8**	**2,6**
St.Dev	**0,3**	**0,2**	**0,3**	**1,3**	**4,2**	**17,5**	**37,1**	**65,3**	**21,5**	**4,0**	**0,9**	**0,6**
Cv	**2,6**	**1,8**	**1,4**	**1,2**	**0,9**	**0,5**	**0,2**	**0,3**	**0,4**	**0,7**	**1,2**	**2,4**
1968	0,0	0,0	0,0	0,0	0,9	22,0	166,1	269,1	92,1	10,8	0,2	0,0
1969	0,0	0,1	0,0	0,7	1,5	29,0	233,7	281,0	37,0	9,2	0,5	2,3
1970	0,0	0,0	0,0	0,4	0,4	11,8	233,9	205,4	40,2	3,5	0,1	0,0
1971	0,2	0,1	0,0	0,4	2,2	48,1	88,7	271,5	88,4	4,4	0,9	0,0
1972	0,0	0,2	0,0	0,9	1,7	66,4	127,4	142,4	33,8	2,9	1,7	0,0
1973	0,1	0,0	0,0	1,1	8,2	12,4	149,3	191,9	51,0	6,5	0,7	0,1
1974	0,0	0,1	0,0	0,0	16,6	55,1	168,9	193,3	98,4	2,2	0,0	0,0
1975	0,4	0,3	0,0	0,0	1,1	31,7	191,4	288,3	90,2	4,9	0,7	2,5
1976	0,0	0,0	0,0	0,9	4,5	30,1	161,0	187,5	51,2	4,0	1,8	0,0
1977	0,0	0,0	0,1	0,4	6,8	85,2	163,7	240,7	97,2	15,6	1,2	2,6
1978	0,1	0,0	0,3	0,3	2,5	23,9	124,4	216,1	63,2	3,4	0,3	0,9
1979	0,0	0,1	0,0	0,0	2,9	12,8	137,9	185,5	23,9	5,9	0,1	0,1
1980	0,0	0,2	0,0	5,4	4,2	14,5	187,4	182,7	63,2	4,1	0,7	0,0
1981	0,3	0,1	0,3	3,7	5,6	20,2	236,1	147,7	49,1	2,5	1,7	0,1
1982	0,0	0,4	1,3	4,3	4,4	9,6	100,1	160,9	40,4	6,5	0,2	0,0
1983	0,0	0,0	0,0	0,0	3,8	34,4	139,6	221,4	28,3	2,4	2,8	0,1
1984	0,0	0,0	0,2	1,5	9,3	39,8	161,2	207,1	91,8	2,4	0,5	0,5
1985	0,0	0,0	0,4	0,8	5,8	39,1	167,2	205,4	38,5	6,0	0,1	0,0
1986	0,0	0,0	0,4	0,0	0,5	30,5	165,4	296,5	76,7	4,1	0,2	0,0
1987	0,0	0,0	0,1	0,3	15,8	58,9	156,9	199,1	85,5	5,5	0,1	0,0
1988	0,0	0,9	0,2	1,0	2,3	28,6	158,3	144,6	39,4	13,2	0,2	0,0
1989	0,0	0,2	0,0	0,1	4,7	38,9	117,1	131,7	46,2	2,5	0,1	0,0
1990	0,1	0,1	0,0	0,9	0,8	17,4	203,4	208,4	36,6	3,7	1,6	0,1
1991	0,0	0,0	0,0	0,1	2,8	17,1	156,4	237,0	40,8	1,9	0,2	0,0
1992	0,0	0,0	0,0	0,1	2,0	14,7	168,0	202,8	67,5	20,3	4,8	0,1
1993	0,0	0,2	0,2	1,4	6,5	40,0	124,1	159,9	40,1	9,0	0,2	0,0
1994	0,0	0,1	0,0	0,3	2,8	25,0	201,0	426,2	97,5	5,2	0,4	0,0
1995	0,0	0,0	1,0	0,4	5,4	17,4	156,1	141,6	35,3	1,6	0,2	0,0
1996	0,0	0,8	1,1	3,2	18,7	58,0	99,6	176,6	43,8	3,5	1,9	0,1
1997	0,0	0,1	0,4	0,6	5,2	18,9	234,4	229,7	55,5	10,6	1,3	0,1
1998	0,1	0,0	0,2	0,1	8,9	30,2	184,7	200,1	51,2	5,1	0,4	0,0
1999	0,7	0,1	0,0	0,8	6,2	48,0	159,1	224,4	77,6	8,6	0,6	0,4
2000	0,0	0,0	0,0	3,8	3,2	36,7	174,4	249,6	55,5	5,6	0,7	0,0
2001	0,0	0,1	0,4	2,8	4,3	32,2	170,8	201,6	83,2	9,5	0,3	0,1
2002	0,1	0,1	0,2	0,7	1,8	28,0	185,3	265,4	68,4	3,9	1,0	0,5
2003	0,0	0,5	0,0	0,1	1,5	47,4	192,2	212,6	60,3	2,7	0,5	0,0
2004	1,9	0,4	0,2	1,4	1,0	25,1	177,5	212,2	57,1	6,9	0,8	0,1
2005	0,0	0,1	0,9	0,7	1,5	55,9	142,5	245,7	57,6	1,3	0,4	0,0
2006	0,0	0,0	0,1	0,9	9,0	44,1	234,0	260,8	83,9	4,8	0,2	0,0
2007	0,1	0,0	0,4	1,6	4,6	74,4	209,1	269,8	51,1	2,7	1,0	0,0
2008	0,7	0,0	0,0	3,2	6,4	40,0	180,4	311,0	49,5	1,5	0,1	0,9
2009	0,0	0,0	0,5	0,2	0,4	26,9	183,1	230,8	32,8	1,2	0,5	0,1
2010	0,7	0,0	1,1	2,8	8,3	32,3	212,8	452,7	59,8	1,9	0,1	0,0

Table-Annex 1. 1 Zarima reservoir, in case one total inflow

Scenario “R-A”

Irrigation and Enviromental outlet Outflow (m^3/s)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	48.00	45.02	42.64	37.05	25.86	11.59	35.68	48.00	48.00	48.00	32.99	29.20
1969	34.80	42.60	42.64	37.05	25.86	11.59	32.93	48.00	48.00	45.68	31.35	29.20
1970	34.80	42.83	42.42	36.89	25.30	11.21	30.16	48.00	48.00	42.01	31.16	29.20
1971	34.80	42.83	42.42	36.89	25.30	11.21	13.51	48.00	48.00	46.24	31.16	29.20
1972	34.80	42.73	42.64	37.05	25.86	11.59	30.49	48.00	48.00	41.26	31.53	29.15
1973	34.19	42.83	42.64	36.89	25.30	11.21	20.47	48.00	48.00	44.63	31.35	29.15
1974	34.49	42.60	42.64	37.05	25.86	11.59	35.68	48.00	48.00	45.84	31.35	29.20
1975	34.80	42.83	42.42	36.89	25.30	11.21	30.16	48.00	48.00	46.30	31.16	29.20
1976	34.80	42.73	42.64	37.05	25.86	11.59	26.03	48.00	48.00	43.46	31.35	29.15
1977	34.49	42.60	42.64	37.05	25.86	11.59	41.17	48.00	48.00	48.00	34.53	29.15
1978	34.49	42.60	42.64	37.05	25.86	11.59	19.10	48.00	48.00	44.57	31.35	29.20
1979	34.80	42.60	42.64	37.05	25.86	11.59	14.93	48.00	48.00	41.22	31.35	29.20
1980	34.80	42.73	42.64	37.05	25.86	11.59	26.03	48.00	48.00	44.58	31.35	29.15
1981	34.49	42.60	42.64	37.05	25.86	11.59	31.55	48.00	48.00	42.58	31.35	29.15
1982	34.49	42.60	42.64	37.05	25.86	11.59	5.16	48.00	48.00	43.95	31.53	29.15
1983	34.19	42.83	42.64	36.89	25.30	11.21	23.29	48.00	48.00	36.75	31.35	29.15
1984	34.49	42.49	42.87	37.19	26.42	11.98	27.43	48.00	48.00	45.72	31.53	29.15
1985	34.49	42.60	42.64	37.05	25.86	11.59	28.80	48.00	48.00	43.25	31.35	29.15
1986	34.49	42.60	42.64	37.05	25.86	11.59	24.65	48.00	48.00	45.60	31.35	29.15
1987	34.49	42.60	42.64	37.05	25.86	11.59	35.68	48.00	48.00	46.85	31.35	29.15
1988	34.49	42.49	42.87	37.19	26.42	11.98	23.29	48.00	48.00	48.00	32.44	29.15
1989	34.49	42.35	42.87	37.19	26.42	11.98	19.13	48.00	48.00	43.12	31.53	29.15
1990	34.49	42.60	42.64	37.05	25.86	11.59	26.03	48.00	48.00	42.37	31.35	29.15
1991	34.49	42.60	42.64	37.05	25.86	11.59	20.49	48.00	48.00	42.14	31.35	29.15
1992	34.49	42.49	42.87	37.19	26.42	11.98	19.13	48.00	48.00	48.00	37.58	29.12
1993	33.90	42.60	42.87	37.05	25.86	11.59	26.03	48.00	48.00	45.28	31.53	29.12
1994	34.19	42.35	42.87	37.19	26.42	11.98	27.43	48.00	48.00	48.00	32.05	29.15
1995	34.49	42.60	42.64	37.05	25.86	11.59	21.88	48.00	48.00	40.56	31.35	29.15
1996	34.49	42.49	42.87	37.19	26.42	11.98	27.43	48.00	48.00	43.77	31.53	29.12
1997	34.19	42.35	42.87	37.19	26.42	11.98	29.73	48.00	48.00	48.00	32.45	29.12
1998	34.19	42.35	42.87	37.19	26.42	11.98	28.81	48.00	48.00	44.57	31.53	29.15
1999	34.49	42.35	42.87	37.19	26.42	11.98	28.81	48.00	48.00	48.00	31.68	29.15
2000	34.49	42.49	42.87	37.19	26.42	11.98	28.81	48.00	48.00	45.72	31.53	29.12
2001	34.19	42.35	42.87	37.19	26.42	11.98	26.17	48.00	48.00	48.00	32.24	29.12
2002	34.19	42.35	42.87	37.19	26.42	11.98	27.43	48.00	48.00	46.13	31.70	29.12
2003	33.90	42.60	42.87	37.05	25.86	11.59	32.93	48.00	48.00	44.26	31.53	29.12
2004	34.19	42.24	43.08	37.34	26.97	12.38	23.32	48.00	48.00	46.58	31.70	29.12
2005	34.19	42.35	42.87	37.19	26.42	11.98	28.81	48.00	48.00	43.62	31.53	29.12
2006	34.19	42.35	42.87	37.19	26.42	11.98	34.32	48.00	48.00	47.11	31.53	29.12
2007	34.19	42.35	42.87	37.19	26.42	11.98	38.44	48.00	48.00	43.80	31.53	29.12
2008	34.19	42.24	43.08	37.34	26.97	12.38	28.84	48.00	48.00	43.67	31.70	29.12
2009	34.19	42.09	43.08	37.34	26.97	12.38	23.32	48.00	48.00	41.30	31.70	29.12
2010	34.19	42.35	42.87	37.19	26.42	11.98	31.57	48.00	48.00	45.22	31.53	29.12

Table-Annex 1. 2 Zarima reservoir simulation, sugarcane for 40 000 ha Irrigation and Environmental outlet outflow (m3/s).

Irrigatiom outlet outflow(m3/s)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	45.50	42.52	40.14	34.55	23.36	9.09	33.18	45.50	45.50	45.50	30.49	26.70
1969	32.30	40.10	40.14	34.55	23.36	9.09	30.43	45.50	45.50	43.18	28.85	26.70
1970	32.30	40.33	39.92	34.39	22.80	8.71	27.66	45.50	45.50	39.51	28.66	26.70
1971	32.30	40.33	39.92	34.39	22.80	8.71	11.01	45.50	45.50	43.74	28.66	26.70
1972	32.30	40.23	40.14	34.55	23.36	9.09	27.99	45.50	45.50	38.76	29.03	26.65
1973	31.69	40.33	40.14	34.39	22.80	8.71	17.97	45.50	45.50	42.13	28.85	26.65
1974	31.99	40.10	40.14	34.55	23.36	9.09	33.18	45.50	45.50	43.34	28.85	26.70
1975	32.30	40.33	39.92	34.39	22.80	8.71	27.66	45.50	45.50	43.80	28.66	26.70
1976	32.30	40.23	40.14	34.55	23.36	9.09	23.53	45.50	45.50	40.96	28.85	26.65
1977	31.99	40.10	40.14	34.55	23.36	9.09	38.67	45.50	45.50	45.50	32.03	26.65
1978	31.99	40.10	40.14	34.55	23.36	9.09	16.60	45.50	45.50	42.07	28.85	26.70
1979	32.30	40.10	40.14	34.55	23.36	9.09	12.43	45.50	45.50	38.72	28.85	26.70
1980	32.30	40.23	40.14	34.55	23.36	9.09	23.53	45.50	45.50	42.08	28.85	26.65
1981	31.99	40.10	40.14	34.55	23.36	9.09	29.05	45.50	45.50	40.08	28.85	26.65
1982	31.99	40.10	40.14	34.55	23.36	9.09	2.66	45.50	45.50	41.45	29.03	26.65
1983	31.69	40.33	40.14	34.39	22.80	8.71	20.79	45.50	45.50	34.25	28.85	26.65
1984	31.99	39.99	40.37	34.69	23.92	9.48	24.93	45.50	45.50	43.22	29.03	26.65
1985	31.99	40.10	40.14	34.55	23.36	9.09	26.30	45.50	45.50	40.75	28.85	26.65
1986	31.99	40.10	40.14	34.55	23.36	9.09	22.15	45.50	45.50	43.10	28.85	26.65
1987	31.99	40.10	40.14	34.55	23.36	9.09	33.18	45.50	45.50	44.35	28.85	26.65
1988	31.99	39.99	40.37	34.69	23.92	9.48	20.79	45.50	45.50	45.50	29.94	26.65
1989	31.99	39.85	40.37	34.69	23.92	9.48	16.63	45.50	45.50	40.62	29.03	26.65
1990	31.99	40.10	40.14	34.55	23.36	9.09	23.53	45.50	45.50	39.87	28.85	26.65
1991	31.99	40.10	40.14	34.55	23.36	9.09	17.99	45.50	45.50	39.64	28.85	26.65
1992	31.99	39.99	40.37	34.69	23.92	9.48	16.63	45.50	45.50	45.50	35.08	26.62
1993	31.40	40.10	40.37	34.55	23.36	9.09	23.53	45.50	45.50	42.78	29.03	26.62
1994	31.69	39.85	40.37	34.69	23.92	9.48	24.93	45.50	45.50	45.50	29.55	26.65
1995	31.99	40.10	40.14	34.55	23.36	9.09	19.38	45.50	45.50	38.06	28.85	26.65
1996	31.99	39.99	40.37	34.69	23.92	9.48	24.93	45.50	45.50	41.27	29.03	26.62
1997	31.69	39.85	40.37	34.69	23.92	9.48	27.23	45.50	45.50	45.50	29.95	26.62
1998	31.69	39.85	40.37	34.69	23.92	9.48	26.31	45.50	45.50	42.07	29.03	26.65
1999	31.99	39.85	40.37	34.69	23.92	9.48	26.31	45.50	45.50	45.50	29.18	26.65
2000	31.99	39.99	40.37	34.69	23.92	9.48	26.31	45.50	45.50	43.22	29.03	26.62
2001	31.69	39.85	40.37	34.69	23.92	9.48	23.67	45.50	45.50	45.50	29.74	26.62
2002	31.69	39.85	40.37	34.69	23.92	9.48	24.93	45.50	45.50	43.63	29.20	26.62
2003	31.40	40.10	40.37	34.55	23.36	9.09	30.43	45.50	45.50	41.76	29.03	26.62
2004	31.69	39.74	40.58	34.84	24.47	9.88	20.82	45.50	45.50	44.08	29.20	26.62
2005	31.69	39.85	40.37	34.69	23.92	9.48	26.31	45.50	45.50	41.12	29.03	26.62
2006	31.69	39.85	40.37	34.69	23.92	9.48	31.82	45.50	45.50	44.61	29.03	26.62
2007	31.69	39.85	40.37	34.69	23.92	9.48	35.94	45.50	45.50	41.30	29.03	26.62
2008	31.69	39.74	40.58	34.84	24.47	9.88	26.34	45.50	45.50	41.17	29.20	26.62
2009	31.69	39.59	40.58	34.84	24.47	9.88	20.82	45.50	45.50	38.80	29.20	26.62
2010	31.69	39.85	40.37	34.69	23.92	9.48	29.07	45.50	45.50	42.72	29.03	26.62

Table-Annex 1. 3 Zarima reservoir simulation, sugarcane for 40 000 ha Irrigation outlet outflow (m3/s).

Irrigation Demand CWR(m3/s)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1969	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1970	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1971	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1972	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1973	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1974	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1975	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1976	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1977	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1978	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1979	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1980	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1981	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1982	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1983	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1984	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1985	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1986	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1987	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1988	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1989	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1990	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1991	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1992	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1993	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1994	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1995	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1996	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1997	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1998	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1999	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2000	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2001	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2002	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2003	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2004	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2005	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2006	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2007	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2008	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2009	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2010	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98

Table-Annex 1. 4 Zarima reservoir simulation, monthly Irrigation demand for 40 000 ha (m3/s).

Irrigation outlet monthely deficit (m^3/s)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	-	-	(3.64)	(2.19)	(9.00)	(5.83)	-	-	-	-	(1.22)	-
1969	-	-	(3.64)	(2.19)	(9.00)	(5.83)	-	-	-	-	(2.86)	-
1970	-	-	(3.86)	(2.35)	(9.56)	(6.21)	-	-	-	-	(3.05)	-
1971	-	-	(3.86)	(2.35)	(9.56)	(6.21)	-	-	-	-	(3.05)	-
1972	-	-	(3.64)	(2.19)	(9.00)	(5.83)	-	-	-	-	(2.68)	-
1973	-	-	(3.64)	(2.35)	(9.56)	(6.21)	-	-	-	-	(2.86)	-
1974	-	-	(3.64)	(2.19)	(9.00)	(5.83)	-	-	-	-	(2.86)	-
1975	-	-	(3.86)	(2.35)	(9.56)	(6.21)	-	-	-	-	(3.05)	-
1976	-	-	(3.64)	(2.19)	(9.00)	(5.83)	-	-	-	-	(2.86)	-
1977	-	-	(3.64)	(2.19)	(9.00)	(5.83)	-	-	-	-	0.32	-
1978	-	-	(3.64)	(2.19)	(9.00)	(5.83)	-	-	-	-	(2.86)	-
1979	-	-	(3.64)	(2.19)	(9.00)	(5.83)	-	-	-	-	(2.86)	-
1980	-	-	(3.64)	(2.19)	(9.00)	(5.83)	-	-	-	-	(2.86)	-
1981	-	-	(3.64)	(2.19)	(9.00)	(5.83)	-	-	-	-	(2.86)	-
1982	-	-	(3.64)	(2.19)	(9.00)	(5.83)	-	-	-	-	(2.68)	-
1983	-	-	(3.64)	(2.35)	(9.56)	(6.21)	-	-	-	-	(2.86)	-
1984	-	-	(3.41)	(2.04)	(8.44)	(5.43)	-	-	-	-	(2.68)	-
1985	-	-	(3.64)	(2.19)	(9.00)	(5.83)	-	-	-	-	(2.86)	-
1986	-	-	(3.64)	(2.19)	(9.00)	(5.83)	-	-	-	-	(2.86)	-
1987	-	-	(3.64)	(2.19)	(9.00)	(5.83)	-	-	-	-	(2.86)	-
1988	-	-	(3.41)	(2.04)	(8.44)	(5.43)	-	-	-	-	(1.77)	-
1989	-	-	(3.41)	(2.04)	(8.44)	(5.43)	-	-	-	-	(2.68)	-
1990	-	-	(3.64)	(2.19)	(9.00)	(5.83)	-	-	-	-	(2.86)	-
1991	-	-	(3.64)	(2.19)	(9.00)	(5.83)	-	-	-	-	(2.86)	-
1992	-	-	(3.41)	(2.04)	(8.44)	(5.43)	-	-	-	-	3.37	-
1993	-	-	(3.41)	(2.19)	(9.00)	(5.83)	-	-	-	-	(2.68)	-
1994	-	-	(3.41)	(2.04)	(8.44)	(5.43)	-	-	-	-	(2.16)	-
1995	-	-	(3.64)	(2.19)	(9.00)	(5.83)	-	-	-	-	(2.86)	-
1996	-	-	(3.41)	(2.04)	(8.44)	(5.43)	-	-	-	-	(2.68)	-
1997	-	-	(3.41)	(2.04)	(8.44)	(5.43)	-	-	-	-	(1.76)	-
1998	-	-	(3.41)	(2.04)	(8.44)	(5.43)	-	-	-	-	(2.68)	-
1999	-	-	(3.41)	(2.04)	(8.44)	(5.43)	-	-	-	-	(2.53)	-
2000	-	-	(3.41)	(2.04)	(8.44)	(5.43)	-	-	-	-	(2.68)	-
2001	-	-	(3.41)	(2.04)	(8.44)	(5.43)	-	-	-	-	(1.97)	-
2002	-	-	(3.41)	(2.04)	(8.44)	(5.43)	-	-	-	-	(2.51)	-
2003	-	-	(3.41)	(2.19)	(9.00)	(5.83)	-	-	-	-	(2.68)	-
2004	-	-	(3.20)	(1.89)	(7.89)	(5.03)	-	-	-	-	(2.51)	-
2005	-	-	(3.41)	(2.04)	(8.44)	(5.43)	-	-	-	-	(2.68)	-
2006	-	-	(3.41)	(2.04)	(8.44)	(5.43)	-	-	-	-	(2.68)	-
2007	-	-	(3.41)	(2.04)	(8.44)	(5.43)	-	-	-	-	(2.68)	-
2008	-	-	(3.20)	(1.89)	(7.89)	(5.03)	-	-	-	-	(2.51)	-
2009	-	-	(3.20)	(1.89)	(7.89)	(5.03)	-	-	-	-	(2.51)	-
2010	-	-	(3.41)	(2.04)	(8.44)	(5.43)	-	-	-	-	(2.68)	-

Table-Annex 1. 5 Zarima reservoir simulation, monthly Irrigation deficit for 40 000 ha (m3).

Emergency spillway Outflow (m^3/s)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	-	-	-	-	-	-	127.51	532.10	281.30	50.38	0.57	-
1969	-	-	-	-	-	-	168.30	588.52	201.13	16.95	-	-
1970	-	-	-	-	-	-	147.41	440.75	150.71	12.48	-	-
1971	-	-	-	-	-	-	2.95	459.89	261.46	36.93	-	-
1972	-	-	-	-	-	-	60.74	267.24	115.07	9.90	-	-
1973	-	-	-	-	-	-	26.45	344.84	159.80	19.17	-	-
1974	-	-	-	-	-	-	130.74	391.36	247.51	44.69	-	-
1975	-	-	-	-	-	-	107.52	582.59	273.77	38.30	-	-
1976	-	-	-	-	-	-	60.76	363.25	168.24	20.32	-	-
1977	-	-	-	-	-	-	159.56	480.07	273.60	58.20	1.89	-
1978	-	-	-	-	-	-	14.29	372.74	180.91	26.36	-	-
1979	-	-	-	-	-	-	9.19	313.66	127.06	7.01	-	-
1980	-	-	-	-	-	-	68.97	366.82	183.96	26.93	-	-
1981	-	-	-	-	-	-	164.63	339.82	141.71	17.68	-	-
1982	-	-	-	-	-	-	164.63	339.82	141.71	17.68	-	-
1983	-	-	-	-	-	-	36.21	61.75	18.17	2.25	-	-
1984	-	-	-	-	-	-	62.81	397.13	253.22	47.14	-	-
1985	-	-	-	-	-	-	82.84	405.31	160.01	14.74	-	-
1986	-	-	-	-	-	-	53.39	567.29	270.38	35.73	-	-
1987	-	-	-	-	-	-	116.37	394.90	229.07	40.99	-	-
1988	-	-	-	-	-	-	41.20	276.29	132.20	20.95	0.12	-
1989	-	-	-	-	-	-	13.77	227.20	136.46	18.48	-	-
1990	-	-	-	-	-	-	85.99	425.63	159.14	12.76	-	-
1991	-	-	-	-	-	-	27.23	436.62	181.46	14.50	-	-
1992	-	-	-	-	-	-	26.79	373.03	212.42	48.84	4.11	-
1993	-	-	-	-	-	-	39.29	284.84	134.82	16.53	-	-
1994	-	-	-	-	-	-	91.75	660.98	427.73	57.06	0.07	-
1995	-	-	-	-	-	-	35.97	266.25	116.66	10.19	-	-
1996	-	-	-	-	-	-	29.92	300.74	159.80	18.07	-	-
1997	-	-	-	-	-	-	135.77	487.82	213.09	31.63	0.13	-
1998	-	-	-	-	-	-	91.56	403.36	186.89	23.98	-	-
1999	-	-	-	-	-	-	75.73	98.25	87.15	38.81	0.09	-
2000	-	-	-	-	-	-	81.18	484.97	225.60	27.80	-	-
2001	-	-	-	-	-	-	67.67	393.21	235.62	48.60	0.39	-
2002	-	-	-	-	-	-	77.41	517.74	255.17	34.80	-	-
2003	-	-	-	-	-	-	127.24	433.98	197.31	24.87	-	-
2004	-	-	-	-	-	-	49.48	405.29	214.76	32.46	-	-
2005	-	-	-	-	-	-	59.79	456.84	225.97	26.36	-	-
2006	-	-	-	-	-	-	188.16	550.26	276.39	45.24	-	-
2007	-	-	-	-	-	-	205.08	554.99	232.27	23.62	-	-
2008	-	-	-	-	-	-	84.66	590.88	274.84	25.53	-	-
2009	-	-	-	-	-	-	53.53	441.76	195.36	13.79	-	-
2010	-	-	-	-	-	-	131.51	671.55	369.89	32.06	-	-

Table-Annex 1. 6 Zarima reservoir simulation, sugarcane for 40 000 ha Emergency Spillway outflow (m3/s

Scenario “R-B”

Irrigation and Enviromental outlet Outflow (m3/s)

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1968	48.00	45.02	42.64	37.05	25.86	11.59	35.68	48.00	48.00	48.00	32.99	29.20
1969	34.80	42.83	42.42	36.89	25.30	11.21	34.30	48.00	48.00	45.23	31.16	29.25
1970	35.11	43.05	42.19	36.71	24.75	10.85	31.52	48.00	48.00	41.56	30.99	29.31
1971	35.41	43.25	41.97	36.53	24.20	10.49	16.24	48.00	48.00	45.32	30.82	29.38
1972	35.71	43.35	41.97	36.53	24.20	10.49	34.58	48.00	48.00	39.89	30.82	29.38
1973	35.71	43.43	41.76	36.33	23.66	10.15	24.57	48.00	48.00	43.24	30.66	29.46
1974	36.01	43.60	41.54	36.11	23.13	9.82	42.51	48.00	48.00	43.52	30.50	29.55
1975	36.31	43.75	41.33	35.89	22.60	9.50	37.00	48.00	48.00	43.95	30.36	29.64
1976	36.60	43.84	41.33	35.89	22.60	9.50	34.23	48.00	48.00	40.67	30.36	29.64
1977	36.60	43.89	41.12	35.65	22.08	11.93	48.00	48.00	48.00	48.00	30.16	29.75
1978	36.90	44.02	40.92	35.40	21.56	8.89	30.05	48.00	48.00	40.79	30.09	29.86
1979	37.19	44.12	40.71	35.13	21.05	8.60	27.25	48.00	48.00	36.94	29.97	29.98
1980	37.47	44.19	40.71	35.13	21.05	8.60	38.35	48.00	48.00	40.30	29.97	29.98
1981	37.48	44.22	40.51	34.85	20.54	8.33	45.25	48.00	48.00	37.80	29.85	30.11
1982	37.77	44.29	40.31	34.56	20.04	8.06	20.22	48.00	48.00	38.65	29.75	30.25
1983	38.05	44.36	40.12	34.25	19.55	7.81	38.37	48.00	46.33	33.06	29.65	30.40
1984	38.32	44.40	40.12	34.25	19.55	7.81	45.24	48.00	48.00	39.46	29.65	30.40
1985	38.34	44.40	39.92	33.93	19.06	7.57	46.62	48.00	48.00	36.90	29.55	30.55
1986	38.62	44.43	39.73	33.59	18.57	7.34	43.85	48.00	48.00	38.72	29.47	30.72
1987	38.90	44.45	39.55	33.25	18.09	15.39	48.00	48.00	48.00	39.43	29.39	30.89
1988	39.14	44.48	39.55	33.25	18.09	7.12	45.23	48.00	48.00	40.61	29.39	30.89
1989	39.18	44.45	39.36	32.89	17.62	6.91	42.46	48.00	48.00	34.72	29.32	31.07
1990	39.45	44.44	39.18	32.51	17.15	8.10	48.00	48.00	48.00	33.86	29.26	31.26
1991	39.72	44.41	39.00	32.12	16.69	6.53	45.23	48.00	48.00	33.08	29.21	31.46
1992	39.95	44.43	39.00	32.12	16.69	6.53	45.23	48.00	48.00	43.48	29.21	31.46
1993	40.00	44.36	38.82	31.72	16.24	10.51	48.00	48.00	48.00	35.66	29.16	31.66
1994	40.27	44.30	38.65	31.31	15.79	14.50	48.00	48.00	48.00	37.44	29.12	31.88
1995	40.53	44.23	38.47	30.88	15.34	8.82	48.00	48.00	45.18	32.61	29.09	32.10
1996	40.74	44.24	38.47	30.88	15.34	15.73	48.00	48.00	47.95	32.61	29.09	32.10
1997	40.80	44.14	38.31	30.44	14.90	19.28	48.00	48.00	48.00	36.68	29.07	32.33
1998	41.06	44.03	38.14	29.98	14.47	19.63	48.00	48.00	48.00	32.19	29.05	32.57
1999	41.32	43.91	37.97	29.51	14.04	20.90	48.00	48.00	48.00	34.74	29.04	32.82
2000	41.50	43.92	37.97	29.51	14.04	20.90	48.00	48.00	48.00	32.75	29.04	32.82
2001	41.58	43.78	37.81	29.03	13.62	19.55	48.00	48.00	48.00	34.70	29.04	33.08
2002	41.84	43.63	37.65	28.54	13.20	22.11	48.00	48.00	47.95	32.01	29.05	33.34
2003	42.09	43.46	37.50	28.03	12.79	27.56	48.00	48.00	46.07	31.86	29.06	33.62
2004	42.24	43.46	37.50	28.03	12.79	20.66	48.00	48.00	48.00	31.34	29.06	33.62
2005	42.35	43.28	37.34	27.51	12.38	26.13	48.00	48.00	44.52	31.70	29.09	33.90
2006	42.60	43.08	37.19	26.97	11.98	32.97	48.00	48.00	47.56	31.53	29.12	34.19
2007	42.83	42.87	37.05	26.42	11.59	38.44	48.00	48.00	43.80	31.35	29.15	34.49
2008	42.95	42.87	37.05	26.42	11.59	30.19	48.00	48.00	43.22	31.35	29.15	34.49
2009	43.05	42.64	36.89	25.86	11.21	26.03	48.00	48.00	40.41	31.16	29.20	34.80
2010	43.25	42.42	36.71	25.30	10.85	34.30	48.00	48.00	44.32	30.99	29.18	34.80

Table-Annex 1. 7 Zarima reservoir simulation, sugarcane for 30 000 ha Irrigation and Environmental outlet outflow (m3/s).

Irrigation outlet Outflow (m3/s)

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1968	45.50	42.52	40.14	34.55	23.36	9.09	33.18	45.50	45.50	45.50	30.49	26.70
1969	32.30	40.33	39.92	34.39	22.80	8.71	31.80	45.50	45.50	42.73	28.66	26.75
1970	32.61	40.55	39.69	34.21	22.25	8.35	29.02	45.50	45.50	39.06	28.49	26.81
1971	32.91	40.75	39.47	34.03	21.70	7.99	13.74	45.50	45.50	42.82	28.32	26.88
1972	33.21	40.85	39.47	34.03	21.70	7.99	32.08	45.50	45.50	37.39	28.32	26.88
1973	33.21	40.93	39.26	33.83	21.16	7.65	22.07	45.50	45.50	40.74	28.16	26.96
1974	33.51	41.10	39.04	33.61	20.63	7.32	40.01	45.50	45.50	41.02	28.00	27.05
1975	33.81	41.25	38.83	33.39	20.10	7.00	34.50	45.50	45.50	41.45	27.86	27.14
1976	34.10	41.34	38.83	33.39	20.10	7.00	31.73	45.50	45.50	38.17	27.86	27.14
1977	34.10	41.39	38.62	33.15	19.58	9.43	45.50	45.50	45.50	45.50	27.66	27.25
1978	34.40	41.52	38.42	32.90	19.06	6.39	27.55	45.50	45.50	38.29	27.59	27.36
1979	34.69	41.62	38.21	32.63	18.55	6.10	24.75	45.50	45.50	34.44	27.47	27.48
1980	34.97	41.69	38.21	32.63	18.55	6.10	35.85	45.50	45.50	37.80	27.47	27.48
1981	34.98	41.72	38.01	32.35	18.04	5.83	42.75	45.50	45.50	35.30	27.35	27.61
1982	35.27	41.79	37.81	32.06	17.54	5.56	17.72	45.50	45.50	36.15	27.25	27.75
1983	35.55	41.86	37.62	31.75	17.05	5.31	35.87	45.50	43.83	30.56	27.15	27.90
1984	35.82	41.90	37.62	31.75	17.05	5.31	42.74	45.50	45.50	36.96	27.15	27.90
1985	35.84	41.90	37.42	31.43	16.56	5.07	44.12	45.50	45.50	34.40	27.05	28.05
1986	36.12	41.93	37.23	31.09	16.07	4.84	41.35	45.50	45.50	36.22	26.97	28.22
1987	36.40	41.95	37.05	30.75	15.59	12.89	45.50	45.50	45.50	36.93	26.89	28.39
1988	36.64	41.98	37.05	30.75	15.59	4.62	42.73	45.50	45.50	38.11	26.89	28.39
1989	36.68	41.95	36.86	30.39	15.12	4.41	39.96	45.50	45.50	32.22	26.82	28.57
1990	36.95	41.94	36.68	30.01	14.65	5.60	45.50	45.50	45.50	31.36	26.76	28.76
1991	37.22	41.91	36.50	29.62	14.19	4.03	42.73	45.50	45.50	30.58	26.71	28.96
1992	37.45	41.93	36.50	29.62	14.19	4.03	42.73	45.50	45.50	40.98	26.71	28.96
1993	37.50	41.86	36.32	29.22	13.74	8.01	45.50	45.50	45.50	33.16	26.66	29.16
1994	37.77	41.80	36.15	28.81	13.29	12.00	45.50	45.50	45.50	34.94	26.62	29.38
1995	38.03	41.73	35.97	28.38	12.84	6.32	45.50	45.50	42.68	30.11	26.59	29.60
1996	38.24	41.74	35.97	28.38	12.84	13.23	45.50	45.50	45.45	30.11	26.59	29.60
1997	38.30	41.64	35.81	27.94	12.40	16.78	45.50	45.50	45.50	34.18	26.57	29.83
1998	38.56	41.53	35.64	27.48	11.97	17.13	45.50	45.50	45.50	29.69	26.55	30.07
1999	38.82	41.41	35.47	27.01	11.54	18.40	45.50	45.50	45.50	32.24	26.54	30.32
2000	39.00	41.42	35.47	27.01	11.54	18.40	45.50	45.50	45.50	30.25	26.54	30.32
2001	39.08	41.28	35.31	26.53	11.12	17.05	45.50	45.50	45.50	32.20	26.54	30.58
2002	39.34	41.13	35.15	26.04	10.70	19.61	45.50	45.50	45.45	29.51	26.55	30.84
2003	39.59	40.96	35.00	25.53	10.29	25.06	45.50	45.50	43.57	29.36	26.56	31.12
2004	39.74	40.96	35.00	25.53	10.29	18.16	45.50	45.50	45.50	28.84	26.56	31.12
2005	39.85	40.78	34.84	25.01	9.88	23.63	45.50	45.50	42.02	29.20	26.59	31.40
2006	40.10	40.58	34.69	24.47	9.48	30.47	45.50	45.50	45.06	29.03	26.62	31.69
2007	40.33	40.37	34.55	23.92	9.09	35.94	45.50	45.50	41.30	28.85	26.65	31.99
2008	40.45	40.37	34.55	23.92	9.09	27.69	45.50	45.50	40.72	28.85	26.65	31.99
2009	40.55	40.14	34.39	23.36	8.71	23.53	45.50	45.50	37.91	28.66	26.70	32.30
2010	40.75	39.92	34.21	22.80	8.35	31.80	45.50	45.50	41.82	28.49	26.68	32.30

Table-Annex 1. 8 Zarima reservoir simulation, sugarcane for 30 000 ha Irrigation outlet outflow (m3/s).

irrigation demand (CWR)

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1968	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1969	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1970	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1971	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1972	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1973	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1974	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1975	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1976	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1977	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1978	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1979	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1980	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1981	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1982	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1983	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1984	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1985	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1986	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1987	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1988	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1989	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1990	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1991	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1992	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1993	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1994	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1995	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1996	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1997	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1998	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
1999	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
2000	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
2001	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
2002	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
2003	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
2004	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
2005	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
2006	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
2007	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
2008	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
2009	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48
2010	20.53	27.69	32.83	27.55	24.27	11.19	2.44	1.57	9.55	20.96	23.78	19.48

Table-Annex 1. 9 Zarima reservoir simulation, monthly Irrigation demand for 30 000 ha (m3/s).

Irrigation outlet monthely deficit (m3/s)												
	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1968	-	-	-	-	(0.91)	(2.10)	-	-	-	-	-	-
1969	-	-	-	-	(1.47)	(2.48)	-	-	-	-	-	-
1970	-	-	-	-	(2.02)	(2.84)	-	-	-	-	-	-
1971	-	-	-	-	(2.56)	(3.20)	-	-	-	-	-	-
1972	-	-	-	-	(2.56)	(3.20)	-	-	-	-	-	-
1973	-	-	-	-	(3.10)	(3.54)	-	-	-	-	-	-
1974	-	-	-	-	(3.64)	(3.87)	-	-	-	-	-	-
1975	-	-	-	-	(4.17)	(4.19)	-	-	-	-	-	-
1976	-	-	-	-	(4.17)	(4.19)	-	-	-	-	-	-
1977	-	-	-	-	(4.69)	(1.76)	-	-	-	-	-	-
1978	-	-	-	-	(5.21)	(4.80)	-	-	-	-	-	-
1979	-	-	-	-	(5.72)	(5.09)	-	-	-	-	-	-
1980	-	-	-	-	(5.72)	(5.09)	-	-	-	-	-	-
1981	-	-	-	-	(6.23)	(5.36)	-	-	-	-	-	-
1982	-	-	-	-	(6.73)	(5.63)	-	-	-	-	-	-
1983	-	-	-	-	(7.22)	(5.88)	-	-	-	-	-	-
1984	-	-	-	-	(7.22)	(5.88)	-	-	-	-	-	-
1985	-	-	-	-	(7.71)	(6.12)	-	-	-	-	-	-
1986	-	-	-	-	(8.20)	(6.35)	-	-	-	-	-	-
1987	-	-	-	-	(8.67)	1.70	-	-	-	-	-	-
1988	-	-	-	-	(8.67)	(6.57)	-	-	-	-	-	-
1989	-	-	-	-	(9.15)	(6.78)	-	-	-	-	-	-
1990	-	-	-	-	(9.62)	(5.59)	-	-	-	-	-	-
1991	-	-	-	-	(10.08)	(7.16)	-	-	-	-	-	-
1992	-	-	-	-	(10.08)	(7.16)	-	-	-	-	-	-
1993	-	-	-	-	(10.53)	(3.18)	-	-	-	-	-	-
1994	-	-	-	-	(10.98)	0.81	-	-	-	-	-	-
1995	-	-	-	-	(11.43)	(4.87)	-	-	-	-	-	-
1996	-	-	-	-	(11.43)	-	-	-	-	-	-	-
1997	-	-	-	-	(11.87)	-	-	-	-	-	-	-
1998	-	-	-	(0.07)	(12.30)	-	-	-	-	-	-	-
1999	-	-	-	(0.54)	(12.73)	-	-	-	-	-	-	-
2000	-	-	-	(0.54)	(12.73)	-	-	-	-	-	-	-
2001	-	-	-	(1.02)	(13.15)	-	-	-	-	-	-	-
2002	-	-	-	(1.51)	(13.57)	-	-	-	-	-	-	-
2003	-	-	-	(2.02)	(13.98)	-	-	-	-	-	-	-
2004	-	-	-	(2.02)	(13.98)	-	-	-	-	-	-	-
2005	-	-	-	(2.54)	(14.38)	-	-	-	-	-	-	-
2006	-	-	-	(3.08)	(14.78)	-	-	-	-	-	-	-
2007	-	-	-	(3.63)	(15.18)	-	-	-	-	-	-	-
2008	-	-	-	(3.63)	(15.18)	-	-	-	-	-	-	-
2009	-	-	-	(4.19)	(15.56)	-	-	-	-	-	-	-
2010	-	-	-	(4.75)	(15.92)	-	-	-	-	-	-	-

Table-Annex 1. 10 Zarima reservoir simulation, monthly Irrigation deficit for 30 000 ha (m3).

Irrigation outlet monthely deficit (m3)

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1968	-	-	-	-	2,357,450.56	5,620,010.93	-	-	-	-	-	-
1969	-	-	-	-	3,801,110.95	6,630,718.13	-	-	-	-	-	-
1970	-	-	-	-	5,230,222.69	7,611,012.53	-	-	-	-	-	-
1971	-	-	-	-	6,644,785.79	8,561,066.93	-	-	-	-	-	-
1972	-	-	-	-	6,644,785.79	8,561,066.93	-	-	-	-	-	-
1973	-	-	-	-	8,044,883.85	9,480,794.93	-	-	-	-	-	-
1974	-	-	-	-	9,430,349.66	10,370,196.53	-	-	-	-	-	-
1975	-	-	-	-	10,801,350.44	11,229,271.73	-	-	-	-	-	-
1976	-	-	-	-	10,801,350.44	11,229,271.73	-	-	-	-	-	-
1977	-	-	-	-	12,157,802.56	4,716,612.53	-	-	-	-	-	-
1978	-	-	-	-	13,499,622.44	12,856,442.93	-	-	-	-	-	-
1979	-	-	-	-	14,826,977.27	13,624,625.33	-	-	-	-	-	-
1980	-	-	-	-	14,826,977.27	13,624,625.33	-	-	-	-	-	-
1981	-	-	-	-	16,139,783.47	14,362,394.93	-	-	-	-	-	-
1982	-	-	-	-	17,438,041.02	15,069,838.13	-	-	-	-	-	-
1983	-	-	-	-	18,721,749.92	15,747,041.33	-	-	-	-	-	-
1984	-	-	-	-	18,721,749.92	15,747,041.33	-	-	-	-	-	-
1985	-	-	-	-	19,990,910.18	16,393,918.13	-	-	-	-	-	-
1986	-	-	-	-	21,245,521.79	17,010,382.13	-	-	-	-	-	-
1987	-	-	-	-	22,485,584.76	(4,545,121.88)	-	-	-	-	-	-
1988	-	-	-	-	22,485,584.76	17,596,606.13	-	-	-	-	-	-
1989	-	-	-	-	23,711,182.69	18,152,503.73	-	-	-	-	-	-
1990	-	-	-	-	24,922,148.37	14,973,070.13	-	-	-	-	-	-
1991	-	-	-	-	26,118,649.02	19,173,319.73	-	-	-	-	-	-
1992	-	-	-	-	26,118,649.02	19,173,319.73	-	-	-	-	-	-
1993	-	-	-	-	27,300,601.02	8,513,546.93	-	-	-	-	-	-
1994	-	-	-	-	28,467,920.76	(2,166,789.08)	-	-	-	-	-	-
1995	-	-	-	-	29,620,775.47	13,044,362.93	-	-	-	-	-	-
1996	-	-	-	-	29,620,775.47	-	-	-	-	-	-	-
1997	-	-	-	-	30,759,081.53	-	-	-	-	-	-	-
1998	-	-	-	182,451.20	31,882,838.95	-	-	-	-	-	-	-
1999	-	-	-	1,437,152.00	32,992,047.73	-	-	-	-	-	-	-
2000	-	-	-	1,437,152.00	32,992,047.73	-	-	-	-	-	-	-
2001	-	-	-	2,727,881.60	34,086,707.85	-	-	-	-	-	-	-
2002	-	-	-	4,054,553.60	35,166,819.34	-	-	-	-	-	-	-
2003	-	-	-	5,417,340.80	36,232,382.18	-	-	-	-	-	-	-
2004	-	-	-	5,417,340.80	36,232,382.18	-	-	-	-	-	-	-
2005	-	-	-	6,816,070.40	37,283,479.98	-	-	-	-	-	-	-
2006	-	-	-	8,250,828.80	38,319,945.53	-	-	-	-	-	-	-
2007	-	-	-	9,721,616.00	39,341,946.05	-	-	-	-	-	-	-
2008	-	-	-	9,721,616.00	39,341,946.05	-	-	-	-	-	-	-
2009	-	-	-	11,228,432.00	40,320,049.79	-	-	-	-	-	-	-
2010	-	-	-	12,720,214.40	41,268,721.79	-	-	-	-	-	-	-

Table-Annex 1. 11 Zarima reservoir simulation, monthly Irrigation deficit for 30 000 ha (m3/s).

Emergency spillway Outflow (m^3/s)

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1968	-	-	-	-	-	-	127.51	532.10	281.30	50.38	0.57	-
1969	-	-	-	-	-	-	183.44	592.26	183.09	15.05	-	-
1970	-	-	-	-	-	-	161.62	438.65	138.96	10.72	-	-
1971	-	-	-	-	-	-	9.09	485.49	235.23	28.19	-	-
1972	-	-	-	-	-	-	81.47	270.79	92.64	6.06	-	-
1973	-	-	-	-	-	-	47.11	362.06	132.18	12.85	-	-
1974	-	-	-	-	-	-	186.20	392.61	210.18	22.03	-	-
1975	-	-	-	-	-	-	179.72	584.32	211.11	19.58	-	-
1976	-	-	-	-	-	-	117.47	364.54	116.92	8.41	-	-
1977	-	-	-	-	-	0.22	247.87	482.30	206.24	29.72	0.05	-
1978	-	-	-	-	-	-	72.74	384.29	122.90	8.09	-	-
1979	-	-	-	-	-	-	67.09	324.84	55.86	1.31	-	-
1980	-	-	-	-	-	-	166.40	348.16	118.88	7.25	-	-
1981	-	-	-	-	-	-	290.45	280.98	83.99	3.33	-	-
1982	-	-	-	-	-	-	26.77	251.00	68.06	2.91	-	-
1983	-	-	-	-	-	-	71.44	28.57	13.73	-	-	-
1984	-	-	-	-	-	-	207.97	384.78	153.81	6.86	-	-
1985	-	-	-	-	-	-	236.74	350.84	63.66	1.78	-	-
1986	-	-	-	-	-	-	268.34	515.23	124.69	4.43	-	-
1987	-	-	-	-	-	6.77	287.53	349.09	125.70	4.94	-	-
1988	-	-	-	-	-	-	176.51	230.36	53.60	3.87	-	-
1989	-	-	-	-	-	-	120.36	212.64	56.83	0.52	-	-
1990	-	-	-	-	-	0.14	310.41	315.12	46.53	0.16	-	-
1991	-	-	-	-	-	-	251.75	345.15	49.80	0.06	-	-
1992	-	-	-	-	-	-	234.57	316.51	92.48	11.41	-	-
1993	-	-	-	-	-	0.94	202.56	225.07	43.76	0.72	-	-
1994	-	-	-	-	-	9.79	517.13	565.35	128.38	2.64	-	-
1995	-	-	-	-	-	0.52	209.75	182.83	28.95	-	-	-
1996	-	-	-	-	-	4.40	220.65	233.22	41.27	-	-	-
1997	-	-	-	-	-	38.62	456.17	301.97	57.68	1.56	-	-
1998	-	-	-	-	-	30.00	368.50	251.45	45.25	0.03	-	-
1999	-	-	-	-	-	30.98	136.29	73.00	61.62	0.93	-	-
2000	-	-	-	-	-	31.82	429.14	296.36	48.20	0.06	-	-
2001	-	-	-	-	-	29.28	362.26	270.69	73.01	1.39	-	-
2002	-	-	-	-	-	41.69	478.34	298.81	51.84	-	-	-
2003	-	-	-	-	-	83.02	422.41	231.12	38.95	-	-	-
2004	-	-	-	-	-	34.26	391.15	226.12	39.16	0.00	-	-
2005	-	-	-	-	-	46.05	436.10	239.82	33.17	-	-	-
2006	-	-	-	-	-	173.14	546.77	276.39	50.41	-	-	-
2007	-	-	-	-	-	205.08	554.99	216.01	23.62	-	-	-
2008	-	-	-	-	-	94.67	603.20	236.07	22.57	-	-	-
2009	-	-	-	-	-	71.67	455.81	152.07	10.35	-	-	-
2010	-	-	-	-	-	159.01	689.21	313.13	24.38	-	-	-

Table-Annex 1. 12 Zarima reservoir simulation, sugarcane for 30 000 ha Emergency Spillway outflow (m3/s).

Scenario “R-C”

Irrigation and Enviromental outlet Outflow (m3/s)

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1968	48.00	44.82	42.64	36.97	25.86	11.40	35.68	48.00	48.00	48.00	32.49	29.20
1969	34.80	43.08	42.42	36.81	25.30	11.02	34.30	48.00	48.00	45.23	31.07	29.25
1970	35.11	43.29	42.19	36.64	24.75	10.65	31.52	48.00	48.00	41.56	30.89	29.31
1971	35.41	43.49	41.97	36.45	24.20	10.30	16.24	48.00	48.00	45.32	30.72	29.38
1972	35.71	43.58	41.97	36.45	24.20	10.30	34.58	48.00	48.00	39.89	30.72	29.38
1973	35.71	43.67	41.76	36.25	23.66	9.96	24.57	48.00	48.00	43.24	30.56	29.46
1974	36.01	43.83	41.54	36.04	23.13	9.63	42.51	48.00	48.00	43.52	30.41	29.55
1975	36.31	43.98	41.33	35.81	22.60	9.31	37.00	48.00	48.00	43.95	30.27	29.64
1976	36.60	44.05	41.33	35.81	22.60	9.31	34.23	48.00	48.00	40.67	30.27	29.64
1977	36.60	44.11	41.12	35.56	22.08	11.83	48.00	48.00	48.00	48.00	29.56	29.75
1978	36.90	44.22	40.92	35.31	21.56	8.71	30.05	48.00	48.00	40.79	30.00	29.86
1979	37.19	44.32	40.71	35.04	21.05	8.42	27.25	48.00	48.00	36.94	29.88	29.98
1980	37.47	44.38	40.71	35.04	21.05	8.42	38.35	48.00	48.00	40.30	29.88	29.98
1981	37.48	44.40	40.51	34.75	20.54	8.15	45.25	48.00	48.00	37.80	29.77	30.11
1982	37.77	44.47	40.31	34.45	20.04	7.89	20.22	48.00	48.00	38.65	29.67	30.25
1983	38.05	44.52	40.12	34.14	19.55	7.64	38.37	48.00	46.27	33.06	29.57	30.40
1984	38.32	44.56	40.12	34.14	19.55	7.64	45.24	48.00	48.00	39.46	29.57	30.40
1985	38.34	44.55	39.92	33.81	19.06	7.41	46.62	48.00	48.00	36.90	29.48	30.55
1986	38.62	44.57	39.73	33.47	18.57	7.18	43.85	48.00	48.00	38.72	29.40	30.72
1987	38.90	44.57	39.55	33.12	18.09	15.51	48.00	48.00	48.00	39.43	29.33	30.89
1988	39.14	44.60	39.55	33.12	18.09	6.97	45.23	48.00	48.00	40.61	29.33	30.89
1989	39.18	44.55	39.36	32.75	17.62	6.77	42.46	48.00	48.00	34.72	29.26	31.07
1990	39.45	44.52	39.18	32.37	17.15	8.01	48.00	48.00	48.00	33.86	29.21	31.26
1991	39.72	44.47	39.00	31.97	16.69	6.40	45.23	48.00	48.00	33.08	29.16	31.46
1992	39.95	44.49	39.00	31.97	16.69	6.40	45.23	48.00	48.00	43.48	29.16	31.46
1993	40.00	44.41	38.82	31.56	16.24	10.53	48.00	48.00	48.00	35.66	29.11	31.66
1994	40.27	44.33	38.65	31.14	15.79	14.66	48.00	48.00	48.00	37.44	29.08	31.88
1995	40.53	44.23	38.47	30.70	15.34	8.80	48.00	48.00	45.09	32.61	29.05	32.10
1996	40.74	44.24	38.47	30.70	15.34	15.95	48.00	48.00	47.95	32.61	29.05	32.10
1997	40.80	44.12	38.31	30.25	14.90	19.63	48.00	48.00	48.00	36.68	29.04	32.33
1998	41.06	43.99	38.14	29.79	14.47	20.00	48.00	48.00	48.00	32.19	29.03	32.57
1999	41.32	43.84	37.97	29.31	14.04	21.33	48.00	48.00	48.00	34.74	29.02	32.82
2000	41.50	43.85	37.97	29.31	14.04	21.33	48.00	48.00	48.00	32.75	29.02	32.82
2001	41.58	43.68	37.81	28.81	13.62	19.94	48.00	48.00	48.00	34.70	29.03	33.08
2002	41.84	43.50	37.65	28.31	13.20	22.60	48.00	48.00	47.94	32.01	29.04	33.34
2003	42.09	43.31	37.50	27.79	12.79	28.24	48.00	48.00	46.00	31.86	29.06	33.62
2004	42.24	43.31	37.50	27.79	12.79	21.12	48.00	48.00	48.00	31.34	29.06	33.62
2005	42.35	43.10	37.34	27.25	12.38	26.78	48.00	48.00	44.41	31.70	29.09	33.90
2006	42.60	42.87	37.19	26.70	11.98	33.86	48.00	48.00	47.54	31.53	29.13	34.19
2007	42.83	42.64	37.05	26.14	11.59	39.53	48.00	48.00	43.66	31.35	29.18	34.49
2008	42.95	42.64	37.05	26.14	11.59	31.01	48.00	48.00	43.06	31.35	29.18	34.49
2009	42.95	42.64	37.05	26.14	11.59	31.01	48.00	48.00	43.06	31.35	29.18	34.49
2010	43.25	42.19	36.71	25.02	10.85	35.25	48.00	48.00	44.20	30.99	29.20	34.49

Table-Annex 1. 13 Zarima reservoir simulation, sugarcane for 25 000 ha Irrigation and Environmental outlet outflow (m3/s).

Irrigation outlet Outflow (m3/s)

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1968	45.50	42.32	40.14	34.47	23.36	8.90	33.18	45.50	45.50	45.50	29.99	26.70
1969	32.30	40.58	39.92	34.31	22.80	8.52	31.80	45.50	45.50	42.73	28.57	26.75
1970	32.61	40.79	39.69	34.14	22.25	8.15	29.02	45.50	45.50	39.06	28.39	26.81
1971	32.91	40.99	39.47	33.95	21.70	7.80	13.74	45.50	45.50	42.82	28.22	26.88
1972	33.21	41.08	39.47	33.95	21.70	7.80	32.08	45.50	45.50	37.39	28.22	26.88
1973	33.21	41.17	39.26	33.75	21.16	7.46	22.07	45.50	45.50	40.74	28.06	26.96
1974	33.51	41.33	39.04	33.54	20.63	7.13	40.01	45.50	45.50	41.02	27.91	27.05
1975	33.81	41.48	38.83	33.31	20.10	6.81	34.50	45.50	45.50	41.45	27.77	27.14
1976	34.10	41.55	38.83	33.31	20.10	6.81	31.73	45.50	45.50	38.17	27.77	27.14
1977	34.10	41.61	38.62	33.06	19.58	9.33	45.50	45.50	45.50	45.50	27.06	27.25
1978	34.40	41.72	38.42	32.81	19.06	6.21	27.55	45.50	45.50	38.29	27.50	27.36
1979	34.69	41.82	38.21	32.54	18.55	5.92	24.75	45.50	45.50	34.44	27.38	27.48
1980	34.97	41.88	38.21	32.54	18.55	5.92	35.85	45.50	45.50	37.80	27.38	27.48
1981	34.98	41.90	38.01	32.25	18.04	5.65	42.75	45.50	45.50	35.30	27.27	27.61
1982	35.27	41.97	37.81	31.95	17.54	5.39	17.72	45.50	45.50	36.15	27.17	27.75
1983	35.55	42.02	37.62	31.64	17.05	5.14	35.87	45.50	43.77	30.56	27.07	27.90
1984	35.82	42.06	37.62	31.64	17.05	5.14	42.74	45.50	45.50	36.96	27.07	27.90
1985	35.84	42.05	37.42	31.31	16.56	4.91	44.12	45.50	45.50	34.40	26.98	28.05
1986	36.12	42.07	37.23	30.97	16.07	4.68	41.35	45.50	45.50	36.22	26.90	28.22
1987	36.40	42.07	37.05	30.62	15.59	13.01	45.50	45.50	45.50	36.93	26.83	28.39
1988	36.64	42.10	37.05	30.62	15.59	4.47	42.73	45.50	45.50	38.11	26.83	28.39
1989	36.68	42.05	36.86	30.25	15.12	4.27	39.96	45.50	45.50	32.22	26.76	28.57
1990	36.95	42.02	36.68	29.87	14.65	5.51	45.50	45.50	45.50	31.36	26.71	28.76
1991	37.22	41.97	36.50	29.47	14.19	3.90	42.73	45.50	45.50	30.58	26.66	28.96
1992	37.45	41.99	36.50	29.47	14.19	3.90	42.73	45.50	45.50	40.98	26.66	28.96
1993	37.50	41.91	36.32	29.06	13.74	8.03	45.50	45.50	45.50	33.16	26.61	29.16
1994	37.77	41.83	36.15	28.64	13.29	12.16	45.50	45.50	45.50	34.94	26.58	29.38
1995	38.03	41.73	35.97	28.20	12.84	6.30	45.50	45.50	42.59	30.11	26.55	29.60
1996	38.24	41.74	35.97	28.20	12.84	13.45	45.50	45.50	45.45	30.11	26.55	29.60
1997	38.30	41.62	35.81	27.75	12.40	17.13	45.50	45.50	45.50	34.18	26.54	29.83
1998	38.56	41.49	35.64	27.29	11.97	17.50	45.50	45.50	45.50	29.69	26.53	30.07
1999	38.82	41.34	35.47	26.81	11.54	18.83	45.50	45.50	45.50	32.24	26.52	30.32
2000	39.00	41.35	35.47	26.81	11.54	18.83	45.50	45.50	45.50	30.25	26.52	30.32
2001	39.08	41.18	35.31	26.31	11.12	17.44	45.50	45.50	45.50	32.20	26.53	30.58
2002	39.34	41.00	35.15	25.81	10.70	20.10	45.50	45.50	45.44	29.51	26.54	30.84
2003	39.59	40.81	35.00	25.29	10.29	25.74	45.50	45.50	43.50	29.36	26.56	31.12
2004	39.74	40.81	35.00	25.29	10.29	18.62	45.50	45.50	45.50	28.84	26.56	31.12
2005	39.85	40.60	34.84	24.75	9.88	24.28	45.50	45.50	41.91	29.20	26.59	31.40
2006	40.10	40.37	34.69	24.20	9.48	31.36	45.50	45.50	45.04	29.03	26.63	31.69
2007	40.33	40.14	34.55	23.64	9.09	37.03	45.50	45.50	41.16	28.85	26.68	31.99
2008	40.45	40.14	34.55	23.64	9.09	28.51	45.50	45.50	40.56	28.85	26.68	31.99
2009	40.45	40.14	34.55	23.64	9.09	28.51	45.50	45.50	40.56	28.85	26.68	31.99
2010	40.75	39.69	34.21	22.52	8.35	32.75	45.50	45.50	41.70	28.49	26.70	31.99

Table-Annex 1. 14 Zarima reservoir simulation, sugarcane for 25 000 ha Irrigation and Environmental outlet outflow (m3/s).

irrigation demand (CWR)

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1968	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1969	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1970	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1971	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1972	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1973	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1974	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1975	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1976	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1977	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1978	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1979	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1980	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1981	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1982	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1983	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1984	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1985	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1986	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1987	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1988	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1989	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1990	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1991	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1992	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1993	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1994	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1995	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1996	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1997	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1998	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
1999	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
2000	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
2001	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
2002	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
2003	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
2004	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
2005	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
2006	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
2007	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
2008	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
2009	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24
2010	17.11	23.07	27.36	22.96	20.22	9.32	2.04	1.31	7.96	17.46	19.82	16.24

Table-Annex 1. 15 Zarima reservoir simulation, monthly Irrigation demand for 25 000 ha (m3/s).

Irrigation outlet monthely deficit (m3/s)

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1968	-	-	-	-	-	(0.43)	-	-	-	-	-	-
1969	-	-	-	-	-	(0.80)	-	-	-	-	-	-
1970	-	-	-	-	-	(1.17)	-	-	-	-	-	-
1971	-	-	-	-	-	(1.52)	-	-	-	-	-	-
1972	-	-	-	-	-	(1.52)	-	-	-	-	-	-
1973	-	-	-	-	-	(1.87)	-	-	-	-	-	-
1974	-	-	-	-	-	(2.20)	-	-	-	-	-	-
1975	-	-	-	-	(0.12)	(2.51)	-	-	-	-	-	-
1976	-	-	-	-	(0.12)	(2.51)	-	-	-	-	-	-
1977	-	-	-	-	(0.65)	0.01	-	-	-	-	-	-
1978	-	-	-	-	(1.16)	(3.12)	-	-	-	-	-	-
1979	-	-	-	-	(1.68)	(3.40)	-	-	-	-	-	-
1980	-	-	-	-	(1.68)	(3.40)	-	-	-	-	-	-
1981	-	-	-	-	(2.18)	(3.67)	-	-	-	-	-	-
1982	-	-	-	-	(2.68)	(3.93)	-	-	-	-	-	-
1983	-	-	-	-	(3.18)	(4.18)	-	-	-	-	-	-
1984	-	-	-	-	(3.18)	(4.18)	-	-	-	-	-	-
1985	-	-	-	-	(3.67)	(4.42)	-	-	-	-	-	-
1986	-	-	-	-	(4.15)	(4.64)	-	-	-	-	-	-
1987	-	-	-	-	(4.63)	-	-	-	-	-	-	-
1988	-	-	-	-	(4.63)	(4.85)	-	-	-	-	-	-
1989	-	-	-	-	(5.10)	(5.06)	-	-	-	-	-	-
1990	-	-	-	-	(5.57)	(3.82)	-	-	-	-	-	-
1991	-	-	-	-	(6.03)	(5.42)	-	-	-	-	-	-
1992	-	-	-	-	(6.03)	(5.42)	-	-	-	-	-	-
1993	-	-	-	-	(6.49)	(1.30)	-	-	-	-	-	-
1994	-	-	-	-	(6.94)	2.84	-	-	-	-	-	-
1995	-	-	-	-	(7.38)	(3.02)	-	-	-	-	-	-
1996	-	-	-	-	(7.38)	-	-	-	-	-	-	-
1997	-	-	-	-	(7.82)	-	-	-	-	-	-	-
1998	-	-	-	-	(8.26)	-	-	-	-	-	-	-
1999	-	-	-	-	(8.68)	-	-	-	-	-	-	-
2000	-	-	-	-	(8.68)	-	-	-	-	-	-	-
2001	-	-	-	-	(9.11)	-	-	-	-	-	-	-
2002	-	-	-	-	(9.52)	-	-	-	-	-	-	-
2003	-	-	-	-	(9.93)	-	-	-	-	-	-	-
2004	-	-	-	-	(9.93)	-	-	-	-	-	-	-
2005	-	-	-	-	(10.34)	-	-	-	-	-	-	-
2006	-	-	-	-	(10.74)	-	-	-	-	-	-	-
2007	-	-	-	-	(11.13)	-	-	-	-	-	-	-
2008	-	-	-	-	(11.13)	-	-	-	-	-	-	-
2009	-	-	-	-	(11.13)	-	-	-	-	-	-	-
2010	-	-	-	-	(11.88)	-	-	-	-	-	-	-

Table-Annex 1. 16 Zarima reservoir simulation, monthly Irrigation deficit for 25 000 ha (m3/s).

Irrigation outlet monthely deficit (m3)

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1968	-	-	-	-	-	1,109,098.88	-	-	-	-	-	-
1969	-	-	-	-	-	2,086,196.48	-	-	-	-	-	-
1970	-	-	-	-	-	3,032,967.68	-	-	-	-	-	-
1971	-	-	-	-	-	3,949,412.48	-	-	-	-	-	-
1972	-	-	-	-	-	3,949,412.48	-	-	-	-	-	-
1973	-	-	-	-	-	4,835,530.88	-	-	-	-	-	-
1974	-	-	-	-	-	5,691,409.28	-	-	-	-	-	-
1975	-	-	-	-	328,062.08	6,516,874.88	-	-	-	-	-	-
1976	-	-	-	-	328,062.08	6,516,874.88	-	-	-	-	-	-
1977	-	-	-	-	1,729,729.28	(29,393.93)	-	-	-	-	-	-
1978	-	-	-	-	3,116,276.48	8,076,913.28	-	-	-	-	-	-
1979	-	-	-	-	4,487,876.48	8,811,486.08	-	-	-	-	-	-
1980	-	-	-	-	4,487,876.48	8,811,486.08	-	-	-	-	-	-
1981	-	-	-	-	5,844,442.88	9,515,646.08	-	-	-	-	-	-
1982	-	-	-	-	7,185,975.68	10,189,566.08	-	-	-	-	-	-
1983	-	-	-	-	8,512,474.87	10,833,159.68	-	-	-	-	-	-
1984	-	-	-	-	8,512,474.87	10,833,159.68	-	-	-	-	-	-
1985	-	-	-	-	9,823,940.47	11,446,426.88	-	-	-	-	-	-
1986	-	-	-	-	11,120,372.48	12,029,367.68	-	-	-	-	-	-
1987	-	-	-	-	12,401,770.88	-	-	-	-	-	-	-
1988	-	-	-	-	12,401,770.88	12,581,982.08	-	-	-	-	-	-
1989	-	-	-	-	13,668,222.08	13,104,270.08	-	-	-	-	-	-
1990	-	-	-	-	14,919,553.28	9,891,313.28	-	-	-	-	-	-
1991	-	-	-	-	16,155,937.28	14,057,953.28	-	-	-	-	-	-
1992	-	-	-	-	16,155,937.28	14,057,953.28	-	-	-	-	-	-
1993	-	-	-	-	17,377,287.68	3,364,570.88	-	-	-	-	-	-
1994	-	-	-	-	18,583,518.08	-	-	-	-	-	-	-
1995	-	-	-	-	19,774,801.28	-	-	-	-	-	-	-
1996	-	-	-	-	19,774,801.28	-	-	-	-	-	-	-
1997	-	-	-	-	20,951,050.88	-	-	-	-	-	-	-
1998	-	-	-	-	22,112,266.88	-	-	-	-	-	-	-
1999	-	-	-	-	23,258,449.28	-	-	-	-	-	-	-
2000	-	-	-	-	23,258,449.28	-	-	-	-	-	-	-
2001	-	-	-	-	24,389,598.08	-	-	-	-	-	-	-
2002	-	-	-	-	25,505,713.28	-	-	-	-	-	-	-
2003	-	-	-	-	26,606,794.88	-	-	-	-	-	-	-
2004	-	-	-	-	26,606,794.88	-	-	-	-	-	-	-
2005	-	-	-	-	27,692,929.28	-	-	-	-	-	-	-
2006	-	-	-	-	28,763,943.68	-	-	-	-	-	-	-
2007	-	-	-	-	29,820,010.88	-	-	-	-	-	-	-
2008	-	-	-	-	29,820,010.88	-	-	-	-	-	-	-
2009	-	-	-	-	29,820,010.88	-	-	-	-	-	-	-
2010	-	-	-	-	31,811,012.48	-	-	-	-	-	-	-

Table-Annex 1. 17 Zarima reservoir simulation, sugarcane for 25 000 ha Emergency Spillway outflow (m3/s).

ANNEX II

Result of Zarrim Reservoir operation

and

Irrigation deficit

Case Two

Total inflow for case two

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Min	**0.00**	**0.00**	**0.00**	**0.00**	**0.30**	**7.20**	**66.53**	**16.05**	**17.93**	**0.90**	**0.00**	**0.00**
Avg	**0.10**	**0.09**	**0.18**	**0.84**	**3.61**	**25.69**	**127.06**	**161.94**	**44.15**	**4.08**	**0.56**	**0.20**
Max	**1.43**	**0.70**	**0.98**	**4.05**	**14.03**	**63.90**	**177.08**	**339.53**	**73.80**	**15.23**	**3.60**	**1.95**
Max-Min	**1.43**	**0.70**	**0.98**	**4.05**	**13.73**	**56.70**	**110.55**	**323.48**	**55.88**	**14.33**	**3.60**	**1.95**
St.Dev	**0.25**	**0.16**	**0.26**	**1.01**	**3.18**	**13.13**	**27.79**	**58.60**	**16.09**	**3.02**	**0.67**	**0.48**
Cv	**2.6**	**1.7**	**1.5**	**1.2**	**0.9**	**0.5**	**0.2**	**0.4**	**0.4**	**0.7**	**1.2**	**2.4**
1968	0.0	0.0	0.0	0.0	0.7	16.5	124.6	201.8	69.1	8.1	0.2	0.0
1969	0.0	0.1	0.0	0.5	1.1	21.8	175.3	210.8	27.8	6.9	0.4	1.7
1970	0.0	0.0	0.0	0.3	0.3	8.9	175.4	154.1	30.2	2.6	0.1	0.0
1971	0.2	0.1	0.0	0.3	1.7	36.1	66.5	203.6	66.3	3.3	0.7	0.0
1972	0.0	0.2	0.0	0.7	1.3	49.8	95.6	106.8	25.4	2.2	1.3	0.0
1973	0.1	0.0	0.0	0.8	6.2	9.3	112.0	143.9	38.3	4.9	0.5	0.1
1974	0.0	0.1	0.0	0.0	12.5	41.3	126.7	145.0	73.8	1.7	0.0	0.0
1975	0.3	0.2	0.0	0.0	0.8	23.8	143.6	216.2	67.7	3.7	0.5	1.9
1976	0.0	0.0	0.0	0.7	3.4	22.6	120.8	140.6	38.4	3.0	1.4	0.0
1977	0.0	0.0	0.1	0.3	5.1	63.9	122.8	180.5	72.9	11.7	0.9	2.0
1978	0.1	0.0	0.2	0.2	1.9	17.9	93.3	154.7	47.4	2.6	0.2	0.7
1979	0.0	0.1	0.0	0.0	2.2	9.6	103.4	139.1	17.9	4.4	0.1	0.1
1980	0.0	0.2	0.0	4.1	3.2	10.9	140.6	137.0	47.4	3.1	0.5	0.0
1981	0.2	0.1	0.2	2.8	4.2	15.2	177.1	110.8	36.8	1.9	1.3	0.1
1982	0.0	0.3	1.0	3.2	3.3	7.2	75.1	120.7	30.3	4.9	0.2	0.0
1983	0.0	0.0	0.0	0.0	2.9	25.8	104.7	16.1	21.2	1.8	2.1	0.1
1984	0.0	0.0	0.2	1.1	7.0	29.9	120.9	155.3	68.9	1.8	0.4	0.4
1985	0.0	0.0	0.3	0.6	4.4	29.3	125.4	154.1	28.9	4.5	0.1	0.0
1986	0.0	0.0	0.3	0.0	0.4	22.9	124.1	222.4	57.3	3.1	0.2	0.0
1987	0.0	0.0	0.1	0.2	11.9	44.2	117.7	149.3	64.1	4.1	0.1	0.0
1988	0.0	0.7	0.2	0.8	1.7	21.5	118.7	108.5	29.6	9.9	0.2	0.0
1989	0.0	0.2	0.0	0.1	3.5	29.2	87.8	103.3	35.0	1.9	0.1	0.0
1990	0.1	0.1	0.0	0.7	0.6	13.1	152.6	156.3	27.5	2.8	1.2	0.1
1991	0.0	0.0	0.0	0.1	2.1	12.8	117.3	177.8	30.6	1.4	0.2	0.0
1992	0.0	0.0	0.0	0.1	1.5	11.0	126.0	152.1	50.6	15.2	3.6	0.1
1993	0.0	0.2	0.2	1.1	4.9	30.0	93.1	119.9	30.1	6.8	0.2	0.0
1994	0.0	0.1	0.1	0.2	2.1	18.8	150.8	319.7	73.1	3.9	0.3	0.0
1995	0.0	0.0	0.8	0.3	4.1	13.1	117.1	106.2	26.5	1.2	0.2	0.0
1996	0.0	0.6	0.8	2.4	14.0	43.5	74.7	132.5	32.9	2.6	1.4	0.1
1997	0.0	0.1	0.3	0.5	3.9	14.2	175.8	172.3	41.6	8.0	1.0	0.1
1998	0.1	0.0	0.2	0.1	6.7	22.7	138.5	150.1	38.4	3.8	0.3	0.0
1999	0.5	0.1	0.0	0.6	4.7	36.0	119.3	18.3	58.2	6.5	0.5	0.3
2000	0.0	0.0	0.0	2.9	2.4	27.5	130.8	187.2	41.6	4.2	0.5	0.0
2001	0.0	0.1	0.3	2.1	3.2	24.2	128.1	151.2	62.4	7.1	0.2	0.1
2002	0.1	0.1	0.2	0.5	1.4	21.0	139.0	199.1	51.3	2.9	0.8	0.4
2003	0.0	0.4	0.0	0.1	1.1	35.6	144.2	159.5	45.2	2.0	0.4	0.0
2004	1.4	0.3	0.2	1.1	0.8	18.8	133.1	159.2	42.8	5.2	0.6	0.1
2005	0.0	0.1	0.7	0.5	1.1	41.9	106.9	184.3	43.2	1.0	0.3	0.0
2006	0.0	0.0	0.1	0.7	6.8	33.1	175.5	195.6	62.9	3.6	0.2	0.0
2007	0.1	0.0	0.3	1.2	3.5	55.8	156.8	202.4	38.3	2.0	0.8	0.0
2008	0.5	0.0	0.0	2.4	4.8	30.0	135.3	233.3	37.1	1.1	0.1	0.7
2009	0.0	0.0	0.4	0.2	0.3	20.2	137.3	173.1	24.6	0.9	0.4	0.1
2010	0.5	0.0	0.8	2.1	6.2	24.2	159.6	339.5	44.9	1.4	0.1	0.0

Table-Annex 1. 18 Zarima reservoir, case two total inflow

Scenario "R-A"

Irrigation and Enviromental outlet Outflow (m3/s)												
	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1968	34.80	48.47	42.64	36.97	25.86	11.40	5.16	99.35	106.49	46.62	31.25	29.20
1969	34.80	42.97	42.64	36.97	25.86	11.40	5.16	47.75	76.71	34.60	31.25	29.20
1970	34.80	42.97	42.64	36.97	25.86	7.23	5.16	14.90	37.60	33.47	31.25	29.20
1971	34.80	42.97	42.64	36.97	21.07	11.40	5.16	10.08	32.98	35.21	31.25	29.20
1972	34.80	44.50	42.64	36.97	24.26	11.40	5.16	10.08	23.09	33.47	31.25	29.20
1973	34.80	42.97	29.66	-	-	2.46	5.16	10.08	23.09	33.47	31.25	29.20
1974	34.80	42.97	42.64	17.80	6.77	11.40	5.16	10.08	41.54	37.39	31.25	29.20
1975	34.80	42.97	42.64	36.97	25.86	11.40	5.16	26.24	80.74	42.95	31.25	29.20
1976	34.80	44.50	42.64	36.97	25.86	11.40	5.16	10.08	23.09	33.47	31.25	29.20
1977	34.80	42.97	42.64	36.97	3.57	11.40	5.16	20.60	72.94	44.81	31.25	29.20
1978	34.80	42.97	42.64	36.97	25.86	11.40	5.16	10.08	23.09	33.47	31.25	29.20
1979	34.80	42.97	42.64	35.81	-	3.82	5.16	10.08	23.09	33.47	31.25	29.20
1980	34.80	44.50	28.32	-	-	4.92	5.16	10.08	23.09	33.47	31.25	29.20
1981	34.80	42.97	42.64	36.97	11.24	9.92	5.16	10.08	23.09	33.47	31.25	29.20
1982	34.80	42.97	42.64	36.97	12.08	3.78	5.16	10.08	23.09	33.47	31.25	29.20
1983	34.80	41.32	-	-	-	5.44	5.16	10.08	23.09	33.47	31.25	29.20
1984	2.95	-	-	-	-	5.03	5.16	10.08	30.43	34.84	31.25	29.20
1985	34.80	42.97	42.64	36.97	25.86	11.40	5.16	10.08	23.09	33.47	31.25	29.20
1986	34.80	42.97	42.64	36.97	7.36	9.20	5.16	19.64	69.27	39.57	31.25	29.20
1987	34.80	42.97	42.64	36.97	25.86	11.40	5.16	10.08	47.77	35.71	31.25	29.20
1988	34.80	44.50	42.64	36.97	25.86	11.40	5.16	10.08	23.09	33.47	31.25	29.20
1989	34.80	42.97	37.54	-	-	8.69	5.16	10.08	23.09	33.47	31.25	29.20
1990	34.80	42.97	7.35	-	-	-	5.16	10.08	23.09	33.47	31.25	29.20
1991	34.80	42.97	42.64	36.97	16.34	8.49	5.16	10.08	23.09	33.47	31.25	29.20
1992	34.80	44.50	42.64	36.97	5.35	5.17	5.16	10.08	23.09	33.47	31.25	29.20
1993	34.80	42.97	42.64	36.97	25.86	11.40	5.16	10.08	23.09	33.47	31.25	29.20
1994	34.80	42.97	30.99	-	-	5.03	5.16	82.07	128.54	48.53	31.25	29.20
1995	34.80	42.97	42.64	36.97	25.86	11.40	5.16	10.08	23.09	33.47	31.25	29.20
1996	34.80	44.50	28.32	-	7.17	11.40	5.16	10.08	23.09	33.47	31.25	29.20
1997	34.80	42.97	34.94	-	-	5.51	5.16	20.53	59.91	33.86	31.25	29.20
1998	34.80	42.97	42.64	36.97	25.86	11.40	5.16	10.08	24.89	33.47	31.25	29.20
1999	34.80	42.97	42.64	36.97	25.86	11.40	5.16	10.08	23.09	33.47	31.25	29.20
2000	34.80	34.71	-	-	-	5.86	5.16	13.57	46.85	33.47	31.25	29.20
2001	34.80	42.97	42.64	36.97	25.86	11.40	5.16	10.08	29.99	34.45	31.25	29.20
2002	34.80	42.97	42.64	36.97	25.86	11.40	5.16	18.53	62.46	36.92	31.25	29.20
2003	34.80	42.97	42.64	36.97	25.86	11.40	5.16	13.50	48.45	33.47	31.25	29.20
2004	34.80	44.50	42.64	36.97	21.54	10.90	5.16	10.08	23.09	33.47	31.25	29.20
2005	34.80	42.97	42.64	36.97	22.21	11.40	5.16	11.14	40.92	33.47	31.25	29.20
2006	34.80	42.97	42.64	36.97	25.64	11.40	5.16	38.30	85.23	43.07	31.25	29.20
2007	34.80	42.97	42.64	36.97	25.86	11.40	5.16	50.81	80.87	36.14	31.25	29.20
2008	34.80	44.50	42.64	36.97	25.86	11.40	5.16	34.90	77.02	35.46	31.25	29.20
2009	34.80	42.97	42.64	36.97	24.72	11.31	5.16	10.44	24.67	33.47	31.25	29.20
2010	34.80	42.97	42.64	36.97	24.70	11.40	5.16	106.87	121.66	41.53	31.25	27.27

Table-Annex 1. 19 Zarima reservoir simulation, sugarcane for 40 000 ha Irrigation and Environmental outlet outflow (m3/s).

Irrigation outlet Outflow (m3/s)

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1968	32.30	45.97	40.14	34.47	23.36	8.90	2.66	96.85	103.99	44.12	28.75	26.70
1969	32.30	40.47	40.14	34.47	23.36	8.90	2.66	45.25	74.21	32.10	28.75	26.70
1970	32.30	40.47	40.14	34.47	23.36	4.73	2.66	12.40	35.10	30.97	28.75	26.70
1971	32.30	40.47	40.14	34.47	18.57	8.90	2.66	7.58	30.48	32.71	28.75	26.70
1972	32.30	42.00	40.14	34.47	21.76	8.90	2.66	7.58	20.59	30.97	28.75	26.70
1973	32.30	40.47	27.16	(2.50)	(2.50)	(0.04)	2.66	7.58	20.59	30.97	28.75	26.70
1974	32.30	40.47	40.14	15.30	4.27	8.90	2.66	7.58	39.04	34.89	28.75	26.70
1975	32.30	40.47	40.14	34.47	23.36	8.90	2.66	23.74	78.24	40.45	28.75	26.70
1976	32.30	42.00	40.14	34.47	23.36	8.90	2.66	7.58	20.59	30.97	28.75	26.70
1977	32.30	40.47	40.14	34.47	1.07	8.90	2.66	18.10	70.44	42.31	28.75	26.70
1978	32.30	40.47	40.14	34.47	23.36	8.90	2.66	7.58	20.59	30.97	28.75	26.70
1979	32.30	40.47	40.14	33.31	(2.50)	1.32	2.66	7.58	20.59	30.97	28.75	26.70
1980	32.30	42.00	25.82	(2.50)	(2.50)	2.42	2.66	7.58	20.59	30.97	28.75	26.70
1981	32.30	40.47	40.14	34.47	8.74	7.42	2.66	7.58	20.59	30.97	28.75	26.70
1982	32.30	40.47	40.14	34.47	9.58	1.28	2.66	7.58	20.59	30.97	28.75	26.70
1983	32.30	38.82	(2.50)	(2.50)	(2.50)	2.94	2.66	7.58	20.59	30.97	28.75	26.70
1984	0.45	(2.50)	(2.50)	(2.50)	(2.50)	2.53	2.66	7.58	27.93	32.34	28.75	26.70
1985	32.30	40.47	40.14	34.47	23.36	8.90	2.66	7.58	20.59	30.97	28.75	26.70
1986	32.30	40.47	40.14	34.47	4.86	6.70	2.66	17.14	66.77	37.07	28.75	26.70
1987	32.30	40.47	40.14	34.47	23.36	8.90	2.66	7.58	45.27	33.21	28.75	26.70
1988	32.30	42.00	40.14	34.47	23.36	8.90	2.66	7.58	20.59	30.97	28.75	26.70
1989	32.30	40.47	35.04	(2.50)	(2.50)	6.19	2.66	7.58	20.59	30.97	28.75	26.70
1990	32.30	40.47	4.85	(2.50)	(2.50)	(2.50)	2.66	7.58	20.59	30.97	28.75	26.70
1991	32.30	40.47	40.14	34.47	13.84	5.99	2.66	7.58	20.59	30.97	28.75	26.70
1992	32.30	42.00	40.14	34.47	2.85	2.67	2.66	7.58	20.59	30.97	28.75	26.70
1993	32.30	40.47	40.14	34.47	23.36	8.90	2.66	7.58	20.59	30.97	28.75	26.70
1994	32.30	40.47	28.49	(2.50)	(2.50)	2.53	2.66	79.57	126.04	46.03	28.75	26.70
1995	32.30	40.47	40.14	34.47	23.36	8.90	2.66	7.58	20.59	30.97	28.75	26.70
1996	32.30	42.00	25.82	(2.50)	4.67	8.90	2.66	7.58	20.59	30.97	28.75	26.70
1997	32.30	40.47	32.44	(2.50)	(2.50)	3.01	2.66	18.03	57.41	31.36	28.75	26.70
1998	32.30	40.47	40.14	34.47	23.36	8.90	2.66	7.58	22.39	30.97	28.75	26.70
1999	32.30	40.47	40.14	34.47	23.36	8.90	2.66	7.58	20.59	30.97	28.75	26.70
2000	32.30	32.21	(2.50)	(2.50)	(2.50)	3.36	2.66	11.07	44.35	30.97	28.75	26.70
2001	32.30	40.47	40.14	34.47	23.36	8.90	2.66	7.58	27.49	31.95	28.75	26.70
2002	32.30	40.47	40.14	34.47	23.36	8.90	2.66	16.03	59.96	34.42	28.75	26.70
2003	32.30	40.47	40.14	34.47	23.36	8.90	2.66	11.00	45.95	30.97	28.75	26.70
2004	32.30	42.00	40.14	34.47	19.04	8.40	2.66	7.58	20.59	30.97	28.75	26.70
2005	32.30	40.47	40.14	34.47	19.71	8.90	2.66	8.64	38.42	30.97	28.75	26.70
2006	32.30	40.47	40.14	34.47	23.14	8.90	2.66	35.80	82.73	40.57	28.75	26.70
2007	32.30	40.47	40.14	34.47	23.36	8.90	2.66	48.31	78.37	33.64	28.75	26.70
2008	32.30	42.00	40.14	34.47	23.36	8.90	2.66	32.40	74.52	32.96	28.75	26.70
2009	32.30	40.47	40.14	34.47	22.22	8.81	2.66	7.94	22.17	30.97	28.75	26.70
2010	32.30	40.47	40.14	34.47	22.20	8.90	2.66	104.37	119.16	39.03	28.75	24.77

Table-Annex 1. 20 Zarima reservoir simulation, sugarcane for 40 000 ha Irrigation and Environmental outlet outflow (m3/s).

irrigation demand (CWR)												
	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1968	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1969	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1970	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1971	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1972	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1973	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1974	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1975	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1976	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1977	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1978	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1979	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1980	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1981	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1982	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1983	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1984	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1985	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1986	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1987	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1988	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1989	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1990	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1991	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1992	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1993	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1994	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1995	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1996	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1997	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1998	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
1999	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2000	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2001	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2002	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2003	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2004	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2005	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2006	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2007	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2008	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2009	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98
2010	27.37	36.92	43.78	36.73	32.36	14.92	3.26	2.09	12.73	27.94	31.71	25.98

Table-Annex 1. 21 Zarima reservoir simulation, monthly Irrigation demand for 40 000 ha (m3/s).

Irrigation outlet monthely deficit (m3/s)

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1968	-	-	(3.64)	(2.26)	(9.00)	(6.02)	(0.60)	-	-	-	(2.96)	-
1969	-	-	(3.64)	(2.26)	(9.00)	(6.02)	(0.60)	-	-	-	(2.96)	-
1970	-	-	(3.64)	(2.26)	(9.00)	(10.19)	(0.60)	-	-	-	(2.96)	-
1971	-	-	(3.64)	(2.26)	(13.79)	(6.02)	(0.60)	-	-	-	(2.96)	-
1972	-	-	(3.64)	(2.26)	(10.60)	(6.02)	(0.60)	-	-	-	(2.96)	-
1973	-	-	(16.62)	(39.23)	(34.86)	(14.95)	(0.60)	-	-	-	(2.96)	-
1974	-	-	(3.64)	(21.44)	(28.09)	(6.02)	(0.60)	-	-	-	(2.96)	-
1975	-	-	(3.64)	(2.26)	(9.00)	(6.02)	(0.60)	-	-	-	(2.96)	-
1976	-	-	(3.64)	(2.26)	(9.00)	(6.02)	(0.60)	-	-	-	(2.96)	-
1977	-	-	(3.64)	(2.26)	(31.29)	(6.02)	(0.60)	-	-	-	(2.96)	-
1978	-	-	(3.64)	(2.26)	(9.00)	(6.02)	(0.60)	-	-	-	(2.96)	-
1979	-	-	(3.64)	(3.42)	(34.86)	(13.60)	(0.60)	-	-	-	(2.96)	-
1980	-	-	(17.96)	(39.23)	(34.86)	(12.49)	(0.60)	-	-	-	(2.96)	-
1981	-	-	(3.64)	(2.26)	(23.62)	(7.49)	(0.60)	-	-	-	(2.96)	-
1982	-	-	(3.64)	(2.26)	(22.78)	(13.63)	(0.60)	-	-	-	(2.96)	-
1983	-	-	(46.28)	(39.23)	(34.86)	(11.98)	(0.60)	-	-	-	(2.96)	-
1984	(26.92)	(39.42)	(46.28)	(39.23)	(34.86)	(12.39)	(0.60)	-	-	-	(2.96)	-
1985	-	-	(3.64)	(2.26)	(9.00)	(6.02)	(0.60)	-	-	-	(2.96)	-
1986	-	-	(3.64)	(2.26)	(27.49)	(8.22)	(0.60)	-	-	-	(2.96)	-
1987	-	-	(3.64)	(2.26)	(9.00)	(6.02)	(0.60)	-	-	-	(2.96)	-
1988	-	-	(3.64)	(2.26)	(9.00)	(6.02)	(0.60)	-	-	-	(2.96)	-
1989	-	-	(8.74)	(39.23)	(34.86)	(8.73)	(0.60)	-	-	-	(2.96)	-
1990	-	-	(38.92)	(39.23)	(34.86)	(17.42)	(0.60)	-	-	-	(2.96)	-
1991	-	-	(3.64)	(2.26)	(18.52)	(8.93)	(0.60)	-	-	-	(2.96)	-
1992	-	-	(3.64)	(2.26)	(29.51)	(12.25)	(0.60)	-	-	-	(2.96)	-
1993	-	-	(3.64)	(2.26)	(9.00)	(6.02)	(0.60)	-	-	-	(2.96)	-
1994	-	-	(15.29)	(39.23)	(34.86)	(12.39)	(0.60)	-	-	-	(2.96)	-
1995	-	-	(3.64)	(2.26)	(9.00)	(6.02)	(0.60)	-	-	-	(2.96)	-
1996	-	-	(17.96)	(39.23)	(27.69)	(6.02)	(0.60)	-	-	-	(2.96)	-
1997	-	-	(11.34)	(39.23)	(34.86)	(11.91)	(0.60)	-	-	-	(2.96)	-
1998	-	-	(3.64)	(2.26)	(9.00)	(6.02)	(0.60)	-	-	-	(2.96)	-
1999	-	-	(3.64)	(2.26)	(9.00)	(6.02)	(0.60)	-	-	-	(2.96)	-
2000	-	(4.70)	(46.28)	(39.23)	(34.86)	(11.55)	(0.60)	-	-	-	(2.96)	-
2001	-	-	(3.64)	(2.26)	(9.00)	(6.02)	(0.60)	-	-	-	(2.96)	-
2002	-	-	(3.64)	(2.26)	(9.00)	(6.02)	(0.60)	-	-	-	(2.96)	-
2003	-	-	(3.64)	(2.26)	(9.00)	(6.02)	(0.60)	-	-	-	(2.96)	-
2004	-	-	(3.64)	(2.26)	(13.31)	(6.52)	(0.60)	-	-	-	(2.96)	-
2005	-	-	(3.64)	(2.26)	(12.64)	(6.02)	(0.60)	-	-	-	(2.96)	-
2006	-	-	(3.64)	(2.26)	(9.21)	(6.02)	(0.60)	-	-	-	(2.96)	-
2007	-	-	(3.64)	(2.26)	(9.00)	(6.02)	(0.60)	-	-	-	(2.96)	-
2008	-	-	(3.64)	(2.26)	(9.00)	(6.02)	(0.60)	-	-	-	(2.96)	-
2009	-	-	(3.64)	(2.26)	(10.14)	(6.11)	(0.60)	-	-	-	(2.96)	-
2010	-	-	(3.64)	(2.26)	(10.16)	(6.02)	(0.60)	-	-	-	(2.96)	(1.21)

Table-Annex 1. 22 Zarima reservoir simulation, monthly Irrigation deficit for 40 000 ha (m3/s).

	Emergency spillway Outflow (m^3/s)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
1968	-	-	-	-	-	-	-	-	-	-	-	-	-
1969	-	-	-	-	-	-	-	20.64	28.71	0.09	-	-	-
1970	-	-	-	-	-	-	-	0.52	1.89	-	-	-	-
1971	-	-	-	-	-	-	-	-	0.99	0.21	-	-	-
1972	-	-	-	-	-	-	-	-	-	-	-	-	-
1973	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-	3.54	0.91	-	-	-
1975	-	-	-	-	-	-	-	6.25	32.74	3.66	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	2.89	24.94	4.30	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	-	-	-	-	-	-	-	-	-	-	-	-	-
1980	-	-	-	-	-	-	-	-	-	-	-	-	-
1981	-	-	-	-	-	-	-	-	-	-	-	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	0.72	0.19	-	-	-
1985	-	-	-	-	-	-	-	-	-	-	-	-	-
1986	-	-	-	-	-	-	-	3.04	21.27	1.71	-	-	-
1987	-	-	-	-	-	-	-	-	3.47	0.48	-	-	-
1988	-	-	-	-	-	-	-	-	-	-	-	-	-
1989	-	-	-	-	-	-	-	-	-	-	-	-	-
1990	-	-	-	-	-	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	52.51	80.54	6.88	-	-	-
1995	-	-	-	-	-	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	2.82	11.91	0.11	-	-	-
1998	-	-	-	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	0.28	2.52	-	-	-	-
2001	-	-	-	-	-	-	-	-	0.42	0.08	-	-	-
2002	-	-	-	-	-	-	-	1.94	14.46	0.65	-	-	-
2003	-	-	-	-	-	-	-	0.21	2.23	-	-	-	-
2004	-	-	-	-	-	-	-	-	-	-	-	-	-
2005	-	-	-	-	-	-	-	-	0.11	-	-	-	-
2006	-	-	-	-	-	-	-	13.62	37.23	3.38	-	-	-
2007	-	-	-	-	-	-	-	22.49	32.87	0.71	-	-	-
2008	-	-	-	-	-	-	-	12.58	29.02	0.48	-	-	-
2009	-	-	-	-	-	-	-	-	0.00	-	-	-	-
2010	-	-	-	-	-	-	-	74.81	73.66	2.76	-	-	-

Table-Annex 1. 23 Zarima reservoir simulation, sugarcane for 40 000 ha Emergency Spillway outflow (m3/s).

Scenario “R-B”

Irrigation and Enviromental outlet Outflow (m3/s)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	48.00	46.42	42.64	36.97	25.86	11.40	28.50	48.00	48.00	46.80	31.25	29.20
1969	34.80	42.97	42.64	36.97	25.86	11.40	23.27	48.00	48.00	41.89	31.25	29.20
1970	34.80	42.97	42.64	36.97	25.86	11.40	19.10	48.00	48.00	40.31	31.25	29.20
1971	34.80	42.97	42.64	36.97	25.86	11.40	5.16	41.16	48.00	44.19	31.25	29.20
1972	34.80	44.50	42.64	36.97	25.86	11.40	12.15	48.00	48.00	38.61	31.25	29.20
1973	34.80	42.97	42.64	36.97	25.86	11.40	5.16	46.61	48.00	42.12	31.25	29.20
1974	34.80	42.97	42.64	36.97	25.86	11.40	21.88	48.00	48.00	44.53	31.25	29.20
1975	34.80	42.97	42.64	36.97	25.86	11.40	16.32	48.00	48.00	44.98	31.25	29.20
1976	34.80	44.50	42.64	36.97	25.86	11.40	12.15	48.00	48.00	41.10	31.25	29.20
1977	34.80	42.97	42.64	36.97	25.86	11.40	26.03	48.00	48.00	48.00	31.33	29.20
1978	34.80	42.97	42.64	36.97	25.86	11.40	5.16	45.23	48.00	42.77	31.25	29.20
1979	34.80	42.97	42.64	36.97	25.86	11.40	5.16	42.51	48.00	38.10	31.25	29.20
1980	34.80	44.50	42.64	36.97	25.86	11.40	12.15	48.00	48.00	42.40	31.25	29.20
1981	34.80	42.97	42.64	36.97	25.86	11.40	21.88	48.00	48.00	40.75	31.25	29.20
1982	34.80	42.97	42.64	36.97	25.86	11.40	5.16	33.33	48.00	40.11	31.25	29.20
1983	34.80	42.97	42.64	36.97	25.86	11.40	5.16	32.51	44.21	32.39	31.25	29.20
1984	34.80	44.50	42.64	36.97	25.86	11.40	12.15	48.00	48.00	43.75	31.25	29.20
1985	34.80	42.97	42.64	36.97	25.86	11.40	14.99	48.00	48.00	40.47	31.25	29.20
1986	34.80	42.97	42.64	36.97	25.86	11.40	10.75	48.00	48.00	44.03	31.25	29.20
1987	34.80	42.97	42.64	36.97	25.86	11.40	20.49	48.00	48.00	44.42	31.25	29.20
1988	34.80	44.50	42.64	36.97	25.86	11.40	9.35	48.00	48.00	42.61	31.25	29.20
1989	34.80	42.97	42.64	36.97	25.86	11.40	5.16	43.87	48.00	40.51	31.25	29.20
1990	34.80	42.97	42.64	36.97	25.86	11.40	14.93	48.00	48.00	40.04	31.25	29.20
1991	34.80	42.97	42.64	36.97	25.86	11.40	5.16	48.00	48.00	39.88	31.25	29.20
1992	34.80	44.50	42.64	36.97	25.86	11.40	6.56	48.00	48.00	48.00	31.96	29.20
1993	34.80	42.97	42.64	36.97	25.86	11.40	7.96	48.00	48.00	41.55	31.25	29.20
1994	34.80	42.97	42.64	36.97	25.86	11.40	17.38	48.00	48.00	45.69	31.25	29.20
1995	34.80	42.97	42.64	36.97	25.86	11.40	7.96	48.00	48.00	38.52	31.25	29.20
1996	34.80	44.50	42.64	36.97	25.86	11.40	5.16	47.76	48.00	40.00	31.25	29.20
1997	34.80	42.97	42.64	36.97	25.86	11.40	20.49	48.00	48.00	44.30	31.25	29.20
1998	34.80	42.97	42.64	36.97	25.86	11.40	17.72	48.00	48.00	42.13	31.25	29.20
1999	34.80	42.97	42.64	36.97	25.86	11.40	15.95	48.00	48.00	43.96	31.25	29.20
2000	34.80	44.50	42.64	36.97	25.86	11.40	16.32	48.00	48.00	42.40	31.25	29.20
2001	34.80	42.97	42.64	36.97	25.86	11.40	14.93	48.00	48.00	46.12	31.25	29.20
2002	34.80	42.97	42.64	36.97	25.86	11.40	16.32	48.00	48.00	43.11	31.25	29.20
2003	34.80	42.97	42.64	36.97	25.86	11.40	20.49	48.00	48.00	41.92	31.25	29.20
2004	34.80	44.50	42.64	36.97	25.86	11.40	12.15	48.00	48.00	42.69	31.25	29.20
2005	34.80	42.97	42.64	36.97	25.86	11.40	13.54	48.00	48.00	41.55	31.25	29.20
2006	34.80	42.97	42.64	36.97	25.86	11.40	26.03	48.00	48.00	44.78	31.25	29.20
2007	34.80	42.97	42.64	36.97	25.86	11.40	28.80	48.00	48.00	41.04	31.25	29.20
2008	34.80	44.50	42.64	36.97	25.86	11.40	17.72	48.00	48.00	41.14	31.25	29.20
2009	34.80	42.97	42.64	36.97	25.86	11.40	13.54	48.00	48.00	38.32	31.25	29.20
2010	34.80	42.97	42.64	36.97	25.86	11.40	20.85	48.00	48.00	42.80	31.25	27.27

Table-Annex 1. 24 Zarima reservoir simulation, sugarcane for 30 000 ha Irrigation and Environmental outlet outflow (m3/s).

Irrigation outlet Outflow (m3/s)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	46.00	44.42	40.64	34.97	23.86	9.40	26.50	46.00	46.00	44.80	29.25	27.20
1969	32.80	40.97	40.64	34.97	23.86	9.40	21.27	46.00	46.00	39.89	29.25	27.20
1970	32.80	40.97	40.64	34.97	23.86	9.40	17.10	46.00	46.00	38.31	29.25	27.20
1971	32.80	40.97	40.64	34.97	23.86	9.40	3.16	39.16	46.00	42.19	29.25	27.20
1972	32.80	42.50	40.64	34.97	23.86	9.40	10.15	46.00	46.00	36.61	29.25	27.20
1973	32.80	40.97	40.64	34.97	23.86	9.40	3.16	44.61	46.00	40.12	29.25	27.20
1974	32.80	40.97	40.64	34.97	23.86	9.40	19.88	46.00	46.00	42.53	29.25	27.20
1975	32.80	40.97	40.64	34.97	23.86	9.40	14.32	46.00	46.00	42.98	29.25	27.20
1976	32.80	42.50	40.64	34.97	23.86	9.40	10.15	46.00	46.00	39.10	29.25	27.20
1977	32.80	40.97	40.64	34.97	23.86	9.40	24.03	46.00	46.00	46.00	29.33	27.20
1978	32.80	40.97	40.64	34.97	23.86	9.40	3.16	43.23	46.00	40.77	29.25	27.20
1979	32.80	40.97	40.64	34.97	23.86	9.40	3.16	40.51	46.00	36.10	29.25	27.20
1980	32.80	42.50	40.64	34.97	23.86	9.40	10.15	46.00	46.00	40.40	29.25	27.20
1981	32.80	40.97	40.64	34.97	23.86	9.40	19.88	46.00	46.00	38.75	29.25	27.20
1982	32.80	40.97	40.64	34.97	23.86	9.40	3.16	31.33	46.00	38.11	29.25	27.20
1983	32.80	40.97	40.64	34.97	23.86	9.40	3.16	30.51	42.21	30.39	29.25	27.20
1984	32.80	42.50	40.64	34.97	23.86	9.40	10.15	46.00	46.00	41.75	29.25	27.20
1985	32.80	40.97	40.64	34.97	23.86	9.40	12.99	46.00	46.00	38.47	29.25	27.20
1986	32.80	40.97	40.64	34.97	23.86	9.40	8.75	46.00	46.00	42.03	29.25	27.20
1987	32.80	40.97	40.64	34.97	23.86	9.40	18.49	46.00	46.00	42.42	29.25	27.20
1988	32.80	42.50	40.64	34.97	23.86	9.40	7.35	46.00	46.00	40.61	29.25	27.20
1989	32.80	40.97	40.64	34.97	23.86	9.40	3.16	41.87	46.00	38.51	29.25	27.20
1990	32.80	40.97	40.64	34.97	23.86	9.40	12.93	46.00	46.00	38.04	29.25	27.20
1991	32.80	40.97	40.64	34.97	23.86	9.40	3.16	46.00	46.00	37.88	29.25	27.20
1992	32.80	42.50	40.64	34.97	23.86	9.40	4.56	46.00	46.00	46.00	29.96	27.20
1993	32.80	40.97	40.64	34.97	23.86	9.40	5.96	46.00	46.00	39.55	29.25	27.20
1994	32.80	40.97	40.64	34.97	23.86	9.40	15.38	46.00	46.00	43.69	29.25	27.20
1995	32.80	40.97	40.64	34.97	23.86	9.40	5.96	46.00	46.00	36.52	29.25	27.20
1996	32.80	42.50	40.64	34.97	23.86	9.40	3.16	45.76	46.00	38.00	29.25	27.20
1997	32.80	40.97	40.64	34.97	23.86	9.40	18.49	46.00	46.00	42.30	29.25	27.20
1998	32.80	40.97	40.64	34.97	23.86	9.40	15.72	46.00	46.00	40.13	29.25	27.20
1999	32.80	40.97	40.64	34.97	23.86	9.40	13.95	46.00	46.00	41.96	29.25	27.20
2000	32.80	42.50	40.64	34.97	23.86	9.40	14.32	46.00	46.00	40.40	29.25	27.20
2001	32.80	40.97	40.64	34.97	23.86	9.40	12.93	46.00	46.00	44.12	29.25	27.20
2002	32.80	40.97	40.64	34.97	23.86	9.40	14.32	46.00	46.00	41.11	29.25	27.20
2003	32.80	40.97	40.64	34.97	23.86	9.40	18.49	46.00	46.00	39.92	29.25	27.20
2004	32.80	42.50	40.64	34.97	23.86	9.40	10.15	46.00	46.00	40.69	29.25	27.20
2005	32.80	40.97	40.64	34.97	23.86	9.40	11.54	46.00	46.00	39.55	29.25	27.20
2006	32.80	40.97	40.64	34.97	23.86	9.40	24.03	46.00	46.00	42.78	29.25	27.20
2007	32.80	40.97	40.64	34.97	23.86	9.40	26.80	46.00	46.00	39.04	29.25	27.20
2008	32.80	42.50	40.64	34.97	23.86	9.40	15.72	46.00	46.00	39.14	29.25	27.20
2009	32.80	40.97	40.64	34.97	23.86	9.40	11.54	46.00	46.00	36.32	29.25	27.20
2010	32.80	40.97	40.64	34.97	23.86	9.40	18.85	46.00	46.00	40.80	29.25	25.27

Table-Annex 1. 25 Zarima reservoir simulation, sugarcane for 30 000 ha Irrigation outlet outflow (m3/s).

irrigation demand (CWR)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1969	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1970	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1971	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1972	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1973	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1974	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1975	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1976	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1977	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1978	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1979	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1980	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1981	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1982	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1983	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1984	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1985	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1986	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1987	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1988	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1989	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1990	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1991	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1992	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1993	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1994	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1995	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1996	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1997	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1998	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
1999	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
2000	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
2001	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
2002	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
2003	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
2004	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
2005	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
2006	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
2007	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
2008	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
2009	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98
2010	23.03	30.19	35.33	30.05	26.77	13.69	4.94	4.07	12.05	23.46	26.28	21.98

Table-Annex 1. 26 Zarima reservoir simulation, monthly Irrigation demand for 30 000 ha (m3/s).

Irrigation outlet monthely deficit (m3/s)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968					(2.91)	(4.29)						
1969					(2.91)	(4.29)						
1970					(2.91)	(4.29)						
1971					(2.91)	(4.29)	(1.79)					
1972					(2.91)	(4.29)						
1973					(2.91)	(4.29)	(1.79)					
1974					(2.91)	(4.29)						
1975					(2.91)	(4.29)						
1976					(2.91)	(4.29)						
1977					(2.91)	(4.29)						
1978					(2.91)	(4.29)	(1.79)					
1979					(2.91)	(4.29)	(1.79)					
1980					(2.91)	(4.29)						
1981					(2.91)	(4.29)						
1982					(2.91)	(4.29)	(1.79)					
1983					(2.91)	(4.29)	(1.79)					
1984					(2.91)	(4.29)						
1985					(2.91)	(4.29)						
1986					(2.91)	(4.29)						
1987					(2.91)	(4.29)						
1988					(2.91)	(4.29)						
1989					(2.91)	(4.29)	(1.79)					
1990					(2.91)	(4.29)						
1991					(2.91)	(4.29)	(1.79)					
1992					(2.91)	(4.29)	(0.39)					
1993					(2.91)	(4.29)						
1994					(2.91)	(4.29)						
1995					(2.91)	(4.29)						
1996					(2.91)	(4.29)	(1.79)					
1997					(2.91)	(4.29)						
1998					(2.91)	(4.29)						
1999					(2.91)	(4.29)						
2000					(2.91)	(4.29)						
2001					(2.91)	(4.29)						
2002					(2.91)	(4.29)						
2003					(2.91)	(4.29)						
2004					(2.91)	(4.29)						
2005					(2.91)	(4.29)						
2006					(2.91)	(4.29)						
2007					(2.91)	(4.29)						
2008					(2.91)	(4.29)						
2009					(2.91)	(4.29)						
2010					(2.91)	(4.29)						

Table-Annex 1. 27 Zarima reservoir simulation, monthly Irrigation deficit for 30 000 ha (m3/s).

Emergency spillway Outflow (m^3/s)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968							42.32	345.45	184.65	31.04	-	
1969							43.42	378.94	129.53	8.58	-	
1970							25.81	268.58	103.67	7.42	-	
1971							-	209.98	177.90	26.10	-	
1972							1.98	132.44	68.92	4.38	-	
1973							-	155.50	105.99	11.46	-	
1974							22.86	237.08	161.06	28.25	-	
1975							11.63	352.13	189.50	27.27	-	
1976							2.29	193.55	105.98	10.85	-	
1977							35.73	304.57	179.41	36.13	0.13	
1978							-	177.21	114.37	14.82	-	
1979							-	129.91	75.94	2.85	-	
1980							3.54	196.01	116.78	15.13	-	
1981							40.14	206.95	88.08	9.17	-	
1982							-	56.55	73.31	6.83	-	
1983							-	-	-	-	-	
1984							2.19	217.80	158.56	25.94	-	
1985							7.07	231.95	101.20	7.33	-	
1986							1.15	327.64	176.39	21.68	-	
1987							17.39	236.86	148.67	24.69	-	
1988							0.94	131.31	74.96	8.17	-	
1989							-	85.41	76.32	7.98	-	
1990							7.72	242.50	100.76	6.37	-	
1991							-	222.26	114.89	7.68	-	
1992							-	186.98	128.99	25.54	0.23	
1993							0.20	138.36	81.93	7.66	-	
1994							13.22	540.28	248.33	31.40	-	
1995							0.11	115.35	69.22	4.60	-	
1996							-	144.38	92.29	8.01	-	
1997							33.17	305.75	129.11	15.28	-	
1998							13.28	238.87	112.11	11.37	-	
1999							6.45	26.77	42.66	17.15	-	
2000							9.24	294.38	136.26	13.74	-	
2001							5.17	223.02	146.73	25.78	-	
2002							8.76	315.90	156.28	18.18	-	
2003							22.77	266.53	127.21	14.15	-	
2004							3.48	231.70	122.88	14.23	-	
2005							3.03	268.78	136.64	13.24	-	
2006							59.29	359.35	172.38	24.51	-	
2007							68.83	367.28	139.95	11.65	-	
2008							13.60	383.06	153.10	11.27	-	
2009							4.24	259.09	105.66	5.23	-	
2010							29.35	592.87	217.13	16.18	-	

Table-Annex 1. 28 Zarima reservoir simulation, sugarcane for 30 000 ha Emergency Spillway outflow (m3/s).

Scenario "R-C"

Irrigation and Enviromental outlet Outflow (m3/s)

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1968	48.00	46.42	42.64	36.97	25.86	11.40	23.27	48.00	48.00	45.34	31.25	29.20
1969	34.80	42.97	42.64	36.97	25.86	11.40	17.72	48.00	48.00	40.52	31.25	29.20
1970	34.80	42.97	42.64	36.97	25.86	11.40	13.54	48.00	48.00	38.92	31.25	29.20
1971	34.80	42.97	42.64	36.97	25.86	11.40	5.16	37.20	48.00	43.16	31.25	29.20
1972	34.80	44.50	42.64	36.97	25.86	11.40	5.16	45.05	48.00	37.64	31.25	29.20
1973	34.80	42.97	42.64	36.97	25.86	11.40	5.16	38.51	48.00	40.99	31.25	29.20
1974	34.80	42.97	42.64	36.97	25.86	11.40	13.54	48.00	48.00	42.87	31.25	29.20
1975	34.80	42.97	42.64	36.97	25.86	11.40	9.35	48.00	48.00	43.99	31.25	29.20
1976	34.80	44.50	42.64	36.97	25.86	11.40	5.16	46.61	48.00	40.60	31.25	29.20
1977	34.80	42.97	42.64	36.97	25.86	11.40	17.72	48.00	48.00	47.43	31.25	29.20
1978	34.80	42.97	42.64	36.97	25.86	11.40	5.16	38.86	48.00	41.51	31.25	29.20
1979	34.80	42.97	42.64	36.97	25.86	11.40	5.16	35.90	48.00	36.51	31.25	29.20
1980	34.80	44.50	42.64	36.97	25.86	11.40	5.16	46.95	48.00	41.06	31.25	29.20
1981	34.80	42.97	42.64	36.97	25.86	11.40	16.32	48.00	48.00	39.43	31.25	29.20
1982	34.80	42.97	42.64	36.97	25.86	11.40	5.16	24.69	48.00	38.35	31.25	29.20
1983	34.80	42.97	42.64	36.97	25.86	11.40	5.16	10.08	23.09	32.39	31.25	29.20
1984	34.80	44.50	42.64	36.97	21.54	11.40	5.16	43.87	48.00	43.05	31.25	29.20
1985	34.80	42.97	42.64	36.97	25.86	11.40	6.56	48.00	48.00	39.50	31.25	29.20
1986	34.80	42.97	42.64	36.97	25.86	11.40	5.16	46.61	48.00	43.03	31.25	29.20
1987	34.80	42.97	42.64	36.97	25.86	11.40	12.15	48.00	48.00	43.08	31.25	29.20
1988	34.80	44.50	42.64	36.97	25.86	11.40	5.16	43.87	48.00	40.60	31.25	29.20
1989	34.80	42.97	42.64	36.97	25.86	11.40	5.16	33.33	48.00	38.40	31.25	29.20
1990	34.80	42.97	42.64	36.97	25.86	11.40	7.96	48.00	48.00	38.59	31.25	29.20
1991	34.80	42.97	42.64	36.97	25.86	11.40	5.16	41.65	48.00	38.76	31.25	29.20
1992	34.80	44.50	42.64	36.97	25.86	11.40	5.16	42.33	48.00	47.60	31.25	29.20
1993	34.80	42.97	42.64	36.97	25.86	11.40	5.16	41.16	48.00	39.58	31.25	29.20
1994	34.80	42.97	42.64	36.97	25.86	11.40	9.35	48.00	48.00	43.84	31.25	29.20
1995	34.80	42.97	42.64	36.97	25.86	11.40	5.16	41.16	48.00	37.71	31.25	29.20
1996	34.80	44.50	42.64	36.97	25.86	11.40	5.16	38.51	48.00	39.30	31.25	29.20
1997	34.80	42.97	42.64	36.97	25.86	11.40	14.93	48.00	48.00	42.55	31.25	29.20
1998	34.80	42.97	42.64	36.97	25.86	11.40	10.58	48.00	48.00	40.57	31.25	29.20
1999	34.80	42.97	42.64	36.97	25.86	11.40	6.56	37.04	48.00	42.03	31.25	29.20
2000	34.80	44.50	42.64	36.97	25.86	11.40	7.96	48.00	48.00	41.84	31.25	29.20
2001	34.80	42.97	42.64	36.97	25.86	11.40	5.86	48.00	48.00	44.79	31.25	29.20
2002	34.80	42.97	42.64	36.97	25.86	11.40	7.96	48.00	48.00	42.07	31.25	29.20
2003	34.80	42.97	42.64	36.97	25.86	11.40	13.54	48.00	48.00	40.91	31.25	29.20
2004	34.80	44.50	42.64	36.97	25.86	11.40	5.16	48.00	48.00	41.71	31.25	29.20
2005	34.80	42.97	42.64	36.97	25.86	11.40	5.16	46.61	48.00	40.80	31.25	29.20
2006	34.80	42.97	42.64	36.97	25.86	11.40	19.60	48.00	48.00	43.71	31.25	29.20
2007	34.80	42.97	42.64	36.97	25.86	11.40	23.27	48.00	48.00	40.10	31.25	29.20
2008	34.80	44.50	42.64	36.97	25.86	11.40	10.06	48.00	48.00	40.45	31.25	29.20
2009	34.80	42.97	42.64	36.97	25.86	11.40	5.16	48.00	48.00	37.35	31.25	29.20
2010	34.80	42.97	42.64	36.97	25.86	11.40	14.63	48.00	48.00	41.19	31.25	27.27

Table-Annex 1. 29 Zarima reservoir simulation, sugarcane for 25 000 ha Irrigation and Environmental outlet outflow (m3/s).

Irrigation outlet Outflow (m3/s)

	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1968	45.50	43.92	40.14	34.47	23.36	8.90	20.77	45.50	45.50	42.84	28.75	26.70
1969	32.30	40.47	40.14	34.47	23.36	8.90	15.22	45.50	45.50	38.02	28.75	26.70
1970	32.30	40.47	40.14	34.47	23.36	8.90	11.04	45.50	45.50	36.42	28.75	26.70
1971	32.30	40.47	40.14	34.47	23.36	8.90	2.66	34.70	45.50	40.66	28.75	26.70
1972	32.30	42.00	40.14	34.47	23.36	8.90	2.66	42.55	45.50	35.14	28.75	26.70
1973	32.30	40.47	40.14	34.47	23.36	8.90	2.66	36.01	45.50	38.49	28.75	26.70
1974	32.30	40.47	40.14	34.47	23.36	8.90	11.04	45.50	45.50	40.37	28.75	26.70
1975	32.30	40.47	40.14	34.47	23.36	8.90	6.85	45.50	45.50	41.49	28.75	26.70
1976	32.30	42.00	40.14	34.47	23.36	8.90	2.66	44.11	45.50	38.10	28.75	26.70
1977	32.30	40.47	40.14	34.47	23.36	8.90	15.22	45.50	45.50	44.93	28.75	26.70
1978	32.30	40.47	40.14	34.47	23.36	8.90	2.66	36.36	45.50	39.01	28.75	26.70
1979	32.30	40.47	40.14	34.47	23.36	8.90	2.66	33.40	45.50	34.01	28.75	26.70
1980	32.30	42.00	40.14	34.47	23.36	8.90	2.66	44.45	45.50	38.56	28.75	26.70
1981	32.30	40.47	40.14	34.47	23.36	8.90	13.82	45.50	45.50	36.93	28.75	26.70
1982	32.30	40.47	40.14	34.47	23.36	8.90	2.66	22.19	45.50	35.85	28.75	26.70
1983	32.30	40.47	40.14	34.47	23.36	8.90	2.66	7.58	20.59	29.89	28.75	26.70
1984	32.30	42.00	40.14	34.47	19.04	8.90	2.66	41.37	45.50	40.55	28.75	26.70
1985	32.30	40.47	40.14	34.47	23.36	8.90	4.06	45.50	45.50	37.00	28.75	26.70
1986	32.30	40.47	40.14	34.47	23.36	8.90	2.66	44.11	45.50	40.53	28.75	26.70
1987	32.30	40.47	40.14	34.47	23.36	8.90	9.65	45.50	45.50	40.58	28.75	26.70
1988	32.30	42.00	40.14	34.47	23.36	8.90	2.66	41.37	45.50	38.10	28.75	26.70
1989	32.30	40.47	40.14	34.47	23.36	8.90	2.66	30.83	45.50	35.90	28.75	26.70
1990	32.30	40.47	40.14	34.47	23.36	8.90	5.46	45.50	45.50	36.09	28.75	26.70
1991	32.30	40.47	40.14	34.47	23.36	8.90	2.66	39.15	45.50	36.26	28.75	26.70
1992	32.30	42.00	40.14	34.47	23.36	8.90	2.66	39.83	45.50	45.10	28.75	26.70
1993	32.30	40.47	40.14	34.47	23.36	8.90	2.66	38.66	45.50	37.08	28.75	26.70
1994	32.30	40.47	40.14	34.47	23.36	8.90	6.85	45.50	45.50	41.34	28.75	26.70
1995	32.30	40.47	40.14	34.47	23.36	8.90	2.66	38.66	45.50	35.21	28.75	26.70
1996	32.30	42.00	40.14	34.47	23.36	8.90	2.66	36.01	45.50	36.80	28.75	26.70
1997	32.30	40.47	40.14	34.47	23.36	8.90	12.43	45.50	45.50	40.05	28.75	26.70
1998	32.30	40.47	40.14	34.47	23.36	8.90	8.08	45.50	45.50	38.07	28.75	26.70
1999	32.30	40.47	40.14	34.47	23.36	8.90	4.06	34.54	45.50	39.53	28.75	26.70
2000	32.30	42.00	40.14	34.47	23.36	8.90	5.46	45.50	45.50	39.34	28.75	26.70
2001	32.30	40.47	40.14	34.47	23.36	8.90	3.36	45.50	45.50	42.29	28.75	26.70
2002	32.30	40.47	40.14	34.47	23.36	8.90	5.46	45.50	45.50	39.57	28.75	26.70
2003	32.30	40.47	40.14	34.47	23.36	8.90	11.04	45.50	45.50	38.41	28.75	26.70
2004	32.30	42.00	40.14	34.47	23.36	8.90	2.66	45.50	45.50	39.21	28.75	26.70
2005	32.30	40.47	40.14	34.47	23.36	8.90	2.66	44.11	45.50	38.30	28.75	26.70
2006	32.30	40.47	40.14	34.47	23.36	8.90	17.10	45.50	45.50	41.21	28.75	26.70
2007	32.30	40.47	40.14	34.47	23.36	8.90	20.77	45.50	45.50	37.60	28.75	26.70
2008	32.30	42.00	40.14	34.47	23.36	8.90	7.56	45.50	45.50	37.95	28.75	26.70
2009	32.30	40.47	40.14	34.47	23.36	8.90	2.66	45.50	45.50	34.85	28.75	26.70
2010	32.30	40.47	40.14	34.47	23.36	8.90	12.13	45.50	45.50	38.69	28.75	24.77

Table-Annex 1. 30 Zarima reservoir simulation, sugarcane for 25 000 ha Irrigation outlet outflow (m3/s).

Irrigation outlet monthely deficit (m3/s)												
	jan	feb	mar	apr	may	jun	jul	aug	sep	oct	nov	dec
1968						(2.93)						
1969						(2.93)						
1970						(2.93)						
1971						(2.93)	(1.88)					
1972						(2.93)	(1.88)					
1973						(2.93)	(1.88)					
1974						(2.93)						
1975						(2.93)						
1976						(2.93)	(1.88)					
1977						(2.93)						
1978						(2.93)	(1.88)					
1979						(2.93)	(1.88)					
1980						(2.93)	(1.88)					
1981						(2.93)						
1982						(2.93)	(1.88)					
1983						(2.93)	(1.88)					
1984					(3.69)	(2.93)	(1.88)					
1985						(2.93)	(0.48)					
1986						(2.93)	(1.88)					
1987						(2.93)						
1988						(2.93)	(1.88)					
1989						(2.93)	(1.88)					
1990						(2.93)						
1991						(2.93)	(1.88)					
1992						(2.93)	(1.88)					
1993						(2.93)	(1.88)					
1994						(2.93)						
1995						(2.93)	(1.88)					
1996						(2.93)	(1.88)					
1997						(2.93)						
1998						(2.93)						
1999						(2.93)	(0.48)					
2000						(2.93)						
2001						(2.93)	(1.18)					
2002						(2.93)						
2003						(2.93)						
2004						(2.93)	(1.88)					
2005						(2.93)	(1.88)					
2006						(2.93)						
2007						(2.93)						
2008						(2.93)						
2009						(2.93)	(1.88)					
2010						(2.93)						

Table-Annex 1. 31 Zarima reservoir simulation, monthly Irrigation deficit for 25 000 ha (m3/s).

Emergency spillway Outflow (m^3/s)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1968	-	-	-	-	-	-	19.87	274.24	148.84	24.22	-	-
1968	-	-	-	-	-	-	13.27	292.16	105.23	6.01	-	-
1968	-	-	-	-	-	-	4.77	192.54	81.92	5.13	-	-
1968	-	-	-	-	-	-	-	128.25	139.65	20.35	-	-
1968	-	-	-	-	-	-	-	71.62	50.21	2.67	-	-
1968	-	-	-	-	-	-	-	85.67	80.00	7.99	-	-
1968	-	-	-	-	-	-	3.20	167.27	126.86	22.30	-	-
1968	-	-	-	-	-	-	0.79	257.40	152.72	21.49	-	-
1968	-	-	-	-	-	-	-	119.90	81.93	7.70	-	-
1968	-	-	-	-	-	-	7.72	228.44	143.51	28.10	-	-
1968	-	-	-	-	-	-	-	105.16	87.34	10.86	-	-
1968	-	-	-	-	-	-	-	66.67	55.40	1.49	-	-
1968	-	-	-	-	-	-	-	119.75	90.31	11.13	-	-
1968	-	-	-	-	-	-	11.17	146.38	68.67	6.41	-	-
1968	-	-	-	-	-	-	-	17.84	43.13	3.76	-	-
1968	-	-	-	-	-	-	-	-	-	-	-	-
1968	-	-	-	-	-	-	-	128.16	123.64	20.24	-	-
1968	-	-	-	-	-	-	0.08	155.06	79.35	4.96	-	-
1968	-	-	-	-	-	-	-	226.92	142.00	16.72	-	-
1968	-	-	-	-	-	-	1.67	165.29	117.23	18.95	-	-
1968	-	-	-	-	-	-	-	68.98	54.64	4.98	-	-
1968	-	-	-	-	-	-	-	35.74	51.49	5.02	-	-
1968	-	-	-	-	-	-	0.16	161.71	79.11	4.32	-	-
1968	-	-	-	-	-	-	-	139.33	89.98	5.38	-	-
1968	-	-	-	-	-	-	-	110.78	99.59	18.38	-	-
1968	-	-	-	-	-	-	-	75.37	60.90	4.87	-	-
1968	-	-	-	-	-	-	1.05	415.52	202.91	25.18	-	-
1968	-	-	-	-	-	-	-	58.46	49.28	2.80	-	-
1968	-	-	-	-	-	-	-	76.99	68.94	5.37	-	-
1968	-	-	-	-	-	-	7.41	225.59	103.10	11.06	-	-
1968	-	-	-	-	-	-	0.97	163.59	88.01	8.14	-	-
1968	-	-	-	-	-	-	0.02	0.64	23.57	10.71	-	-
1968	-	-	-	-	-	-	0.26	206.80	109.02	10.14	-	-
1968	-	-	-	-	-	-	-	145.73	115.23	19.51	-	-
1968	-	-	-	-	-	-	0.34	225.82	125.53	13.85	-	-
1968	-	-	-	-	-	-	3.47	191.26	100.64	10.53	-	-
1968	-	-	-	-	-	-	-	150.20	96.29	10.34	-	-
1968	-	-	-	-	-	-	-	182.76	108.71	9.90	-	-
1968	-	-	-	-	-	-	21.47	279.54	138.96	19.06	-	-
1968	-	-	-	-	-	-	26.57	289.01	113.28	8.64	-	-
1968	-	-	-	-	-	-	0.95	283.32	124.22	8.43	-	-
1968	-	-	-	-	-	-	-	174.27	83.72	3.57	-	-
1968	-	-	-	-	-	-	5.73	468.09	176.56	12.56	-	-

Table-Annex 1. 32 Zarima reservoir simulation, sugarcane for 25 000 ha Emergency Spillway outflow (m3/s).

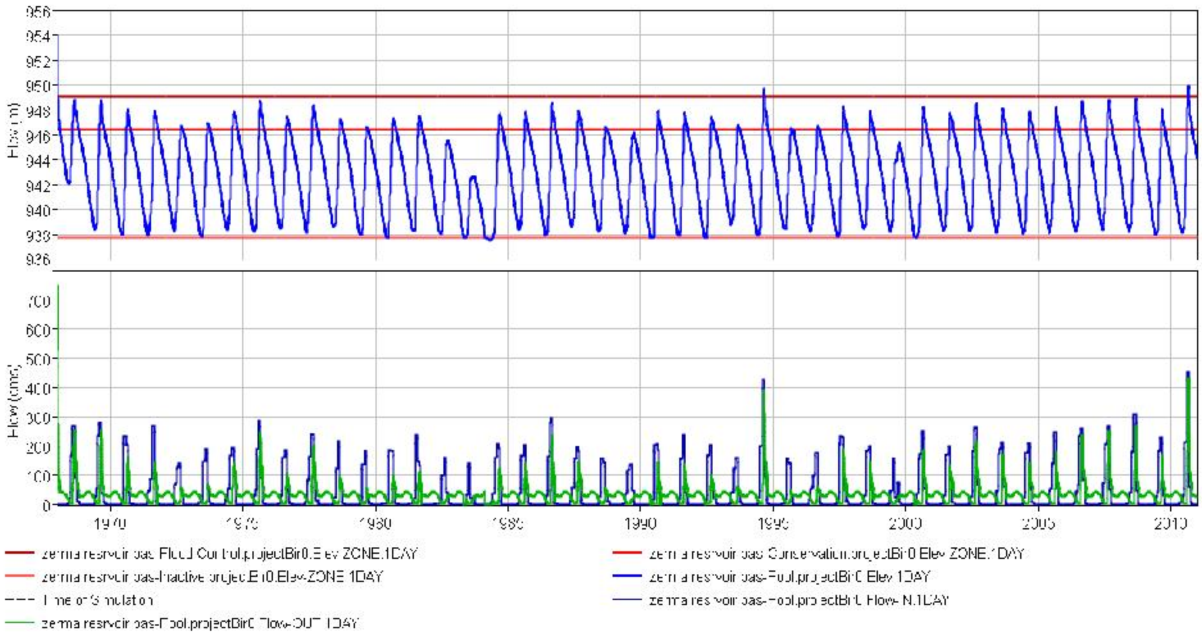

Figure-annex 1. 1 Total inflow and outflow and reservoir water level between 1968-2010 (case$_1$ scenario "R-A")

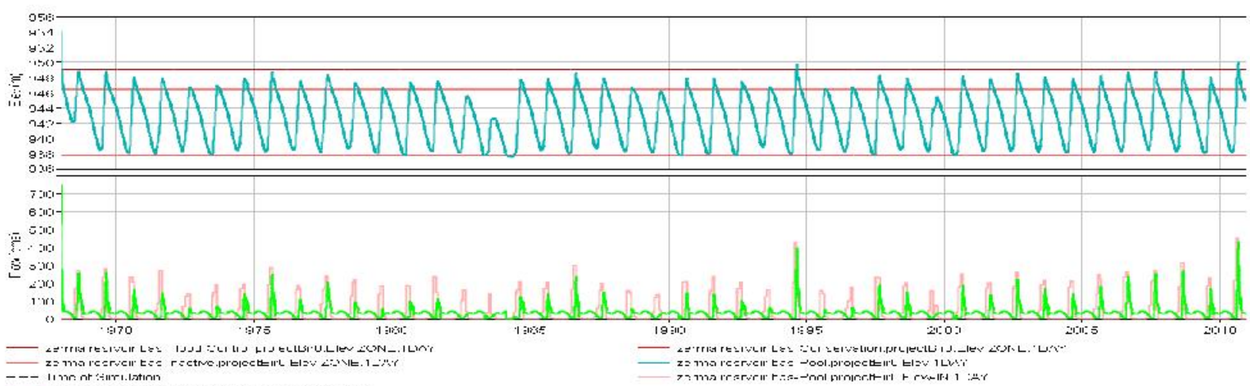

Figure-annex 1. 2 Total inflow and outflow and reservoir water level between 1968-2010 (case1 scenario "R-B")

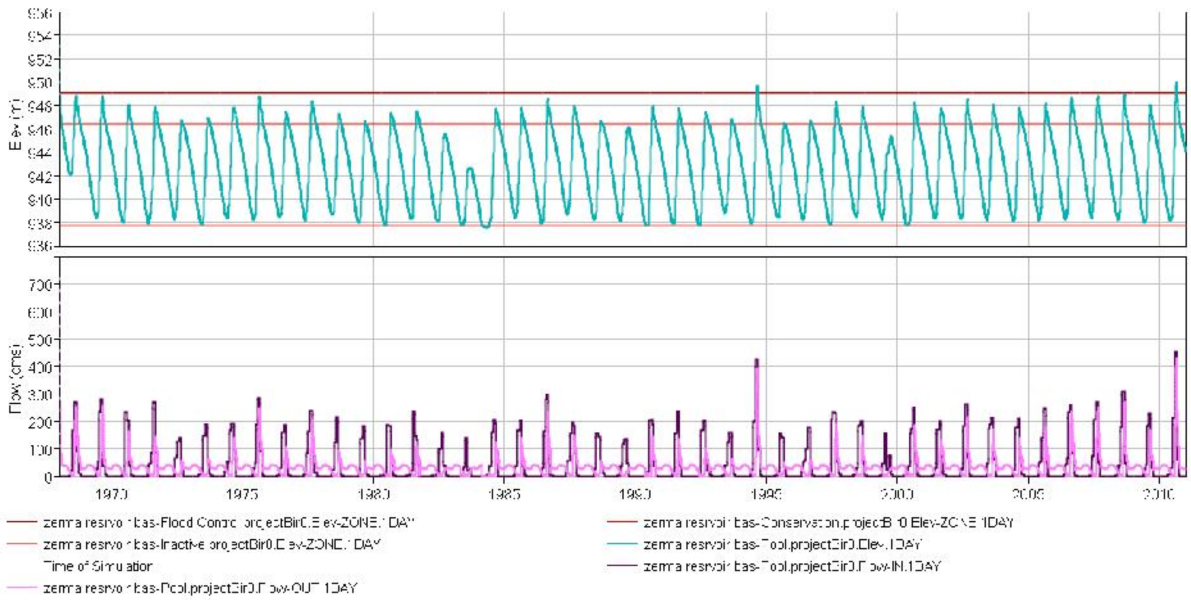

Figure-annex 1. 3 Total inflow and outflow and reservoir water level between 1968-2010 (case1 scenario "R-C")

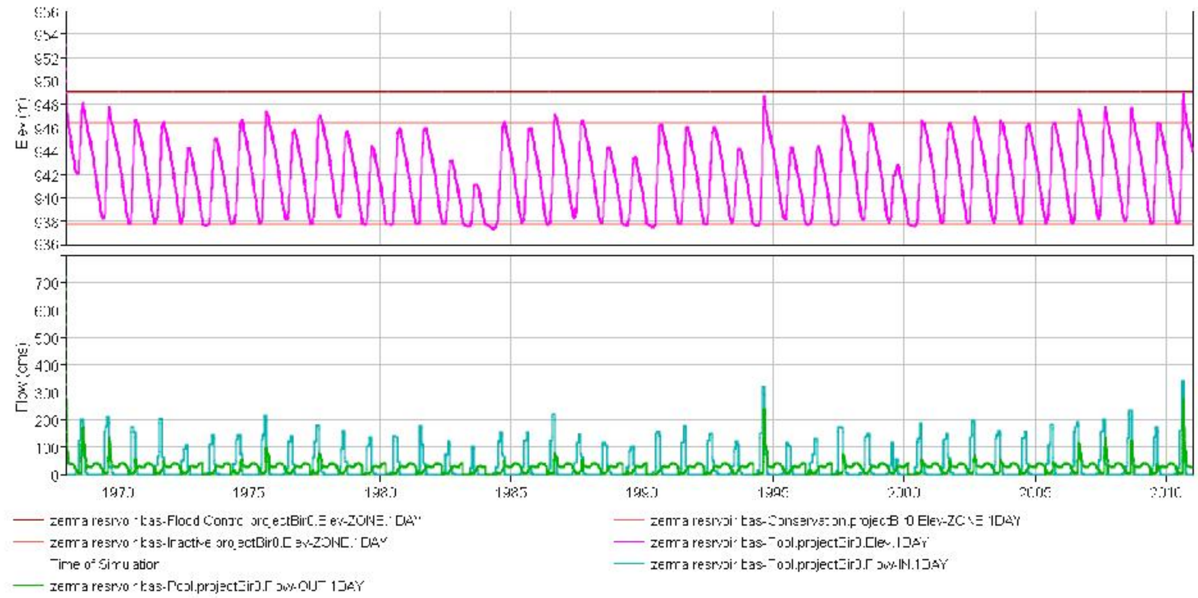

Figure-annex 1. 4 Total inflow and outflow and reservoir water level between 1968-2010 (case2 scenario “R-A”)

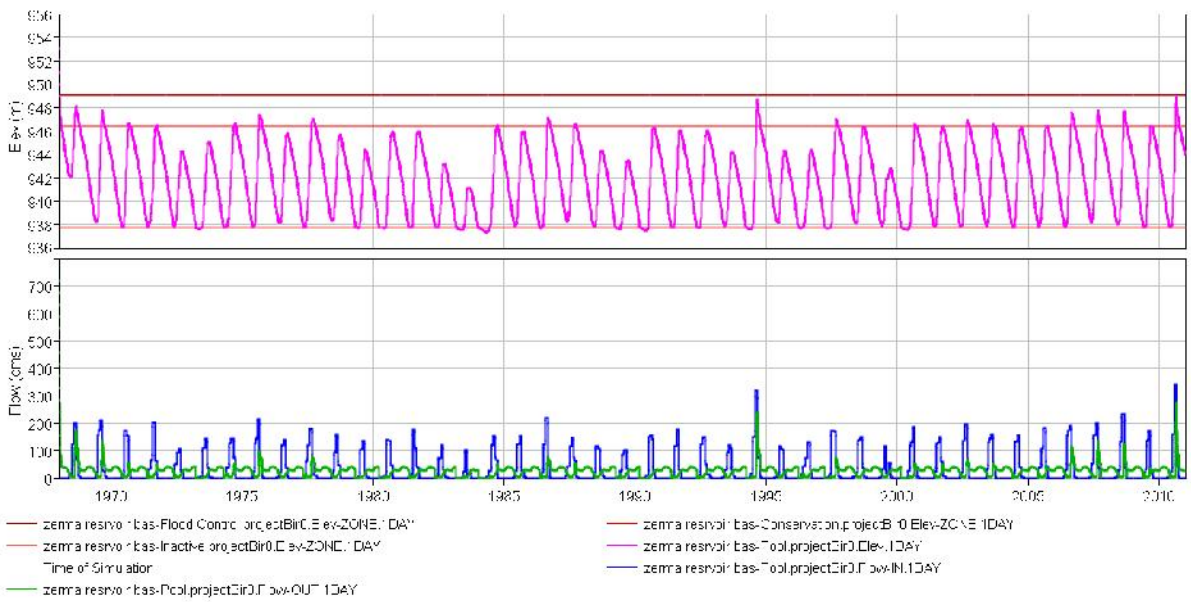

Figure-annex 1. 5 Total inflow and outflow and reservoir water level between 1968-2010 (case2 scenario "R-B")

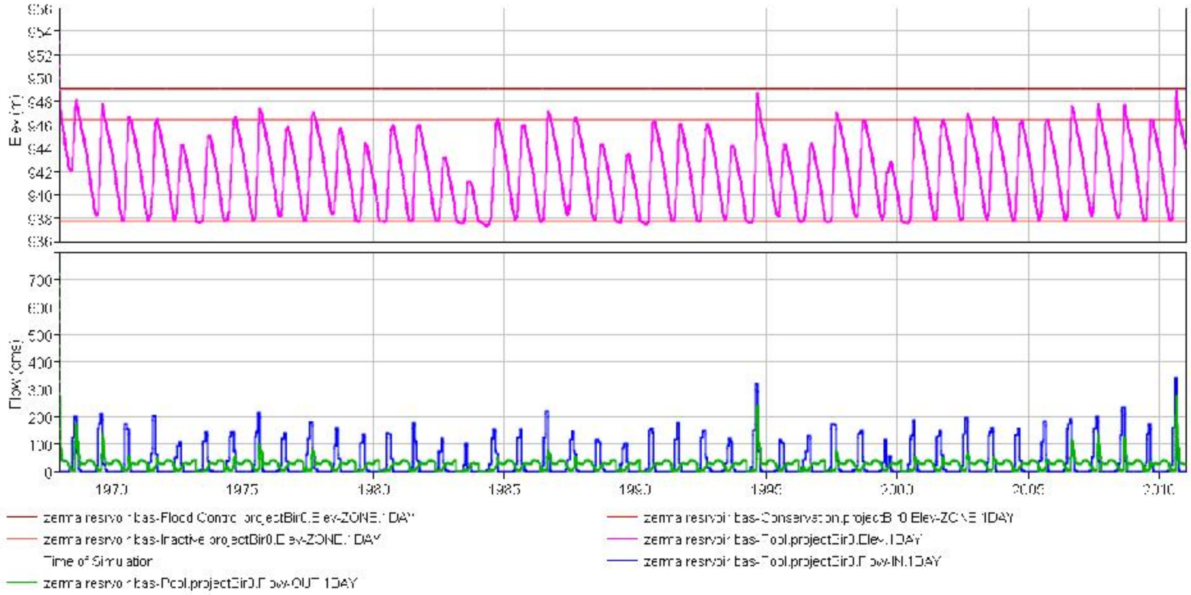

Figure-annex 1. 6 Total inflow and outflow and reservoir water level between 1968-2010 (case2 scenario "R-C")

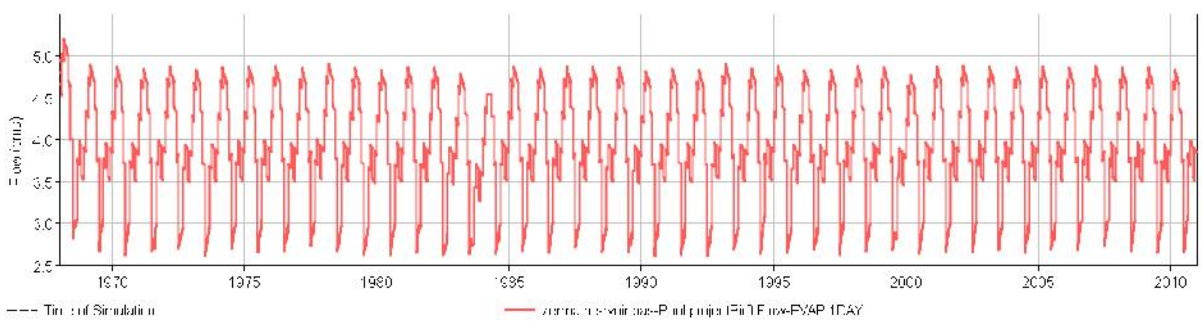

Figure-annex 1. 7 Monthly evaporation from the reservoir between 1968E.C-2010EC.