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WERM016/99

Ravilla - 2
Water Resources Management Roleplay

Information to Participants

IHE DELFT

International Institute for
Infrastructural, Hydraulic and
Environmental Engineering

The Netherlands

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March 1999

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Acknowledgement

The Water Resources Management Roleplay Ravilla-2 builds upon the ideas of Dr. Frank R. Rijsberman of Resource Analysis (Delft, The Netherlands), who was the driving force behind the first version of the roleplay, Ravilla-1.

The new feature in Ravilla-2 is, that it pays particular attention to the Institutional Arrangements of the management system. The roleplay can be played in three different settings of institutional aarangements, each varying in the level of public control, privatization, coordination and specialization of the institutions.

The main body of the roleplay was developed by L. Farczadi from Tirga Mures, Romania, during his M.Sc. study at IHE-Delft, titled "Institutional arrangements for a water resources management roleplay" (1995).

The following persons contrubuted to the development of Ravilla-2:
- L. Farczadi, M.Sc.
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CONTENTS

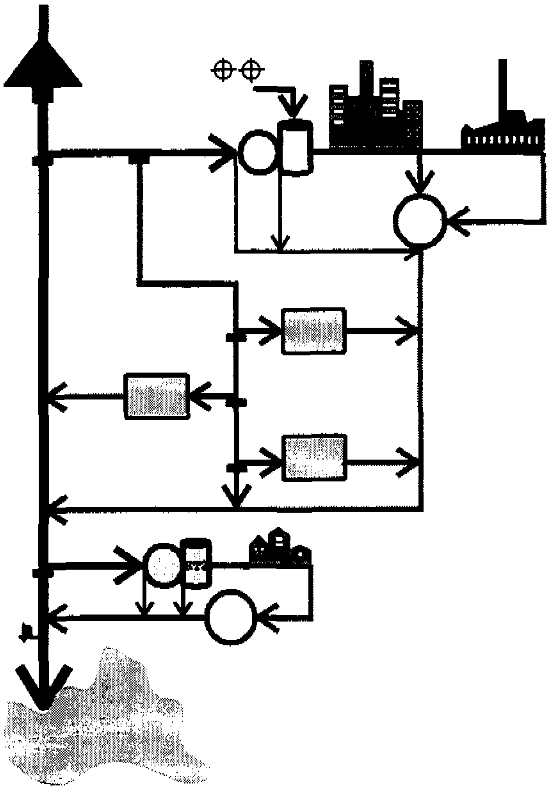
Summary

Concept

- In the simulation game, participants represent institutions, which are responsible for the management of a water resources system (WRS). The actions of participants and consequent performance of the WRS are simulated in a computer model.
- The institutions are responsible for water allocation, demand analysis, operation and maintenance, investments, water - and environmental quality, financial management, the setting of rights and regulations.
- The responsibilities and mandates of the institutions can be defined under three alternative settings, the performance of which may be compared.
- The main objective is to give participants hands-on experience with all important aspects of Integrated Water Resources Management and to make participants aware of the role of other users of water.

The Water Resources System

- a river with seasonal flows
- a reservoir and hydropower plant
- a groundwater pumping field
- a canal system with distribution gates
- two cities: one upstream and one downstream along the river; both with a distribution system, storage tanks, treatment plants, communal standpipes and private connections
- an agro-industry, dependent upon water and electricity supply and market prices of goods produced
- waste water treatment plants
- three agricultural areas with different farm size, soil conditions and with a choice of cropping patterns
- water quality monitoring stations
- a river course and a downstream swamp area, dependent upon quantity and quality of water delivered

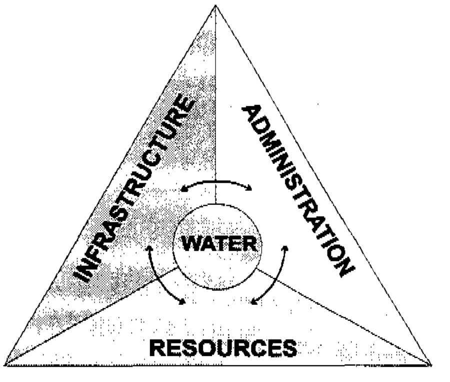


Objectives

- to provide the participants with experience on the technical, financial and institutional aspects of integrated water resources management
- to highlight the multi-disciplinary aspects of IWRM and to create understanding for the role of others
- to create awareness of the role of Institutional Arrangements and their typical problems and to provide the opportunity to experience remedial measures
- to stimulate willingness and creativeness for future institutional reform commitment.

Institutions

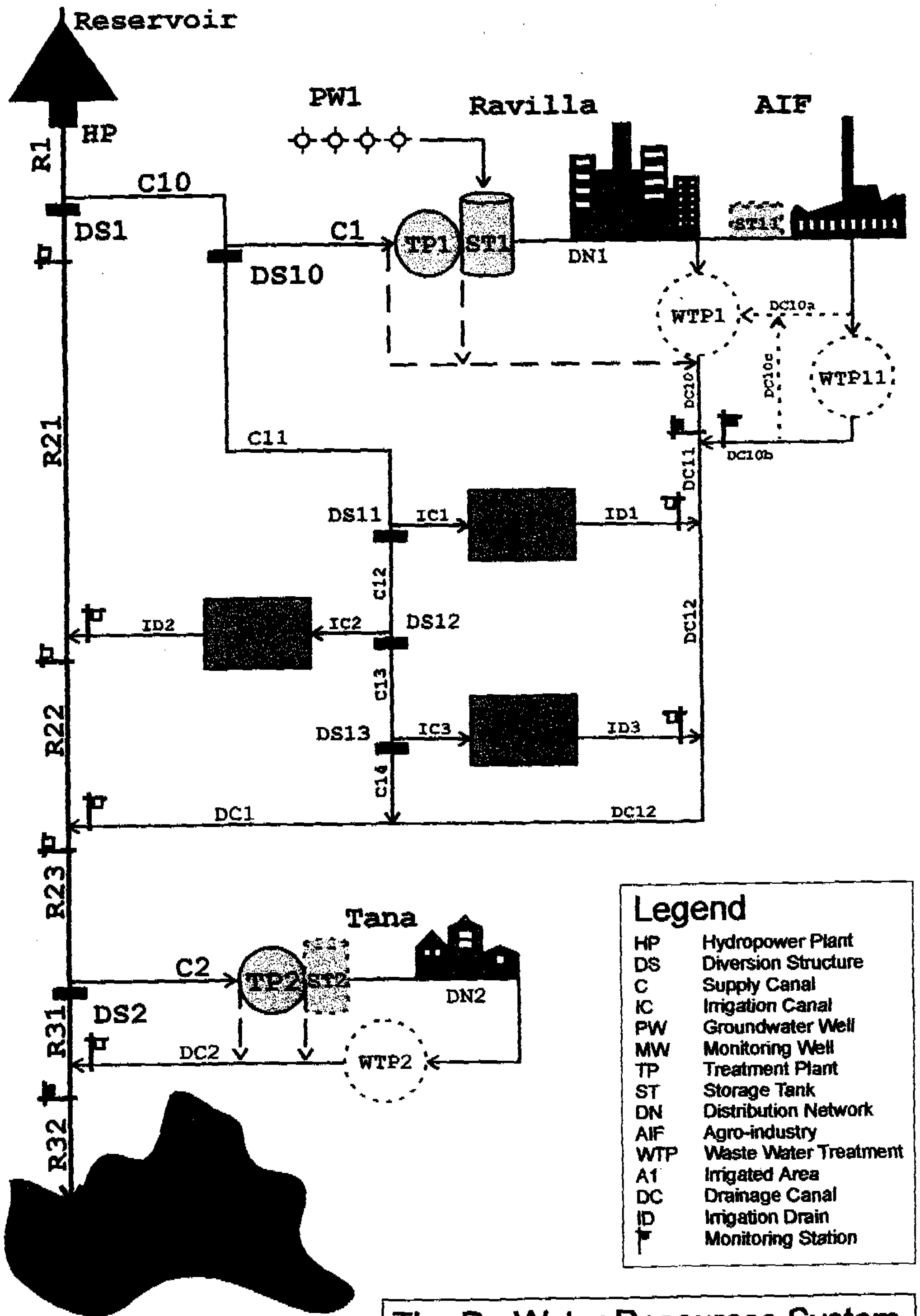
- Water Authority
- Water Supply Utilities
- Agro-industrial Factory
- Sanitation Agency
- Environmental Protection Agency
- Farmers
- River Basin Council
- Central Government



Institutional Arrangements

Three institutional arrangements distinghuish between the main topics of interest in the Water Sector, i.e. *Centralisation* versus *Decentralisation*, *Public* versus *Private,* and highlights issues such as *Cost Recovery, Level of Integration* and *Legal Framework.* The simulation generates performance reports to compare the results of the three alternatives.

CLASSIFICATION	SETTING -1	SETTING - 2	SETTING - 3
Centralised vs. Decentralised	Centralised	Decentralised	Partly
Public vs. Private	Public	Private	Mixed
Integration and Coordination	No	Partly	Yes
Institutional Framework	Poor	Fair	Strong



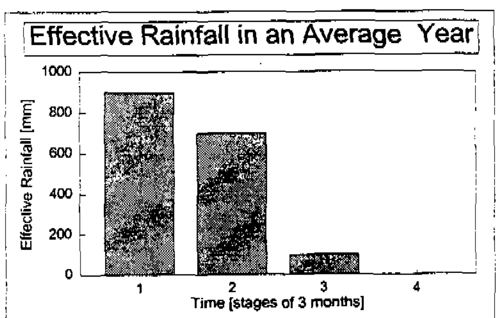
The Ra Water Resources System
(WRM-RP3)

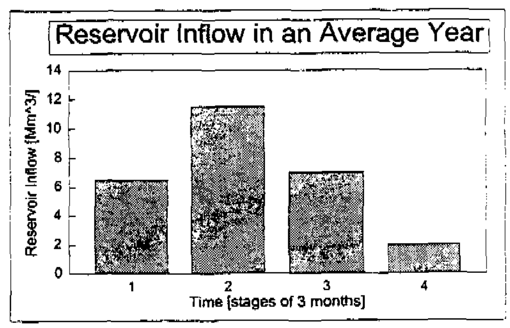
1 The Natural System

The natural subsystem (NS) consists of three components. The surface water resources of the River Ra are the main source of water for the human activities in the area. A shallow groundwater aquifer extends all over the basin. And finally there is a natural swamp into which the river Ra flows.

1.1 The surface water resources

The climate is characterized by a distinct wet and dry season. In a normal year, more than 90% of the mean annual effective rainfall of 1700 mm occurs in the first six months and rarely any rainfall is reported to occur in the last four months of the year. The mean annual flow of the river is about 27 Mm^3. The distribution of effective rainfall and river flow in an average year is shown in the figures below.





The middle and lower stretches of the river Ra and the swamp are valuable natural areas. During the wet season many small lakes form in the flood plains and the swamp, maintaining a complex ecosystem. Several small fishermen communities depend on the swamps for their livelihood. The increasing development and use of surface water resources have disturbed the fragile ecosystem and pose a severe threat to its further existence. Important conditions to maintain the natural area and thus to preserve its environmental and social values are:

- the total volume of water flowing through the river and entering the swamp area during the wet season needs to be sufficient to fill the lakes;
- a minimum discharge needs to be maintained even during the dry season;
- the water quality needs to be acceptable.

The precise flow requirements are not known (to the players). A reasonable starting assumption would be that the minimum flow requirements range from 1Mm^3 to 2 Mm^3 per month during the dry and wet months respectively. Information about discharges is available only where hydraulic structures control the flow or gauging stations exists.

Surface water quality is assessed through an aggregated water quality index (WQI), which takes account of the main types of pollutants generated in the river basin. Pollutants are discharged into the surface water system through urban and industrial waste waters and return flows from the irrigated areas.

The following water quality characteristics can be monitored:

- total suspended solids (TSS)
- biological oxygen demand (BOD)
- nitrogen (N) and phosphorus (P)
- other chemicals (Ch), used as pesticides for crop production on irrigated lands.

Corresponding specific WQI values are computed as ratios of a maximum allowable concentration (a water quality standard) and the actual concentration of the particular pollutant. WQI ranges between 1 and 0, where 1 represents unpolluted water, while any lower value shows that standard requirements are violated.

Some of the pollution levels of effluent waters, can be assessed on average specific concentrations. This is the general case for domestic waste water and the specific case of BOD pollution for industrial waste water and irrigation return flow. Other pollution levels are process-dependent and therefore more difficult to assess. Table 1.1 summarizes the set of numerical values for surface water pollution from different sources, the standard requirements for fresh surface water bodies and the weight coefficients to compute the WQI.

Table 1.1 - Water quality parameters

	Units	**TSS**	**BOD**	**N**	**P**	**Ch**
Domestic waste waters	mg/l	150	200	50	10	0
Industrial waste waters	mg/l	var.	500	0	0	0
Irrigation return flows	mg/l	var.	100	var.	var.	var.
Fresh surface water standard	mg/l	10.0	10.0	1.0	0.10	0.05
Weight coefficient for WQI	-	0.40	0.30	0.10	0.10	0.10

Water quality information on effluent waters, non-fresh and fresh surface water bodies is available only where Water Treatment Plants or monitoring stations exist.

1.2 The groundwater resources

The shallow aquifer is an important natural resource, with associated economic and social values. The aquifer's depth and thickness differ over the area, but locally stable groundwater table depths are a prerequisite for the non-irrigated agricultural activities on which many rural communities depend. The aquifer is the main source of drinking water for the rural population. Therefore, new uses of groundwater should not disturb the existing balance of small scale abstraction and natural recharge capacities.

The abstraction capacity installed for the Public Water Supply (PWS) of Ravilla exceeds the natural recharge capacity of the aquifer. In normal conditions, when the abstraction does not exceed the natural recharge, the water table remains stable at a depth of 8 m. If operated at full capacity, the water depth falls below 12 m and the wells dry out. Significant drops of the groundwater table, and specially when they last for longer periods, result in negative impacts that are accumulatively scored against the performance criteria of the institution responsible for the conservation of the groundwater resources.

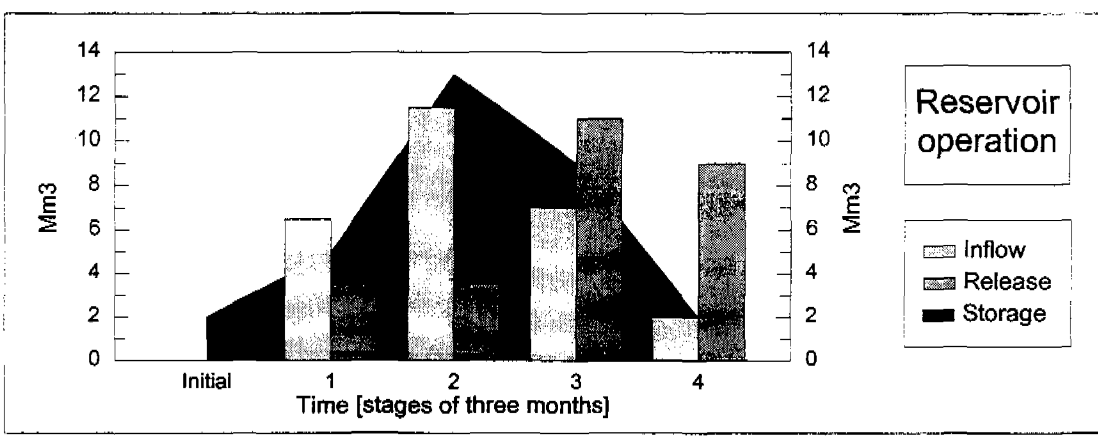
2 The Infrastructural System

Several engineering structures exist to manage the water resources: an upstream storage reservoir to regulate the river flows, production wells to abstract groundwater, diversion structures and surface water canals to divert, allocate and supply surface water users.

Two Public Water Supply (PWS) systems provide potable water to urban households in Ravilla and Tana, and to commercial users and an agro-industrial factory (AIF) in Ravilla. Three agricultural areas make use of surface water for irrigation. Waste waters and return flows are collected in drainage canals and discharged without any treatment, back into the river Ra. Waste Water Treatment Plants (WWTP) are needed to stop and further control the heavy pollution as pointed out by the newly built monitoring station downstream on the river. Additional monitoring stations may be considered in future. A basic layout of the WRS is presented in the Summary and more specific layouts are presented in the Annexes.

2.1 The reservoir and hydropower plant

A fairly small earth dam, build across the river Ra, creates the upstream storage reservoir. It has a usable storage capacity of 13 Mm^3 that allows for seasonal regulation of the river inflow. Sedimentation occurs in the dead storage of the reservoir and therefore does not affect the usable storage. Reservoir operation follows a simple rule: the reservoir fills during the wet season, when releases are made to meet the PWS and environmental requirements, and empties during the dry season when releases have to be allocated to fulfill, as much as possible, all requirements, including those for irrigation. An example of the operation of the reservoir during an average hydrological year is shown below.



Inflows that exceed the available storage capacity of the reservoir are automatically discharged through the spillway. Seepage and leakage occurs through and around the earth dam. The rate depends on the reservoir storage level and the level of maintenance of the dam and reservoir complex.

The hydropower plant uses the release from the reservoir to generate electricity sold to a power company. The amount of energy generated is a linear function of the hydraulic head, the discharge through the turbines and the plant efficiency, which depends on the plant's maintenance level.

2.2 The surface water allocation and supply structures

A diversion structure (DS1), directly downstream of the dam, diverts water into a water supply canal system. The main canal is divided in five sections (C1.0 to C1.4) through four secondary diversion structures (DS1.0 to DS1.3) which divert water into secondary supply canals. The first of them (C1) supplies water to the treatment plant (TP1) of the Ravilla PWS system. The other three secondary canals (IC1 to IC3) are irrigation canals that supply water to the three agricultural areas (A1to A3). The last section of the main canal (C14), downstream of DS13, discharges the unused water into the main drainage canal (DC1).

A second diversion structure (DS2), in the lower stretch of the river Ra, diverts water for PWS in the Tana urban area. An open water canal (C2) supplies the diverted water to the TP2.

The proportion of water that is diverted is arranged by setting the gate of the structure. For example, a gate setting of 60% for an inflow of 1 Mm^3/stage will cause the diversion of 0.6 Mm^3/stage into the lateral canal, and the discharge of the remaining 0.4 Mm^3/stage downstream of the DS. Gates allow for normal operation only if properly maintained. When maintenance level drops below certain critical level, gates may get stuck in their existing position. New settings of the gate become possible only after the complete rehabilitation of the structure.

Water supply canals have limited conveyance capacities and specific loss coefficients according to their design. Only C1 is lined and therefore seepage losses are less than in the other canals. Thus, the maximum discharge that can be supplied by a canal, is the difference between the designed conveyance capacity and the minimum losses. Canal maintenance is mainly intended to keep the maximum conveyance capacities at designed levels, by controlling the seepage losses along the canals. In certain critical situations, an insufficient conveyance capacity of a lateral canal may affect the operation of the upstream DS and thus the water allocation strategy.

2.3 The public water supply systems

Both PWS systems include as basic elements, a fresh water Treatment Plant (TP), a Distribution Network (DN) for public stand pipes and private connections and a Sewerage Network (SN). In Ravilla, the PWS utility exploits groundwater production wells (PW) and has a storage tank (ST) for potable water. The PWS utility has the option to build additional storage, both in Ravilla and in Tana.

There are two open drainage canals DC1 and DC2. DC1 collects domestic sewage and industrial waste water from Ravilla and the AIF, and drainage from two agricultural areas A1 and A3. DC2 collects domestic sewage from Tana. Both canals discharge into the river Ra and consequently affect its water quality. DC1 enters the river upstream from the intake for the PWS of Tana and hence influences the available water quality. The drainage canals both contribute to the pollution of the swamp area.

Waste Water Treatment plants (WWTP) do not exist at present, but may be constructed. Existing technology allows for two consecutive treatment levels, according to the parameters presented in Table 2.1 on the next page.

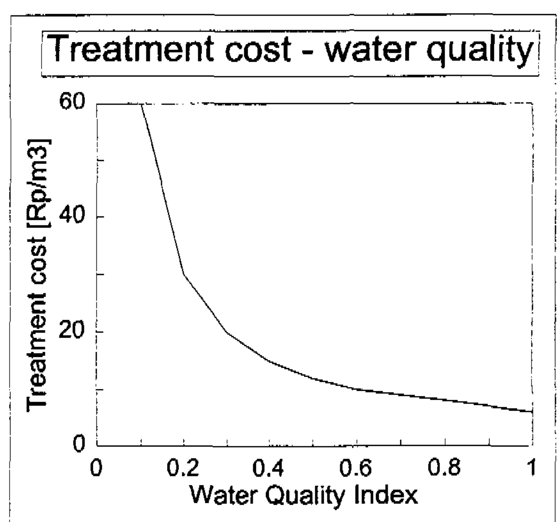
Table 2.1 - Waste water treatment parameters

Removal efficiencies [%]		TSS	BOD	N	P	Ch
Basic treatment level	Domestic waste	50	40	35	35	-
	Industrial waste	40	20	0	0	-
	Mixed waste	35	35	45	45	-
Advanced treatment level	Domestic waste	90	95	85	85	-
	Industrial waste	80	75	0	0	-
	Mixed waste	85	90	95	95	-

The net demand for potable water is given by the number of stand pipes and private connections and their specific consumption. The daily consumption of the private connections is stable throughout the year. Consumption at standpipes shows a clear seasonality: dry season demands are higher than wet season demands. This indicates that standpipe users partly turn to other sources during the wet season such as collecting rainfall. The average consumption per capita is currently quite low but is increasing and higher demands are to be faced in future. Also, the urban areas are growing rapidly. Coverage with PWS services is far from being satisfactory, treatment and supply capacity extensions are required.

The gross demand is higher, because of distribution losses, which increase when the DNs depreciate. If the maintenance level of standpipes and private connections drops below a critical level, then unregulated use occurs, which adds to the existing demand. The TPs have to treat the gross demand. The actual output of the TPs may be below their maximum capacity if maintenance is inadequate. If the surface water supply exceeds the plant capacity, then the extra amounts are spilled into the open drains downstream of the eventually existing WWTPs.

The operation of the downstream TP is financially difficult. Due to the depreciated water quality conditions of the river Ra, the treatment costs at TP2 are very high. Figure 2.3 presents the relationship between actual treatment cost for domestic use and the WQI of the raw surface water.



The practice of the PWS was to avoid shortages in supply by delivering untreated surface water to the DN whenever the TP capacity was insufficient. The Ministry of Health has issued regulations that forbid any further supply of untreated surface water for domestic use. Since then, constant shortages in supply have been the major problem to be solved, before any further development of increasing the coverage should be considered.

The PWS system for Ravilla also owns a number of wells and diesel pumps for groundwater abstraction. The wells were drilled to tap a shallow sandy layer, with a thickness of four meters. The diesel pumps have a given daily capacity and there is a given sustainable pumping rate per well. The pumps require careful maintenance to work at full capacity. When maintenance conditions are insufficient, pumps fail and need replacement. If the aquifer is over pumped then the groundwater level falls, the pumping cost increases and the maximum capacity of the pumps decreases, until the wells fall dry.

The Ravilla PWS system has a medium size storage tank (ST1) for compensation purposes. If excess potable water (groundwater or treated surface water) is produced during any period, then it can be held in the ST1. When its storage capacity is exceeded, potable water is spilled into the open drain system. From ST1 the water is distributed through a gravity system.

2.4 The agro-industrial factory

The industrial complex near Ravilla produces cardboard on the basis of straw. The industry is of high economic importance to the region. However, the industry is also a heavy polluter. It produces a large amount of solid waste, and industrial waste water which flows untreated into the DC1.

The factory consists of three separate units for a sequential production process:

- a mill unit capable to produce one of two alternative product types (P1 or P2);
- a packing unit where products are cut, printed, packed and made ready for shipment, or stored if necessary;
- a transport unit, which consist of a fleet of heavy trucks that distribute the products to the clients.

Each unit has a given production capacity and efficiency. Both are dependent on the maintenance conditions of the unit. The mill uses the whole amount of raw material required in the production process and it is the main water consuming unit. Therefore the efficiencies of water consumption and the rate of production of solid and liquid waste depend mainly on the maintenance of the mill. The energy consumption efficiency depend on the overall maintenance of the factory. Any of these efficiencies is subject to possible technological improvement, if investments are made.

The production of cardboard depends heavily on water. Small shortages in water supply cause high reductions in the mill's production. The water consumption rate at AIF is relatively high because of many uncontrolled losses. Relative affordable investments in new technologies are expected to reduce losses, which will reduce the water demand and AIF's dependence on the PWS system's performance.

Waste water from the factory is polluted with suspended solids, but less with organic matters

(BOD). Nothing can be done about the organic pollution, but the TSS is technology- and efficiency-dependent. Technological improvements in liquid waste control reduce the solid load of the waste water and simultaneously increase the return flow coefficient by reducing consumptive losses. The level of TSS in the effluent is thus reduced by two means, in the same time.

Only one of the two types of products can be produced during a stage. The reason is that the mill unit requires a different configuration for each product. The decision on which product to manufacture depends on market conditions, but it may also be influenced by the actual capacity of the units. When new the mill unit can produce 225 tons/stage of Product P1 or 60 tons/stage of Product P2, but the packing and transport units have the same capacity no matter of the products' type.

2.5 The irrigation systems

The irrigation district consists of three irrigated areas with different characteristics farms as summarized in Table 2.2.

Table 2.2 - Soil and farm characteristics in the irrigation district

Characteristics	A1	A2	A3
Soil	heavy, clay loam	light, silty sand	medium, sandy loam
Farm size	large	medium	small
Family size	small	medium	large
Financial position	rich	medium	poor

A variable share of the family members is available for farm work. Additional labor can be hired, at normal prices if planned in due time, or at emergency prices if it turns out to be necessary without being planned. The labor is used for crop production and for maintenance work of the irrigation system. Excess family labor on the small farms in A3 can be sold for work on other farms, industry, etc.

The crops grown in the area are maize, rice, soybeans and groundnuts. They obviously have different input requirements, yield potential and economic value on the market. The input requirements differs also because the soil conditions are different. Their sensitivity to water shortages differs as well. This means that the choice of crops to be cultivated determines the risk taken by the farmers.

The rainfall during the wet season is usually sufficient for crop production. Even rice, which is the most profitable crop, does not need supplemental irrigation in the wet season of an average hydrological year. Yields can be severely depressed in a dry year, however. In the dry season rice could be grown with sufficient irrigation, but usually other crops are cultivated.

Farmers decide their cropping pattern, select the quality of seeds (treated, locally dressed, or locally retained), and subsequently provide fertilizers (urea and TSP), pesticides (chemicals) and labor. If water, fertilizer or pesticide requirements are not fully satisfied, yields will be depressed. Excess amounts of fertilizers and pesticides do not influence the yields, but do decrease the quality of the drainage water. Labor inputs do not influence yields. Sufficient labor is always available to be hired even if not planned before. The only difference is its cost.

The return flow from the irrigated areas depends on the balance between supply, from rainfall or irrigation, and the crop requirements, as well as on the overall irrigation efficiency, which is related to the level of maintenance. Water quality is affected by constant rates of TSS and BOD pollution, respectively by variable N, P and Ch pollution rates. Variances above certain average characteristic values for N, P and Ch pollution occur when an excess amount of fertilizers is applied.

3 The Administrative System

The Institutional Arrangements (IA) are of special concern in WRM-RP. Three different IA were formulated based on the following classification:

- centralized vs. decentralized, and
- public vs. private choices in structural organization,
- the level of integration, both within the water sector and between different economical sectors as result of specific coordination activities, and
- the effectiveness of existing legal framework (mainly standards and regulations).

Table 3.1 - Institutional arrangement settings

Classification criteria	WRM-RP1	WRM-RP2	WRM-RP3
Centralized or decentralized (cost recovery)	Centralized (no)	Decentralized (yes)	Partly (de)centralized (yes)
Public or private water sector	Public	Private	Public & Private
Integration & coordination	no	partly	yes
Institutional framework	poor	medium	strong

The institutions are specified according to the following items:

- objective,
- tasks and activities,
- infrastructural components to operate and maintain (O&M),
- development options, related to the infrastructural components,
- mandates,
- financial incomes and expenditures,
- state variables and performance criteria, and
- decision variables.

The three sets of role specifications for respectively WRM-RP1, 2 and 3 are given in the Annexes B1, B2 and B3.

The performance of the three different settings of institutional arrangements is evaluated with a systems performance report is made. The report includes the following indicators:

- energy production in physical units [MWh] and financial units [MRp],
- industrial production [tons] and [MRp],
- maize production [tons] - indicator of self-sufficiency in food production,
- crop production [MRp],
- efficiency in water supply [%] - effective supply vs. intake,
- effective water supply to the end uses [Mm^3],
- shortages in water supply to the end uses [%] - effective supply vs. demand,
- accumulated negative impact score for resource conservation criteria,
- water quality index, minimum and average values.
- gross and net growth of the economic value of the system [MRp].

3.1 The first institutional arrangement

The first setting (WRM-RP1), describes a highly centralized structure, with public organizations in the water sector financed by the central government. Water management is clearly sector-oriented, without any formal coordination mechanisms at operational level or significant results for higher levels. All relevant prices are set and controlled by the central government, so their stability is a realistic assumption. However, political changes in the system may disturb this stability. The institutional framework is rather poorly developed and inefficient.

Five roles are defined and assigned to the following organizations and entities:

- ♠ a Water Authority (WA) subordinate to the Ministry of Power and Water Resources and responsible for surface water provision and allocation including generation of hydroelectric power;
- ♠ a Sanitation and Environmental Protection Agency (SEPA) subordinate to the Ministry of Environment and responsible for sewerage, waste water treatment and protection of the environment (resources' conservation and pollution prevention);
- ♥ a Public Water Supply utility (PWS) controlled by a local authority and responsible for water treatment and distribution of potable water in urban areas, and having rights for groundwater abstraction;
- ♦ an Agro-Industrial Factory (AIF) that consumes potable water from the urban distribution system of Ravilla, and generates solid and liquid wastes;
- ♣ three groups of farmers living in three different irrigation areas (A1, A2 and A3) that use surface water and return polluted effluents.

The game-leader is assumed to represent the higher level organizations and the general state of the society and environment, by entering input data for specific parameters.

The main functional characteristic of this organizational structure is the authoritarian dominance of the central government. The water sector organizations, the WA and the SEPA, and the PWS utility are run with governmental budgets, and their objective is to execute the government's policy, as expressed in the following statements:

- Water resources represent national wealth and therefore they have to be used for the benefit of the nation as a whole. The WA is responsible for the development of water resources necessary to support the economic and social development of the country.
- The use of the water resources for economic and social purposes has to be done without damages to the natural environment. The SEPA is responsible for the monitoring and, were necessary, for the control of the quantitative and qualitative aspect of water resources required for environmental protection purposes. It is also responsible for adequate public sanitation services.
- Access to safe drinking water is a basic human right. The local authorities have the responsibility to develop and supply the drinking water in urban area.

Several instruments are available for the implementation of these policy statements:

- a water allocation rule specifying:
  - the absolute priority for uses for drinking water purposes,
  - the obligation to comply with specified minimum flow requirements;

- a special regulation to support the poor farmers, specifying their obligation to pay the irrigation water only when their income exceeds the minimum subsistence requirements;
- rights for groundwater abstraction assigned only to the PWS utility and specifying:
  - the restriction of use only for PWS in Ravilla,
  - the obligation to comply with specified maximum abstraction permits;
- a water quality standard specifying the maximum admissible concentration of relevant pollutants in the fresh surface water bodies.

Two special regulations are also included in the existing institutional framework. Their purpose is to stimulate the farmers to cultivate maize that is very important for the country's self sufficiency in food supply. The first regulation is actually a recommendation for a minimum area of land to be cultivated with maize. The second regulation specifies a maximum amount of fertilizers and pesticides that farmers can get at subsidized prices. If farmers do not comply with the first recommendation, the subsidies are partly or fully redrawn. If extra amounts of fertilizers and/or pesticides are used, they have to be purchased on the black market, with very high rates.

3.2 The second institutional arrangement

The second setting (WRM-RP2), describes a decentralized administration, without significant involvement and control by the central government. Water management activities are the responsibility of an independent (financially autonomous) Water Authority (river basin agency), meanwhile water services delivery is fully privatized. There are favorable conditions for integration of surface-groundwater and quantity-quality aspects of water management, but not yet any intentions to inter-sectoral coordination. The institutional framework is lightly improved, but still insufficient for a privatized administration.

Six roles are defined and assigned to the following organizations and entities:

- ♠ an independent Water Authority (WA) responsible for surface and groundwater management, both quantity and quality, including the protection of the environment and with the possibility to generate revenues from hydroelectric power generation;
- ♥ a private Water Supply Company (Ravilla-WSC) delivering water supply and sewerage services in the upstream urban area, and having rights for groundwater abstraction;
- ♦ an Agro-Industrial Factory (AIF) that consumes potable water from the urban distribution system of Ravilla, and generates solid and liquid wastes;
- ♣ a farmer association (FA) responsible for surface water allocation for irrigation purposes;
- ♣ three groups of farmers living in three different irrigation areas (A1, A2 and A3) that use surface water and return polluted effluents;
- ♥ a private Water Supply Company (Tana-WSC) delivering water supply and sewerage services in the downstream urban area.

The game-leader is assumed to represent the general state of the society and environment (by entering input data for specific parameters).

The main functional characteristic of this organizational structure is the large administrative power of WA combined with the power of market forces controlling water pricing. Due to the insufficient involvement of the government there is no clear policy statement for the management of water resources. The Water Authority is expected to formulate its own policy, and to use its powers to implement corresponding strategies.

The institutional framework consist of:

- two water quality standard specifying the maximum admissible concentration of relevant pollutants in the fresh and non-fresh surface water bodies;
- a regulation that makes surface water pricing dependent on water quality according to the existing standard;
- a water allocation rule specifying the obligation to assess, formulate and comply with specified minimum flow requirements for environmental protection;
- a system of licenses for groundwater abstraction, specifying:
  - conservative limits for abstraction,
  - priority for the first client (Ravilla-WSC),
  - the obligation to comply with specified maximum abstraction permits,
  - financial penalties for non-compliance;
- a system of pollution charges based on threshold and critical values for pollutant concentrations in effluent waters.

There is a special regulation with respect to the farmers' association. It specifies that farmers have an equal right to irrigation water; in other words: allocation should be done according to a uniform "per hectare supply".

3.3 The third institutional arrangement

The third setting (WRM-RP3), describes a balanced organizational structure, with clear governmental involvement in water management, but also with private sector participation and reliance on market forces in the water service area. Formal coordinating mechanisms at river basin and national level tend to implement integrated WRM. The institutional framework is strengthened with a clear statement of the national water policy, and economic instruments to regulate water uses.

Six roles are defined and assigned to the following organizations and entities:

♠ a financially autonomous Water Authority (WA) subordinate to the Ministry of Environment, and responsible for surface water provision and allocation including generation of hydroelectric power;

♠ a financially semi-autonomous Environmental Protection Agency (EPA) subordinate to the Ministry of Environment and responsible for groundwater management and environmental protection (resources' conservation and pollution prevention);

♥ a private Water Supply Company (Ravilla-WSC) delivering water supply and sewerage services in the upstream urban area;

♦ an Agro-Industrial Factory (AIF) that consumes potable water from the urban distribution system of Ravilla, and generates solid and liquid wastes;

♣ three groups of farmers living in three different irrigation areas (A1, A2 and A3) that use surface water and return polluted effluents.

♥ a private Water Supply Company (Tana-WSC) delivering water supply and sewerage services in the downstream urban area.

The game-leader trainer is assumed to represent the general state of the society and environment, the central government and the National Water Council (NWC) - a coordinating body at the central level.

Another coordinating body exists at the regional level: the river Basin Water Committee (BWC) that includes representatives from all interested parties. The committee meets once per year and maintains a permanent Executive Committee (EC) that includes the representatives from the two water management agencies: the WA and the EPA. Its main role is the inter-agency coordination.

The main functional characteristic of this organizational structure is the combination of governmental control (through the NWC) and involvement of stakeholders (through the BWC) as a key to integrated WRM. The national water policy states the following objectives:

- Water resources management is a national affair. Water is a natural resource that has to be managed as an integral part of the nation's social and economic development, without damaging its environmental value. The NWC is responsible for the supervision and coordination of all social and economic activities related to the management and use of water resources.
- The responsibility for the implementation of water resources management is delegated to regional agencies constituted on river basin principles. The WAs are responsible for the quantitative management of surface resources. The EPAs are responsible for the groundwater resources (quantity and quality) and the quality of surface waters.
- Water management administration includes democratic procedures for active participation of all interested parties. Government agencies responsible for water management are accountable to their clients and the general public trough the BWC.
- Water is an economic good, and therefore should be priced according to its value and availability. Private sector involvement in water service delivery has to be regulated by law in order to avoid excessive profits on behalf of unrealistic and for many people unaffordable water rates.
- Poverty alleviation is a major concern of the government. Therefore, subsidies will be used as long as necessary to protect and support the poor.

The institutional framework includes:

- three water quality standards specifying the maximum admissible concentration of relevant pollutants in the fresh, non-fresh and effluent surface water bodies, associated with a system of penalties for non-compliance;
- a water allocation rule specifying:
  - the absolute priority for uses for drinking water purposes,
  - the obligation to comply with specified minimum surface flow requirements, associated with financial penalties for non-compliance;
- a system of licenses for groundwater abstraction specifying:
  - restriction of use only for drinking purposes,
  - allocation priority for the downstream users,
  - the obligation to comply with specified maximum abstraction permits, associated with financial penalties for non-compliance;
- a system of conditioned subsidies for poor farmers specifying:
  - a preliminary condition for acceptable pollution,
  - compensation of irrigation expenditures (water supply and effluent discharge), when incomes are below the minimum subsistence

Annex A

Values of Selected Parameters
WRM - RP.1, 2, 3

Background information - Water Authority - IA1

Structural element	Characteristics	value	units	unit NV MRp	ADR %	AFOCI %
Reservoir	storage capacity	13.00	Mm^3	250.00	5.00	4.00
	initial storage	1.00	Mm^3			
Hydro Power	discharge capacity	3.75	Mm^3/stg	150.00	10.00	6.00
Diversion Structure1	-	-	-	15.00	5.00	2.00
Canal 10	conveyance capacity	15.00	Mm^3/stg	24.00	5.00	1.00
	loss coefficient	0.10	-			
Diversion Structure 10	-	-	-	10.00	5.00	2.00
Canal 11	conveyance capacity	12.00	Mm^3/stg	10.00	5.00	0.50
	loss coefficient	0.10	-			
Diversion Structure 11	-	-	-	9.00	5.00	1.00
Canal 12	conveyance capacity	9.00	Mm^3/stg	6.00	5.00	0.50
	loss coefficient	0.10	-			
Diversion Structure 12	-	-	-	8.00	5.00	1.00
Canal 13	conveyance capacity	6.00	Mm^3/stg	4.00	5.00	0.50
	loss coefficient	0.15	-			
Diversion Structure 13	-	-	-	7.00	5.00	1.00
Canal 14	conveyance capacity	6.00	Mm^3/stg	2.00	5.00	0.50
	loss coefficient	0.15	-			
Diversion Structure 2	-	-	-	15.00	5.00	1.00
Total new value of the existing structures at their initial capacities				510.00	MRp	
Initial capital	20	MRp				

Initial rates			Constant rates/prices		
Hydroelectric energy - sale	15.00	Rp/kWh	Consultant report	5.00	MRp
Surface water	2.00	Rp/m^3			
Groundwater	0.00	Rp/m^3			

Average hydrological conditions		Stages in the year 1	2	3	4	Total year
Effective Rainfall	mm/stg	900	700	100	0	1700
Reservoir Inflow	Mm^3/stg	8	12	7	3	30
Groundwater Recharge	Km^/stg	Qrecharge = 135 + 0.13 x Qabstracted < 300				
Groundwater Level	Km^/stg	-12.00 =< H =< -8.00				
Groundwater Level Drop	Km^/stg	DH = 0.07 x(Qrecharge-Qabstraction)				

Typical water demands		Stages in the year 1	2	3	4	Total year
Minimum flow - river	Mm^3/year	high			low	12
Minimum flow - swamp	Mm^3/year	high			low	15
Ravilla urban area	km^3/year	slowly but steadily increasing				1070
Tana urban area	km^3/year	slowly but steadily increasing				230
Irrigation area	km^3/stg	0	0	3000	4600	7600

Background information - Water Authority - IA2

Structural element	Characteristics	value	units	unit NV MRp	ADR %	AFOCI %
Reservoir	storage capacity	13.00	Mm^3	250.00	5.00	4.00
	initial storage	1.00	Mm^3			
Hydro Power	discharge capacity	3.75	Mm^3/stg	150.00	10.00	6.00
Diversion Structure1	-	-	-	15.00	5.00	2.00
Canal 10	conveyance capacity	15.00	Mm^3/stg	24.00	5.00	1.00
	loss coefficient	0.10	-			
Diversion Structure 10	-	-	-	10.00	5.00	2.00
Diversion Structure 2	-	-	-	15.00	5.00	1.00
Monitoring Well	-	-	-	2.00	2.00	0.50
Monitoring Station WTP 1 effluent		-	-	3.00	5.00	0.20
Monitoring Station WTP 11 effluent		-	-	2.00	5.00	0.20
Monitoring Station Irrigation Drain 1		-	-	3.00	5.00	0.20
Monitoring Station Irrigation Drain 2		-	-	3.00	5.00	0.20
Monitoring Station Irrigation Drain 3		-	-	3.00	5.00	0.20
Monitoring Station Drainage Cnl 14		-	-	4.00	5.00	0.20
Monitoring Station WTP2 effluent		-	-	3.00	5.00	0.20
Monitoring Station River 32 (swamp)		-	-	5.00	5.00	0.30
Total new value of the existing structures at their initial capacities				469.00 MRp		

Initial capital	20	MRp			
Initial rates			Constant rates/prices		
Hydroelectric Energy	15.00	Rp/kWh	Consultant report	3.00	MRp
Surface water-DS10	2.00	Rp/m^3			
Surface water-DS2	2.00	Rp/m^3			
Groundwater	0.00	Rp/m^3			
Domestic pollution charge	0.00	Rp/m^3			
Industrial pollution charge	0.00	Rp/m^3			
Agricultural pollution charge	0.00	Rp/m^3			
NC Penalty - GW abstraction	0.00	Rp/m^3			
Interest	5.00	%			

Average hydrological conditions		Stages in the year 1	2	3	4	Total year
Effective Rainfall	mm/stg	900	700	100	0	1700
Reservoir Inflow	Mm^3/stg	8	12	7	3	30
Groundwater Recharge	Km^/stg	Qrecharge = 135 + 0.13 x Qabstracted < 300				
Groundwater Level	Km^/stg	-12.00 =< H =< -8.00				
Groundwater Level Drop	Km^/stg	DH = 0.07 x(Qrecharge-Qabstraction)				

Typical water demands		Stages in the year 1	2	3	4	Total year
Minimum flow - river	Mm^3/year		high		low	12
Minimum flow - swamp	Mm^3/year		high		low	15
Ravilla urban area	km^3/year	slowly but steadily increasing				1070
Tana urban area	km^3/year	slowly but steadily increasing				230
Irrigation area	km^3/stg	0	0	3000	4600	7600

Existent water quality standards		Polutants TSS	BOD	Nitrogen	Phosphorus	Chemicals
Fresh waters	mg/l	10	10	1.00	0.10	0.001
Effluent waters	mg/l	60	55	5.00	1.00	0.003
Water Quality Index weight coefficients		0.40	0.30	0.10	0.10	0.10

Background information - Water Authority - IA3

Structural element	Characteristics	value	units	unit NV MRp	ADR %	AFOCI %
Reservoir	storage capacity	13.00	Mm^3	250.00	5.00	4.00
	initial storage	1.00	Mm^3			
Hydro Power	discharge capacity	3.75	Mm^3/stg	150.00	10.00	6.00
Diversion Structure1	-	-	-	15.00	5.00	2.00
Canal 10	conveyance capacity	15.00	Mm^3/stg	24.00	5.00	1.00
	loss coefficient	0.10	-			
Diversion Structure 10	-	-	-	10.00	5.00	2.00
Canal 11	conveyance capacity	12.00	Mm^3/stg	10.00	5.00	0.50
	loss coefficient	0.10	-			
Diversion Structure 11	-	-	-	9.00	5.00	1.00
Monitoring Station Irrigation Drain 1		-	-	3.00	5.00	0.20
Canal 12	conveyance capacity	9.00	Mm^3/stg	6.00	5.00	0.50
	loss coefficient	0.10	-			
Diversion Structure 12	-	-	-	8.00	5.00	1.00
Canal 13	conveyance capacity	6.00	Mm^3/stg	4.00	5.00	0.50
	loss coefficient	0.15	-			
Diversion Structure 13	-	-	-	7.00	5.00	1.00
Monitoring Station Irrigation Drain 3		-	-	3.00	5.00	0.20
Canal 14	conveyance capacity	6.00	Mm^3/stg	2.00	5.00	0.50
	loss coefficient	0.15	-			
Drainage Canal 1	natural drainage area	10.00	ha	15.00	5.00	0.50
Total new value of the existing structures at their initial capacities				510.00 MRp		

Initial capital	20	MRp			
Initial rates			*Constant rates/prices*		
Hydroelectric energy	15.00	Rp/kWh	Consultant report	4.00	MRp
Surface water - DS10	2.00	Rp/m^3			
Surface water - DS11...13	2.00	Rp/m^3			
Surface water - R23 (DS2)	2.00	Rp/m^3			
Groundwater	0.00	Rp/m^3			
Effluent discharge - DC1	0.00	Rp/m^3			
Pollution charge (EPA)	0.00	Rp/m^3			
NC penalty - Qmin R2 (EPA)	0.00	Rp/m^3			
NC penalty - Qmin R32 (EPA)	0.00	Rp/m^3			
Interest	5.00	%			

Average hydrological conditions		Stages in the year 1	2	3	4	Total year
Effective Rainfall	mm/stg	900	700	100	0	1700
Reservoir Inflow	Mm^3/stg	8	12	7	3	30
Groundwater Recharge	Km^/stg	Qrecharge = 135 + 0.13 x Qabstracted < 300				
Groundwater Level	Km^/stg	-12.00 =< H =< -8.00				
Groundwater Level Drop	Km^/stg	DH = 0.07 x(Qrecharge-Qabstraction)				
Typical water demands		**Stages in the year 1**	**2**	**3**	**4**	**Total year**
Minimum flow - river	Mm^3/year		high		low	12
Minimum flow - swamp	Mm^3/year		high		low	15
Ravilla urban area	km^3/year	slowly but steadily increasing				1070
Tana urban area	km^3/year	slowly but steadily increasing				230
Irrigation area	km^3/stg	0	0	0	0	0
Existent water quality standards		**Pollutants: TSS**	**BOD**	**Nitrogen**	**Phosphorus**	**Chemicals**
Fresh waters	mg/l	10	10	1.00	0.10	0.001
Non-fresh waters	mg/l	25	25	2.50	0.50	0.002
Effluent waters	mg/l	60	55	5.00	1.00	0.003

Background information - SEPA - IA1

Structural element	Characteristics	value	units	unit NV MRp	ADR %	AFOCI %
Monitoring Well				2.00	2.00	0.50
Sewerage Network 1	returnflow coefficient	0.85	-	100.00	20.00	1.00
	stormwater drainage area	1.00	m^2/inhabitant			
	stormwater drainage coefficient	0.65	-			
Wastewater Treat Plant 1 primary	init. capacity	0.00	km^3/stg	0.40	(new value of unit cap.)	
	extra operation cost	4.00	Rp/m^3			
Wastewater Treat Plant 1 secondary	init. capacity	0.00	km^3/stg	0.50	(new value of unit cap.)	
	extra operation cost	5.00	Rp/m^3			
Wastewater Treatment Plant 1	-	-	-	-	10.00	1.00
Drainage Canal 1	-	-	-	15.00	5.00	0.50
Monitoring Station River 21	-	-	-	5.00	5.00	0.20
Monitoring Station River 22	-	-	-	5.00	5.00	0.20
Monitoring Station River 23	-	-	-	5.00	5.00	0.20
Sewerage Network 2	returnflow coefficient	0.85	-	40.00	20.00	1.00
	stormwater drainage area	1.50	m^2/inhabitant			
	stormwater drainage coefficient	0.35	-			
Wastewater Treat Plant 2 primary	init. capacity	0.00	km^3/stg	0.25	(new value of unit cap.)	
	extra operation cost	4.00	Rp/m^3			
Wastewater Treat Plant 2 secondary	init. capacity	0.00	km^3/stg	0.35	(new value of unit cap.)	
	extra operation cost	5.00	Rp/m^3			
Wastewater Treatment Plant 2	-	-	-		10.00	1.00
Drainage Canal 2	-	-	-	5.00	5.00	0.50
Monitoring Station River 32 (swamp)	-	-	-	5.00	5.00	0.30
Total new value of the existing structures at their initial capacities				165.00	MRp	

Initial capital	100	MRp			
Initial rates			Constant rates/prices		
Dom. wastewater treatment	10.00	Rp/m^3	Consultant report	2.50	MRp
Ind. wastewater treatment - Q	0.00	Rp/m^3			
Ind. wastewater treatment - S	0.00	Rp/kg			

Average hydrological conditions		Stages in the year 1	2	3	4	Total year
Effective Rainfall	mm/stg	900	700	100	0	1700
Reservoir Inflow	Mm^3/stg	8	12	7	3	30
Groundwater Recharge	km^3/stg	Qrecharge = 135 + 0.13 x Qabstracted < 300				
Groundwater Level	km^3/stg	-12.00 =< H =< -8.00				
Groundwater Level Drop	km^3/stg	DH = 0.07 x(Qrecharge-Qabstraction)				

Typical water demands		Stages in the year 1	2	3	4	Total year
Minimum flow - river	Mm^3/year	maximum			minimum	12
Minimum flow - swamp	Mm^3/year	maximum			minimum	15

Existent water quality standards		Pollutants: TSS	BOD	Nitrogen	Phosphorus	Chemicals
Fresh waters	mg/l	10	10	1.00	0.10	0.001
Water Quality Index weight coefficients		0.40	0.30	0.10	0.10	0.10

Background information - EPA - IA3

Structural element	Characteristics	value	units	unit NV MRp	ADR %	AFOCI %
Monitoring Well	-	-	-	2.00	2.00	0.50
Monitoring Station Irrigation Drain 2	-	-	-	3.00	5.00	0.20
Monitoring Station Drainage Cnl 14	-	-	-	4.00	5.00	0.20
Monitoring Station River 22	-	-	-	5.00	5.00	0.20
Monitoring Station Drainage Canal 2	-	-	-	3.00	5.00	0.20
Monitoring Station River 32 (swamp)	-	-	-	5.00	5.00	0.30
ue of the existing structures at their initial capacities				5.00	MRp	

Initial capital	75	MRp			
Initial rates			Constant rates/prices		
Pollution charge	0.00	Rp/m^3	*Consultant report*	1.00	MRp
NC penalty - Qmin river	0.00	Rp/m^3			
NC penalty - Gw abstraction	0.00	Rp/m^3			
NC penalty - Qmin swamp	0.00	Rp/m^3			

Average hydrological conditions		Stages in the year 1	2	3	4	Total year
Effective Rainfall	mm/stg	900	700	100	0	1700
Reservoir Inflow	Mm^3/stg	8	12	7	3	30
Groundwater Recharge	Km^/stg	Qrecharge = 135 + 0.13 x Qabstracted < 300				
Groundwater Level	Km^/stg	-12.00 =< H =< -8.00				
Groundwater Level Drop	Km^/stg	DH = 0.07 x(Qrecharge-Qabstraction)				
Typical water demands		**Stages in the year 1**	**2**	**3**	**4**	**Total year**
Minimum flow - river	Mm^3/year		maximum		minimum	12
Minimum flow - swamp	Mm^3/year		maximum		minimum	15
Existent water quality standards		**Pollutants TSS**	**BOD**	**Nitrogen**	**Phosphorus**	**Chemicals**
Fresh waters	mg/l	10	10	1.00	0.10	0.001
Non-fresh waters	mg/l	25	25	2.50	0.50	0.002
Effluent waters	mg/l	60	55	5.00	1.00	0.003
Water Quality Index weight coefficients		0.40	0.30	0.10	0.10	0.10

Background information - PWSC - IA1

Structural element	Characteristics	value	units	unit NV MRp	ADR %	AFOCI %
Canal 1	conveyance capacity	15.00	Mm^3/stg	4.00	5.00	1.00
	loss coefficient	0.10	-			
Treatment Plant 1	treatment capacity	250.00	km^3/stg	0.60	5.00	0.20
	loss coefficient	0.15	-			
	extra operation costs	6.00	Rp/m^3			
Production Well 1	unit production capacity	10.00	km^3/stg	4.00	10.00	0.30
	initial number of wells	10.00	-			
Storage Tank 1	storage capacity	100.00	km^3	0.15	4.00	0.30
	loss coefficient	0.05	-			
	initial storage	50.00	km^3			
Distribution Network 1	loss coefficient	0.20	-	60.00	20.00	0.50
Stand Pipes 1	initial number	340.00	-	0.40	5.00	0.10
Private Connections 1	initial number	2500.00	-	0.15	2.50	0.10
Canal 2	conveyance capacity	1.50	Mm^3/stg	15.00	5.00	0.50
	loss coefficient	0.10	-			
Tratment Plant 2	treatment capacity	50.00	km^3/stg	0.60	5.00	0.20
	loss coefficient	0.10	-			
	extra operation costs	6.00	Rp/m^3			
Storage Tank 2	storage capacity	0.00	km^3	0.15	4.00	0.30
	loss coefficient	0.05	-			
	initial storage	0.00	km^3			
Distribution Network 2	loss coefficient	0.20	-	10.00	20.00	0.50
Stand Pipes 2	initial number	70.00	-	0.40	5.00	0.10
Private Connections 2	initial number	600.00	-	0.15	2.50	0.10
Total new value of the existing structures at their initial capacities				953.00	MRp	

Initial capital	200	MRp			
Initial rates			Constant rates/prices		
Surface water	2.00	Rp/m^3	Consultant report Ravilla	3.00	MRp
Groundwater	0.00	Rp/m^3	Consultant report Tana	2.00	MRp
Potable water - StP	50.00	Rp/m^3			
Potable water - PrC, CU, AIF	30.00	Rp/m^3			
Dom. wastewater treatment	10.00	Rp/m^3			

Water consumption conditions		Stages in the year 1	2	3	4	Total year
Initial per-capita consumption - StP	l/day	35	35	42	49	161
Initial per-capita consumption - PrC	l/day	80	80	80	80	320
Growth rate for StP consumption	3	% per year				
Growth rate for PrC consumption	2	% per year				
Average number of users for StP	200	inhabitants				
Average number of users for PrC	6	inhabitants				
		Ravilla	Tana			
Commercial Uses	%	40	25	(from total domestic use: StP+PrC)		
Initial population	inhabitants	150000	30000			
Population growth rate	%/year	5	3			

Background information - Ravilla WSC - IA23

Structural element	Characteristics	value	units	unit NV MRp	ADR %	AFOCI %
Canal 1	conveyance capacity	15.00	Mm^3/stg	4.00	5.00	1.00
	loss coefficient	0.10	-			
Treatment Plant 1	treatment capacity	250.00	km^3/stg	0.60	5.00	0.20
	loss coefficient	0.15	-			
	extra operation costs	6.00	Rp/m^3			
Production Well 1	unit production capacity	10.00	km^3/stg	4.00	10.00	0.30
	initial number of wells	10.00	-			
Monitoring Well	-	-	-	2.00	2.00	0.50
Storage Tank 1	storage capacity	100.00	km^3	0.15	4.00	0.30
	loss coefficient	0.05	-			
	initial storage	50.00	km^3			
Distribution Network 1	loss coefficient	0.20	-	60.00	20.00	0.50
Stand Pipes 1	initial number	340.00	-	0.40	5.00	0.10
Private Connections 1	initial number	2500.00	-	0.15	2.50	0.10
Sewerage Network 1	returnflow coefficient	0.85	-	100.00	20.00	1.00
	stormwater drainage area	1.00	^2/inhabitant			
	stormwater drainage coefficient	0.65	-			
Wastewater Treat Plant 1 primary	it. capacity	0.00	km^3/stg	0.40	value of unit cap.)	
	extra operation cost	4.00	Rp/m^3			
Wastewater Treat Plant 1 secondary	it. capacity	0.00	km^3/stg	0.50	value of unit cap.)	
	extra operation cost	5.00	Rp/m^3			
Wastewater Treatment Plant 1	-	-	-	-	10.00	1.00
Drainage Canal 1				15.00	5.00	0.50
Total new value of the existing structures at their initial capacities				895.00	MRp	

Initial capital	30	MRp			
Initial rates			*Constant rates/prices*		
Surface water - DS10	2.00	Rp/m^3	Consultant report	3.00	MRp
Ground water - PW1	0.00	Rp/m^3			
Pollution charge - WTP1	0.00	Rp/m^3			
NC penalty - Gw abs. permit	0.00	Rp/m^3			
Potable water - StP1	50.00	Rp/m^3			
Potable water - PrC1	30.00	Rp/m^3			
Ind. ww. treat. - Q - WTP1	0.00	Rp/m^3			
Ind. ww. treat. - S - WTP1	0.00	Rp/kg			
Ind. eff. discharge - DC1	0.00	kRp/stg/F			
Agr. eff. discharge - DC1	0.00	kRp/stg/A			
Interest	5.00	%			

Water consumption conditions		Stages in the year 1	2	3	4	Total year
Initial per-capita consumption - StP	l/day	35	35	42	49	161
Initial per-capita consumption - PrC	l/day	80	80	80	80	320
Growth rate for StP consumption	3	% per year				
Growth rate for PrC consumption	2	% per year				
Average number of users for StP	200	inhabitants				
Average number of users for PrC	6	inhabitants				
Commercial Uses	40	%	(from total domestic use: StP+PrC)			
Initial population	150000	inhabitants				
Population growth rate	5	%/year				

Background information - Tana WSC - IA23

Structural element	Characteristics	value	units	unit NV MRp	ADR %	AFOCI %
Diversion Structure 2	-	-	-	15.00	5.00	0.50
Canal 2	conveyance capacity	1.50	Mm^3/stg	15.00	5.00	0.50
	loss coefficient	0.10	-			
Tratment Plant 2	treatment capacity	50.00	km^3/stg	0.60	5.00	0.20
	loss coefficient	0.10	-			
	extra operation costs	6.00	Rp/m^3			
Storage Tank 2	storage capacity	0.00	km^3	0.15	4.00	0.30
	loss coefficient	0.05	-			
	initial storage	0.00	km^3			
Distribution Network 2	loss coefficient	0.20	-	10.00	20.00	0.50
Stand Pipes 2	initial number	70.00	-	0.40	5.00	0.10
Private Connections 2	initial number	600.00	-	0.15	2.50	0.10
Sewerage Network 2	returnflow coefficient	0.85	-	40.00	20.00	1.00
	stormwater drainage area	1.50	m^2/inhab.			
	stormwater drainage coefficient	0.35	-			
Wastewater Treat Plant 2 primary	init. capacity	0.00	km^3/stg	0.25	(new value of unit cap.)	
	extra operation cost	4.00	Rp/m^3			
Wastewater Treat Plant 2 secondary	init. capacity	0.00	km^3/stg	0.35	(new value of unit cap.)	
	extra operation cost	5.00	Rp/m^3			
Wastewater Treatment Plant 2	-	-	-		10.00	1.00
Drainage Canal 2	-	-	-	5.00	5.00	0.50
Total new value of the existing structures at their initial capacities				233.00	MRp	

Initial capital	15	MRp			
Initial rates			Constant rates/prices		
Surface water - R23	2.00	Rp/m^3	Consultant report	2.00	MRp
Pollution charge	0.00	Rp/m^3			
Potable water - StP2	50.00	Rp/m^3			
Potable water - PrC2 & CU2	30.00	Rp/m^3			
Interest	5.00	%			

Water consumption conditions		Stages in the year 1	2	3	4	Total year
Initial per-capita consumption - StP	l/day	35	35	42	49	161
Initial per-capita consumption - PrC	l/day	80	80	80	80	320
Growth rate for StP consumption	3	% per year				
Growth rate for PrC consumption	2	% per year				
Average number of users for StP	200	inhabitants				
Average number of users for PrC	6	inhabitants				
Commercial Uses	25	%	(from total domestic use: StP+PrC)			
Initial population	30000	inhabitants				
Population growth rate	3	%/year				

Background information - AIF - IA1

Structural element	Characteristics	value	units	unit NV MRp	ADR %	AFOCI %
AIF's Mill Unit	initial capacity	150	tonsP1/stg	2.50	5.00	0.30
		60	tonsP2/stg			
	efficiency	0.90	-			
AIF's Packing Unit	initial capacity	150	tons/stg	0.50	5.00	0.30
	efficiency	0.95	-			
AIF's Transport Unit	initial capacity	150	tons/stg	0.50	5.00	0.30
	efficiency	0.95	-			
Total new value of the existing structures at their initial capacities				525.00 MRp		

Initial capital	120	MRp			
Initial rates			Constant rates		
Potable water	30.00	Rp/m^3	Raw material P1	5.00	kRp/ton
Energy	30.00	Rp/kWh	Raw material P2	8.00	kRp/ton
Ind. wastewater treatment - Q	0.00	Rp/m^3	Solid waste collection	25.00	Rp/kg
Ind. wastewater treatment - S	0.00	Rp/kg	Planned labor	1000.00	Rp/day
Interest	5.00	%	Emergency labor	2500.00	Rp/day

		P1	P2
Market demand	is high in	2 and 3	1 and 4
Maximum price	kRp/ton	400	1000
Labor requirement	days/ton/stg	10	20

Technology related parameters		Initial	Improved	Note:
Energy consumption	kWh/ton	100.00	60.00	- all values refer to new assets and
Water consumption	m^3/ton	100.00	50.00	input raw material quantities
Solid waste generation	kg/ton	50.00	40.00	- improvements are made by
Liquid waste - returnflow	-	0.40	0.65	investments in technology, in
Liquid waste - solid load	kg/ton	40.00	25.00	average 25% for each 1 MRp inv.

Background information - AIF - IA2

Structural element	Characteristics	value	units	unit NV MRp	ADR %	AFOCI %
Production Well 11	production capacity	10.00	km^3/stg	4.00	10.00	0.30
	initial number of wells	0.00	-			
AIF's Mill Unit	initial capacity	150	tonsP1/stg	2.50	5.00	0.30
		60	tonsP2/stg			
	efficiency	0.90	-			
AIF's Packing Unit	initial capacity	150	tons/stg	0.50	5.00	0.30
	efficiency	0.95	-			
AIF's Transport Unit	initial capacity	150	tons/stg	0.50	5.00	0.30
	efficiency	0.95	-			
Wastewater Treat Plant 11 primary	it. capacity	0.00	km^3/stg	0.25	value of unit cap.)	
	extra operation cost	4.00	Rp/m^3			
Wastewater Treat Plant 11 secondary	it. capacity	0.00	km^3/stg	0.35	value of unit cap.)	
	extra operation cost	5.00	Rp/m^3			
Wastewater Treatment Plant 11	-	-	-		10.00	2.00
Total new value of the existing structures at their initial capacities				525.00	MRp	

Initial capital	120	MRp			
Initial rates			Constant rates		
Potable water	30.00	Rp/m^3	Raw material P1	5.00	kRp/ton
Groundwater	0.00	Rp/m^3	Raw material P2	8.00	kRp/ton
Energy	30.00	Rp/kWh	Solid waste collection	25.00	Rp/kg
Ind. wastewater treatment - Q	0.00	Rp/m^3	Planned labor	1000.00	Rp/day
Ind. wastewater treatment - S	0.00	Rp/kg	Emergency labor	2500.00	Rp/day
Industrial effluent discharge	0.00	Rp/stg/AIF			
Industrial pollution charge	0.00	Rp/m^3			
Interest	5.00	%			

		P1	P2
Market demand	is high in	2 and 3	1 and 4
Maximum price	kRp/ton	400	1000
Labor requirement	days/ton/stg	10	20

Technology related parameters		Initial	Improved	Notes:
Energy consumption	kWh/ton	100.00	60.00	- all values refer to new assets and
Water consumption	m^3/ton	100.00	50.00	input raw material quantities
Solid waste generation	kg/ton	50.00	40.00	- improvements are made by
Liquid waste - returnflow	-	0.40	0.65	investments in technology, in
Liquid waste - solid load	kg/ton	40.00	25.00	average 25% for each 1 MRp inv.

Background information - AIF - IA3

Structural element	Characteristics	value	units	unit NV MRp	ADR %	AFOCI %
Storage Tank 11	storage capacity	0.00	km^3	0.15	4.00	0.30
	loss coefficient	0.05	-			
	initial storage	0.00	m^3			
AIF's Mill Unit	initial capacity	150	tonsP1/stg	2.50	5.00	0.30
		60	tonsP2/stg			
	efficiency	0.90	-			
AIF's Packing Unit	initial capacity	150	tons/stg	0.50	5.00	0.30
	efficiency	0.95	-			
AIF's Transport Unit	initial capacity	150	tons/stg	0.50	5.00	0.30
	efficiency	0.95	-			
Wastewater Treat Plant 11 primary	init. capacity	0.00	km^3/stg	0.25	(new value of unit cap.)	
	extra operation cost	4.00	Rp/m^3			
Wastewater Treat Plant 11 secondary	init. capacity	0.00	km^3/stg	0.35	(new value of unit cap.)	
	extra operation cost	5.00	Rp/m^3			
Wastewater Treatment Plant 11	-	-	-		10.00	2.00
Total new value of the existing structures at their initial capacities				525.00	MRp	

Initial capital	120	MRp			
Initial rates			Constant rates		
Potable water	30.00	Rp/m^3	Raw material P1	5.00	kRp/ton
Energy	30.00	Rp/kWh	Raw material P2	8.00	kRp/ton
Ind. wastewater treatment - Q	0.00	Rp/m^3	Solid waste collection	25.00	Rp/kg
Ind. wastewater treatment - S	0.00	Rp/kg	Planned labor	1000.00	Rp/day
Effluent discharge	0.00	Rp/m^3	Emergency labor	2500.00	Rp/day
Pollution charge	0.00	Rp/m^3			
Interest	5.00	%			

		P1	P2
Market demand	is high in	2 and 3	1 and 4
Maximum price	kRp/ton	400	1000
Labor requirement	days/ton/stg	10	20

Technology related parameters		Initial	Improved	Notes:
Energy consumption	kWh/ton	100.00	60.00	- all values refer to new assets and
Water consumption	m^3/ton	100.00	50.00	input raw material quantities
Solid waste generation	kg/ton	50.00	40.00	- improvements are made by
Liquid waste - returnflow	-	0.40	0.65	investments in technology, in
Liquid waste - solid load	kg/ton	40.00	25.00	average 25% for each 1 MRp inv.

Background information - Farmers - IA1

Farming parameters:		All	F1	F2	F3	
Farm area	[ha]		3.00	2.00	1.00	
New value	MRp		4.50	3.00	1.50	
Annual depreciation rate	%/year		10.00	10.00	10.00	
Annual fix operation cost index	%/year		5.00	4.00	3.00	
Soil characteristics	-		good	fair	poor	
Irrigation efficiency (when new)	[%]		0.60	0.55	0.50	
Family size	nr.		5.00	6.00	7.00	
Active labour coefficient	-		0.40	0.42	0.44	
Number of working days per stage	*days/stg*	72				
Planned labor price	Rp/days	500				
Emergency labor price	Rp/days	1500				
Maintenance labor value	Rp/days	600				
Subsistence cost	Rp/stg/cap	19				
Initial capital	MRp		10.00	10.00	10.00	
Initial rates						
Irrigation water	Rp/m^3	2.00				
Interest	%	5.00				

Average input requirements per cropping season		Crop				Price [Rp/kg]	
		Maize	Rice	Soybeans	Groundnuts	Subsidized	Black market
Seeds	kg/ha	100	100	80	70		
Water	mm	1000	1500	690	450		
first stage	-	0.55	0.56	0.40	0.42		
second stage	-	0.45	0.44	0.60	0.58		
Urea	kg/ha	190	220	50	50	100	300
first stage	-	0.63	0.63	0.56	0.56		
second stage	-	0.37	0.38	0.44	0.44		
TSP	kg/ha	80	70	120	110	100	250
first stage	-	0.00	0.58	0.25	0.25		
second stage	-	1.00	0.42	0.75	0.75		
Chemicals	kg/ha	40	60	40	40	200	400
first stage	-	0.63	0.58	0.63	0.57		
second stage	-	0.38	0.42	0.38	0.43		
Labour	days/ha	80	160	90	90		
first stage	-	0.69	0.76	0.71	0.67		
second stage	-	0.31	0.24	0.29	0.33		

Average output potentials		Maize	Rice	Soybeans	Groundnuts	Relative price of seeds
Yield - seeds type 1	tons/ha	4.40	5.20	1.30	1.70	1.50
Yield - seeds type 2	tons/ha	4.10	4.70	1.20	1.50	1.25
Yield - seeds type 3	tons/ha	3.40	4.30	1.10	1.40	1.00
Price	Rp/kg	160	250	850	600	-

Background information - Farmers - IA23

Farming parameters:		All	F1	F2	F3
Farm area	[ha]		3.00	2.00	1.00
New value	MRp		4.50	3.00	1.50
Annual depreciation rate	%/year		10.00	10.00	10.00
Annual fix operation cost index	%/year		5.00	4.00	3.00
Soil characteristics	-		good	fair	poor
Irrigation efficiency (when new)	[%]		0.60	0.55	0.50
Family size	nr.		5.00	6.00	7.00
Active labour coefficient	-		0.40	0.42	0.44
Number of working days per stage	days/stg	72			
Planned labor price	Rp/days	500			
Emergency labor price	Rp/days	1500			
Maintenance labor value	Rp/days	600			
Subsistence cost	Rp/stg/cap	19			
Initial capital	MRp		10.00	10.00	10.00
Initial rates					
Irrigation water	Rp/m^3		2.00	2.00	2.00
	-		-	-	-
Effluent discharge	Rp/m^3		0.00	-	0.00
Pollution charge	Rp/m^3	0.00			
Interest	%	5.00			

Average input requirements per cropping season		Crop				Price
		Maize	Rice	Soybeans	Groundnuts	Rp/kg
Seeds	kg/ha	100	100	80	70	
Water	mm	1000	1500	690	450	
first stage	-	0.55	0.56	0.40	0.42	
second stage	-	0.45	0.44	0.60	0.58	
Urea	kg/ha	190	220	50	50	200
first stage	-	0.63	0.63	0.56	0.56	
second stage	-	0.37	0.38	0.44	0.44	
TSP	kg/ha	80	70	120	110	175
first stage	-	0.00	0.58	0.25	0.25	
second stage	-	1.00	0.42	0.75	0.75	
Chemicals	kg/ha	40	60	40	40	350
first stage	-	0.63	0.58	0.63	0.57	
second stage	-	0.38	0.42	0.38	0.43	
Labour	days/ha	80	160	90	90	
first stage	-	0.69	0.76	0.71	0.67	
second stage	-	0.31	0.24	0.29	0.33	

Average output potentials		Maize	Rice	Soybeans	Groundnuts	Relative price of seeds
Yield - seeds type 1	tons/ha	4.40	5.20	1.30	1.70	1.50
Yield - seeds type 2	tons/ha	4.10	4.70	1.20	1.50	1.25
Yield - seeds type 3	tons/ha	3.40	4.30	1.10	1.40	1.00
Price	Rp/kg	160	250	850	600	-

Background information - Farmer Association - IA2

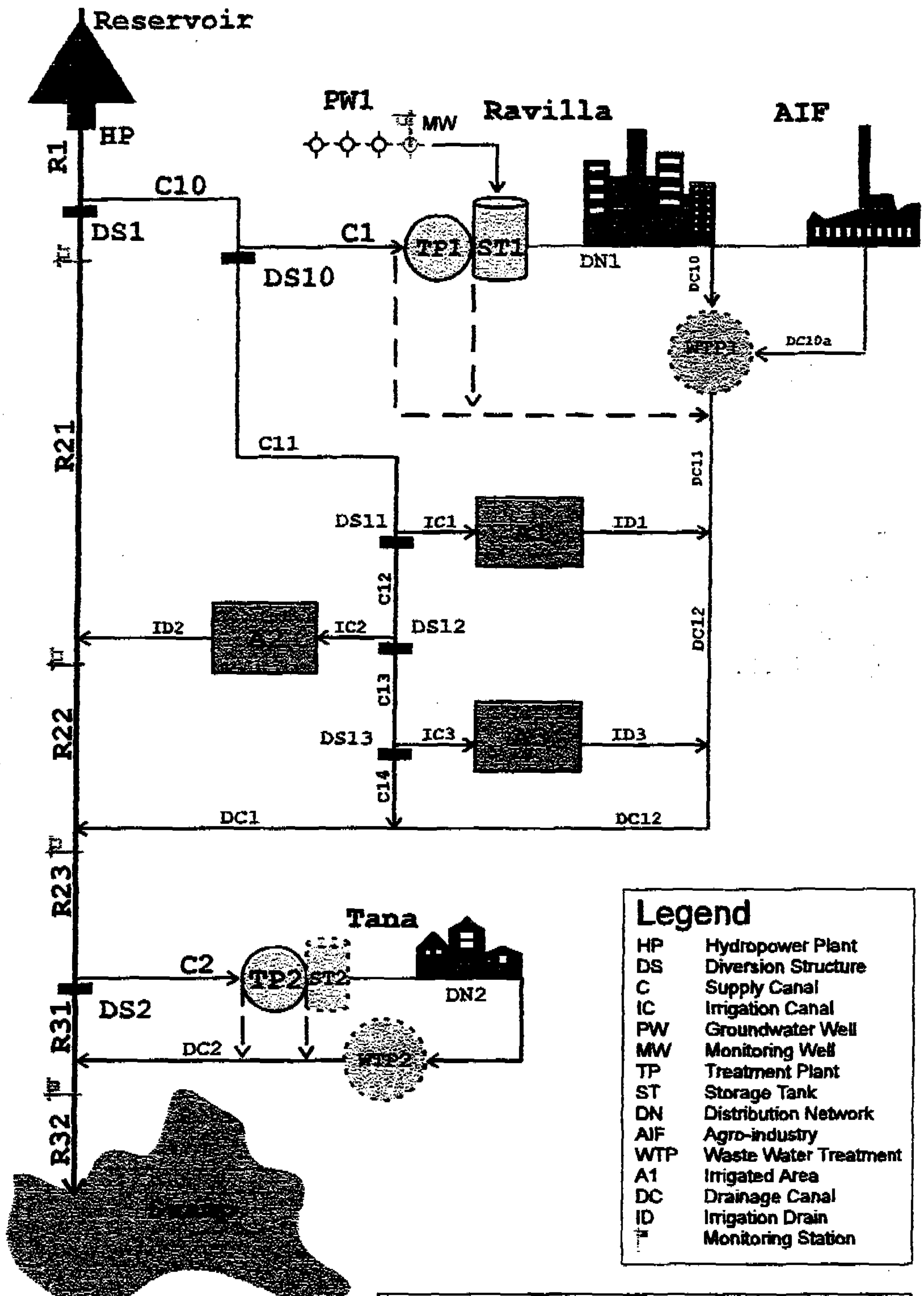
Structural element	Characteristics	value	units	unit NV MRp	ADR %	AFOCI %
Canal 11	conveyance capacity	12.00	Mm^3/stg	10.00	5.00	0.50
	loss coefficient	0.10	-			
Diversion Structure 11	-	-	-	9.00	5.00	1.00
Canal 12	conveyance capacity	9.00	Mm^3/stg	6.00	5.00	0.50
	loss coefficient	0.10	-			
Diversion Structure 12	-	-	-	8.00	5.00	1.00
Canal 13	conveyance capacity	6.00	Mm^3/stg	4.00	5.00	0.50
	loss coefficient	0.15	-			
Diversion Structure 13	-	-	-	7.00	5.00	1.00
Canal 14	conveyance capacity	6.00	Mm^3/stg	2.00	5.00	0.50
	loss coefficient	0.15	-			
Total new value of the existing structures at their initial capacities				46.00	MRp	

Initial capital	*20*	MRp			
Initial rates			Constant rates/prices		
Irrigation Water Rate - DS10	2.00	Rp/m^3	Consultant report	1.00	MRp
Irrigation Water Rate - DS11	2.00	Rp/m^3			
Irrigation Water Rate - DS12	2.00	Rp/m^3			
Irrigation Water Rate - DS13	2.00	Rp/m^3			
Irrigation Tax Rate - A1	0.00	kRp/ha/stg			
Irrigation Tax Rate - A2	0.00	kRp/ha/stg			
Irrigation Tax Rate - A3	0.00	kRp/ha/stg			
Interest Rate	5.00	%			

Farm parameters		A1	A2	A3	Total	
Average farm area	ha	3.00	2.00	1.00	-	
Number of farms per irrigation area	farms	67	100	200	367	
Total irrigation area	ha	200	200	200	600	

Annex B - 1

Role Specifications for WRM - RP.1



The Ra Water Resources System
(WRM-RP1)

The Water Authority (WA)

Objective:	★	execute the national water policy.
Tasks:	★	surface water provision,
	★	hydropower generation,
	★	surface water allocation (priority and minimum flow regulation);
O&M:	★	dam, reservoir and hydropower plant (HP),
	★	diversion structures DS1..2,
	★	primary water supply canals C10..14.
Developments:	☆	
Mandates:	★	annual report, plan and budget proposal,
	★	information purchase (optional).
Income:	★	annual budget,
	★	energy sales - the National Power Company,
	★	water sales - PWS utility,
	★	water sales (payment regulation) - farmers (Fs);
Expenditures:	★	operation cost (fixed),
	★	maintenance costs,
	★	information purchase (optional).
State variables:	★	reservoir storage,
	★	present value of the system (maintenance level);
	★	capital;
Performance criteria:	★	energy production,
	★	effectiveness in water provision and allocation:
	☆	shortages in surface water provision,
	☆	non-compliance to minimum flow requirements.
	★	supply efficiency.
Decision variables:	★	reservoir release,
	★	gate settings for DS1..2,
	★	maintenance level,
	★	information purchase.

The Sanitation and Environmental Protection Agency (SEPA)

Objective:	★	execute national policies for sanitation and environment.
Tasks:	★	urban sewerage,
	★	waste water treatment and effluents discharge,
	★	surface and groundwater resource conservation,
	★	surface water pollution prevention and control;
O&M:	★	sewage networks SN1..2,
	★	waste water treatment plants WTP1..2,
	★	drainage canals DC1, DC2,
	★	surface water monitoring station(s) MR32..,
	★	groundwater monitoring well MW (optional);
Developments:	★	waste water treatment capacities (governmental plan),
	★	monitoring network.
Mandates:	★	annual report, plan and budget proposal,
	★	environmental protection regulation (proposals),
	★	information purchase (optional).
Income	★	annual budget,
	★	waste water treatment services and charges - PWS, AIF
Expenditures:	★	operation costs (fixed and variable),
	★	maintenance costs,
	★	investments in system development,
	★	information purchase (optional).
State variables:	★	initial value of the system (development level),
	★	present value of the system (maintenance level),
	★	capital;
Performance criteria:	★	effectiveness in sanitation (waste water treated),
	★	effectiveness in environmental protection:
	☆	negative impacts of groundwater table drops,
	☆	negative impacts of flow shortages - river Ra, swamp,
	☆	nc with surface water quality standards - river Ra.
Decision variable:	★	proposals for:
	☆	minimum flow requirements - river Ra, swamp,
	☆	groundwater abstraction permit,
	★	maintenance level,
	★	investment in developments,
	★	information purchase.

Public Water Supply (PWS) utility

Objective:	★	execute the local authority's PWS policy.
Tasks:	★	groundwater provision (abstraction permit),
	★	surface water treatment and potable water distribution;
O&M:	★	surface water supply canals C1, C2,
	★	groundwater production wells PW1,
	★	treatment plants TP1..2 and storage tank(s) ST1..,
	★	distribution networks DN1..2;
Developments:	★	groundwater abstraction capacity,
	★	treatment (governmental plan) and storage capacities,
	★	stand pipes and private connections (governmental plan).
Mandates:	★	annual report plan and budget proposal,
	★	information purchase (optional).
Income:	★	annual budget,
	★	potable water sales - urban households and offices, AIF;
Expenditures:	★	operation costs (fixed and variable),
	★	maintenance costs,
	★	investments in system developments,
	★	raw water tariff - WA,
	★	waste water treatment tariff - SEPA,
	★	information purchase (optional).
State variables:	★	initial value of the system (development level),
	★	present value of the system (maintenance level)
	★	capital;
Performance criteria:	★	coverage rate (standpipes and private connections),
	★	supply effectiveness (shortages),
	★	supply efficiency (overall and unaccounted water),
	★	non-compliance with groundwater abstraction permit.
Decision variables:	★	surface water to be treated (demand for surface water),
	★	groundwater abstraction,
	★	maintenance level,
	★	investment in developments,
	★	information purchase.

The Agro-Industry Factory (AIF)

Objective:	★	profit through industrial production.
Activities:	★	industrial production
	☆	potable water consumption,
	☆	solid waste generation,
	☆	industrial waste water generation;
O&M:	★	three units of the factory;
Developments:	★	production capacity - three units.
Mandates:	★	production,
	★	technology.
Iincome:	★	initial capital for rehabilitation,
	★	product sales;
Expenditures:	★	operation cost (fixed and variable),
	★	maintenance costs,
	★	investments in system developments,
	★	investment in technology,
	★	energy, raw materials and labor,
	★	solid waste collection tariff,
	★	water tariff - PWS utility,
	★	waste water treatment service or charge - SEPA.
State variables:	★	initial value of the system (development level),
	★	present value of the system (maintenance level)
	★	capital;
Performance criteria:	★	production,
	★	profit.
Decision variables:	★	production - type and amount,
	★	labor hired,
	★	maintenance level,
	★	investment in developments,
	★	investment in technology.

The Farmer groups (F1..F3)

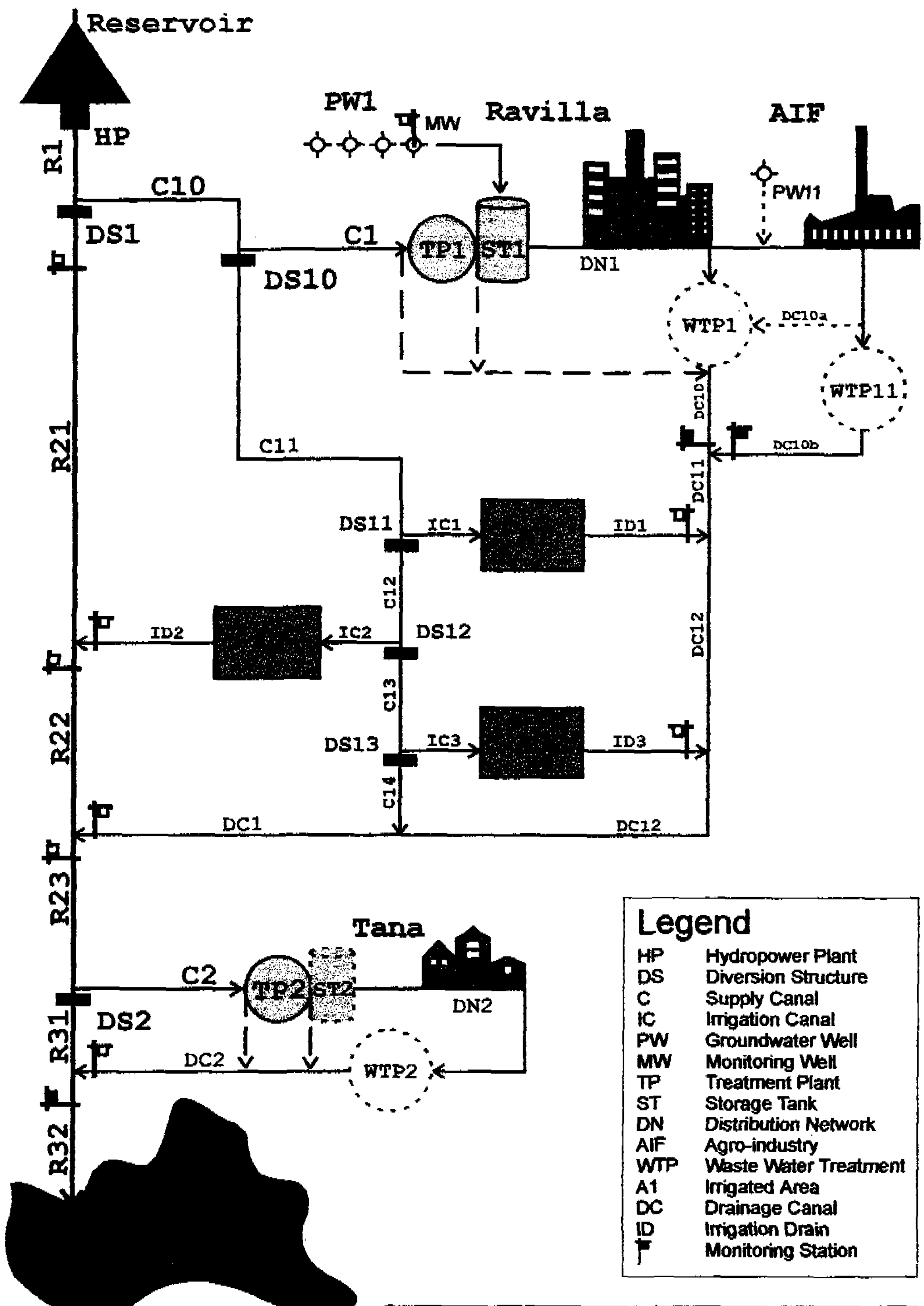
Objective:	★	maximize family income through crop production.
Activities:	★	irrigated agriculture
	☆	surface water consumption,
	☆	irrigation return flow generation;
O&M:	★	irrigation and drainage canals IC+A+ID1..3.
Developments:	☆	
Mandates:	★	cropping pattern (regulation for maize),
	★	use of fertilizers, pesticides (regulation for subsidized use)
Iincome:	★	initial capital for rehabilitation,
	★	credit from the government (when necessary),
	★	product sales,
	★	excess labor sales (only for F3);
Expenditures:	★	operation cost (fixed),
	★	inputs for crop production - seeds and chemicals,
	★	labor (optional),
	★	irrigation water tariff - WA (payment regulation).
State variables:	★	present value of the system (maintenance level),
	★	capital;
Performance criteria:	★	crop yield and production,
Decision variables:	★	cropping pattern (regulation for maize),
	★	inputs of seeds, chemicals (regulation for max. use),
	★	labor hired and sold (only for F3),
	★	maintenance level.

Central Government

Objective:	★ economic and social development.
Activities:	★ policy making and planing, ★ standardization and regulation, ★ pricing, ★ budget allocation, ★ financial assistance (credits);
O&M:	☆ (not relevant);
Developments:	☆ (not relevant).
Mandates:	★ command and control (annual reports).
Income:	☆ (not relevant);
Expenditures:	★ annual budgets - WA, SEPA, PWS utility , ★ credits (when necessary) - Fs.
State variables:	☆ (not relevant);
Performance criteria:	☆ (not relevant).
Decision variables:	★ fresh water bodies quality standard, ★ regulations: ☆ minimum flow - river Ra, swamp (SEPA proposal), ☆ groundwater abstraction permit (SEPA proposal), ☆ minimum area for maize cultivation, ☆ subsidized use of pesticides and chemicals ★ electricity rates (acquisition and consumption), ★ solid waste collection rate, ★ water rates (raw surface water and potable water), ★ waste water treatment rates.
Annual plans exist for:	★ TP1, TP2,, WWTP1, WWTP2 ★ standpipes and private connections
Existing regulations:	★ absolute priority for PWS in water allocation, ★ gw abstraction rights are assigned only to the PWS ★ farmers have to pay for the irrigation water only if their income exceed the subsistence level (no compensations for the WA), ★ farmers have permanent credit from the Government.

ANNEX B - 2

Role Specifications
WRM - RP.2



The Ra Water Resources System
(WRM-RP2)

The Water Authority (WA)

Objective:	★	efficient, environmentally sound use of water resources.
Activities:	★	surface water provision,
	★	hydropower generation,
	★	surface water allocation (minimum flow requirement),
	★	surface and groundwater resources conservation,
	★	surface water pollution prevention and control;
O&M:	★	dam, reservoir and hydropower plant (HP),
	★	div. structures DS1, DS10, DS2 and water supply canal C10,
	★	surface water monitoring station(s) MR32..;
Developments:	★	monitoring network.
Mandates:	★	minimum flow requirements,
	★	groundwater abstraction permit and (optional) penalty rate,
	★	hydro-electric energy rate (maximum price),
	★	pricing (surface and groundwater),
	★	pollution charges (schemes and rates),
	★	information purchase (optional).
Income:	★	initial capital for system upgrade,
	★	energy sales - a Power Company,
	★	water sales - WSCs, Farmers' Association (FA),
	★	pollution charge bills - PWS companies, AIF, farmers (Fs);
Expenditures:	★	operation cost (fixed),
	★	maintenance costs,
	★	investments in monitoring network developments,
	★	information purchase (optional).
State variables:	★	reservoir storage, river and swamp flows,
	★	initial value of the system (development level),
	★	present value of the system (maintenance level);
	★	capital;
Performance criteria:	★	annual energy production,
	★	effectiveness in water provision and allocation (shortages),
	★	effectiveness in environmental protection:
	☆	negative impacts of groundwater table drops,
	☆	negative impacts of flow shortages - river Ra, swamp,
	☆	nc with water quality standards - river Ra, DC1, swamp.
Decision variables:	★	reservoir release and gate settings for DS1, DS10 and DS2,
	★	minimum flow requirements - river Ra, swamp,
	★	energy, surface and groundwater rates,
	★	pollution charge schemes and rates,
	★	maintenance level and investments in MS developments,
	★	information purchase.

Ravilla Water Supply Company (R-WSC)

Objective:	★	profit through effective and efficient public water supply.
Activities:	★	groundwater provision,
	★	water treatment and distribution, and sewerage ,
	★	waste water treatment (optional) and effluent discharge;
O&M:	★	surface water supply canal C1,
	★	groundwater production wells PW1,
	★	treatment plant TP1 and storage tank ST1,
	★	distribution and sewerage networks DN+SN1,
	★	waste water treatment plant WTP1 (optional),
	★	drainage canal DC1;
Developments:	★	groundwater abstraction capacity,
	★	treatment and storage capacities,
	★	stand pipes and private connections,
	★	waste water treatment capacity (optional).
Mandates:	★	gw abstraction right concession (abstraction permit),
	★	pricing (potable water, industrial waste water treatment),
	★	information purchase (optional).
Income:	★	initial capital for system's upgrade,
	★	potable water sales - urban households and offices, AIF,
	★	*industrial waste water treatment bill* - AIF (optional),
	★	effluents discharge bills - AIF, F1, F3;
Expenditures:	★	operation costs (fixed and variable),
	★	maintenance costs,
	★	investments in system developments,
	★	surface and groundwater tariff - WA,
	★	non-compliance fee (gw abstraction permit) - WA (optional),
	★	pollution charges - WA,
	★	information purchase (optional).
State variables:	★	initial value of the system (development level),
	★	present value of the system (maintenance level)
	★	capital;
Performance criteria:	★	supply effectiveness (shortages),
	★	supply efficiency (potable water rate).
Decision variables:	★	surface water treatment,
	★	groundwater abstraction,
	★	potable water, industrial waste water treatment (optional) and effluent discharge rates,
	★	maintenance level,
	★	investment in developments,
	★	information purchase.

The Agro-Industry Factory (AIF)

Objective:	★	profit through industrial production.
Activities:	★	industrial production -->
	☆	potable water consumption,
	☆	solid waste generation,
	☆	industrial waste water generation,
	★	groundwater abstraction (optional and only during shortages);
O&M:	★	three units of the factory,
	★	groundwater production wells PW11 (optional);
	★	waste water treatment plant WTP11 (optional);
Developments:	★	production capacity - three units,
	★	groundwater abstraction capacity (optional),
	★	waste water treatment capacity (optional).
Mandates:	★	production,
	★	technology,
	★	*groundwater abstraction during shortages in pws,*
	★	waste water treatment alternative.
Income:	★	initial capital for rehabilitation,
	★	product sales;
Expenditures:	★	operation cost (fixed and variable),
	★	maintenance costs,
	★	investments in system developments,
	★	investments in technology,
	★	energy, raw materials and labor,
	★	solid waste collection tariff,
	★	water tariff - R-PWS company,
	★	waste water treatment tariff - R-WSC, or pollution charge tariff - WA,
	★	effluent discharge tariff - R-WSC.
State variables:	★	initial value of the system (development level),
	★	present value of the system (maintenance level)
	★	capital;
Performance criteria:	★	annual profit.
Decision variables:	★	production - type and amount,
	★	labor hired,
	★	maintenance level,
	★	investment in developments,
	★	investment in technology.

The Farmer's Association

Objectives:	★	efficient use of surface water for irrigation purposes.
Activities:	★	surface water supply and allocation (equal rights);
O&M:	★	secondary water supply canals C11..13,
	★	diversion structures - DS11..12;
Developments:	☆	
Mandates:	★	represent farmers' interests (annual report),
	★	irrigation water allocation,
	★	common O&M costs allocation through irrigation water pricing.
Incomes:	★	credit from the government (when needed),
	★	irrigation water bills - Fs (according to the allocation of common O&M costs);
Expenditures:	★	operation costs (fixed),
	★	maintenance costs,
	★	interests (for credits),
	★	raw water tariff - WA,
	★	information purchase.
State variables:	★	present value of the system (maintenance level),
	★	capital;
Performance criteria:	★	total income from crop production on A1..3,
	★	fulfillment of subsistence requirements of poor farmers.
Decision variables:	★	gate settings for DS11..12,
	★	maintenance level,
	★	irrigation water rates for A1..3,
	★	information purchase.

The Farmer groups (F1..F3)

Objective:	★	maximize family income through crop production.
Activities:	★	irrigated agricultural production -->
	☆	surface water consumption,
	☆	irrigation return flow generation;
O&M:	★	tertiary irrigation and drainage canals IC+A+ID1..3.
Developments:	☆	
Mandates:	★	cropping pattern,
	★	use of fertilizers and pesticides.
Income:	★	initial capital for rehabilitation,
	★	credit from the government (when needed),
	★	product sales,
	★	excess labor sales (only for F3);
Expenditures:	★	operation cost (fixed),
	★	maintenance costs,
	★	interests (for credits),
	★	labor (optional),
	★	inputs for crop production - seeds and chemicals,
	★	irrigation water tariff - FA (WA) (according to the allocation of common O&M costs),
	★	pollution charge tariff - WA,
	★	effluent discharge tariff - R-WSC (only for F1 and F3).
State variables:	★	present value of the system (maintenance level),
	★	capital;
Performance criteria:	★	crop yield and production,
Decision variables:	★	cropping pattern,
	★	inputs - seeds and chemicals,
	★	labor hired and (only for F3) sold (optional),
	★	maintenance level.

Tana Water Supply Company (T-WSC) company

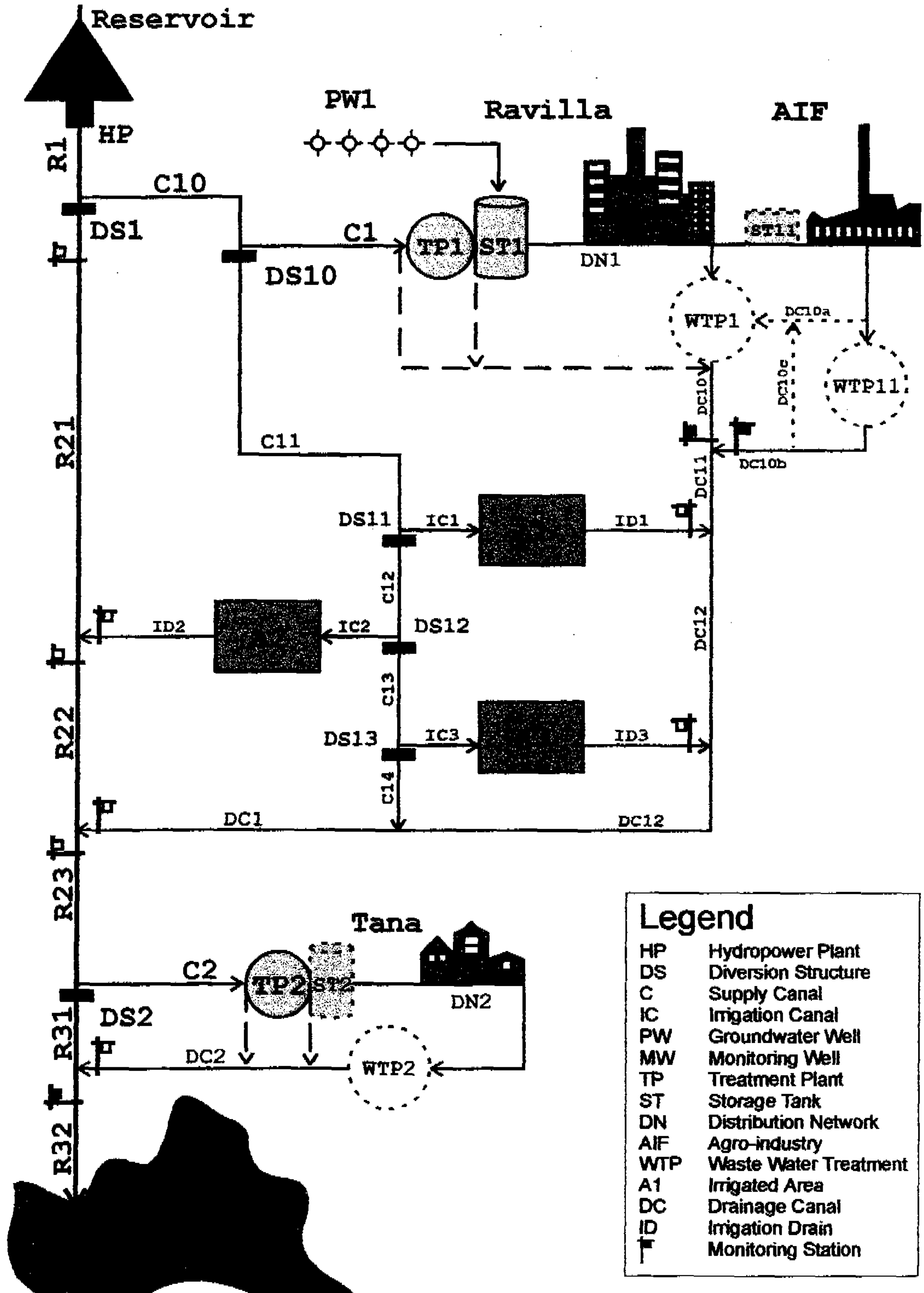
Objective:	★	profit through effective and efficient public water supply.
Activities:	★	surface water supply,
	★	water treatment and distribution, and sewerage,
	★	waste water treatment (optional),
	★	effluent discharge;
O&M:	★	surface water supply canal C2,
	★	treatment plant TP2,
	★	distribution and sewerage networks DN+SN2,
	★	waste water treatment plant WTP2 (optional),
	★	drainage canal DC2;
Developments:	★	treatment capacity,
	★	stand pipes and private connections,
	★	waste water treatment capacity (optional).
Mandates:	★	quality dependent raw water rate (to negotiate),
	★	potable water rates in Town,
	★	information purchase (optional).
Income:	★	initial capital for system's upgrade,
	★	potable water sales - urban households,
Expenditures:	★	operation costs (fixed and variable),
	★	maintenance costs,
	★	investments in system developments,
	★	water tariff - WA,
	★	pollution charge tariff - WA,
	★	information purchase (optional).
State variables:	★	initial value of the system (development level),
	★	present value of the system (maintenance level)
	★	capital;
Performance criteria:	★	supply effectiveness (shortages),
	★	supply efficiency (potable water rate).
Decision variables:	★	surface water treatment,
	★	potable water rate,
	★	maintenance level,
	★	investment in developments
	★	information purchase.

Central and local Government

Objective:	★	economic and social development.
Activities:	★	standardization and regulation,
	★	financial assistance (credits);
O&M:	☆	(not relevant);
Developments:	☆	(not relevant).
Mandates:	★	arbitration.
Inance-income:	☆	(not relevant).
Expenditures:	★	credits (when necessary) - Fs.
State variables:	☆	(not relevant);
Performance criteria:	☆	(not relevant).
Decision variables:	★	fresh water bodies quality standard (rivers),
	★	non-fresh water bodies quality standard (drains).
Existing regulations:	★	gw abstraction rights assigned to the WSCs may be transferred to their clients (AIF) to compensate shortages in supply (subject to abstraction permit),
	★	rural (not relevant) and urban residential households can buy gw abstraction rights (as an alternative to expensive pws services),
	★	farmers provided with irrigation water have rights for equal share of it (if they can pay for),
	★	farmers and Farmers' Association have permanent credit from the Government.

Annex B - 3

Role Specifications for WRM - RP.3



The Ra Water Resources System
(WRM-RP3)

The Water Authority (WA)

Objective:	★	sustainable development and use of water resources .
Activities:	★	surface water provision,
	★	hydropower generation,
	★	surface water allocation (priority and minimum flow regulation),
	★	coordination towards integrated WRM;
O&M:	★	dam, reservoir and hydropower plant,
	★	diversion structures DS1..12,
	★	primary water supply canals C10..13.
Developments:	☆	
Mandates:	★	chair the river Ra Basin Water Council (R-BWC) and its Executive Committee,
	★	hydro-electric energy rate (maximum price),
	★	untreated surface water rates,
	★	information purchase (optional).
Income:	★	initial governmental grant for system rehabilitation,
	★	energy sales - a Power Company,
	★	water sales - WSCs, farmers (Fs);
Expenditures:	★	operation cost (fixed),
	★	maintenance costs,
	★	non-compliance fee (minimum flow) - EPA,
	★	information purchase (optional).
State variables:	★	reservoir storage,
	★	river and swamp flows,
	★	present value of the system (maintenance level);
	★	capital;
Performance criteria:	★	annual energy production,
	★	effectiveness in water provision and allocation (shortages).
Decision variables:	★	reservoir release,
	★	gate settings for DS1..12,
	★	energy and surface water rates,
	★	maintenance level,
	★	information purchase.

The Environmental Protection Agency (EPA)

Objective:	★	conserve and protect environmental resources.
Activities:	★	surface and groundwater resource conservation,
	★	surface water pollution prevention and control;
O&M:	★	surface water monitoring station(s) MR32..,
	★	groundwater monitoring well MW (optional);
Developments:	★	monitoring network.
Mandates:	★	represented in the R-BWC and its Executive Committee,
	★	minimum flow requirements,
	★	groundwater abstraction permit,
	★	groundwater rate,
	★	pollution charge rates,
	★	information purchase (optional).
Income	★	initial governmental funds for a pollution control programme,
	★	groundwater bill - R-WSC,
	★	pollution charge and penalty bills - WSC, AIF, Fs,
	★	non-compliance fee (groundwater abstraction) - R-WSC,
	★	non-compliance fee (minimum flow) - WA;
Expenditures:	★	operation costs (fixed and variable),
	★	maintenance costs,
	★	investments in system development,
	★	information purchase (optional).
State variables:	★	initial value of the system (development level),
	★	present value of the system (maintenance level),
	★	capital;
Performance criteria:	★	effectiveness in environment protection:
	☆	negative impacts of groundwater table drops,
	☆	negative impacts of flow shortages - river Ra and swamp,
	☆	nc with water quality standards - river Ra, DC1, swamp.
Decision variable:	★	minimum flow requirements - river Ra, swamp,
	★	groundwater rate and abstraction permit,
	★	pollution charge rates,
	★	maintenance level,
	★	investment in monitoring network developments,
	★	information purchase.

The river Ra Basin Water Council (R-BWC)

Objective:	★	coordination towards integrated water resources management.
Activities:	★	sectoral coordination,
	★	inter-sectoral coordination.
Mandate:	★	control on water resources' uses (free of charge information),
	★	guiding directions for WSCs,
	★	non-compliance fee and pollution penalty rates.
Organization:	★	annual board meeting:
	☆	reporting and consultation,
	☆	WA (chairman), National Water Council (NWC), EPA, WSCs, AIF, Fs,
	★	Executive Committee:
	☆	sectoral coordination at operational level,
	☆	decision making for regulation enforcement,
	☆	WA, EPA, NWC (veto).
Decision variable:	★	non-compliance fee - groundwater abstraction permit,
	★	non-compliance fee - Qmin river Ra,
	★	non-compliance fee - Qmin swamp,
	★	pollution penalties - WSCs, AIF, Fs,
	★	costs' sharing between WA and EPA (optional).

The Ravilla Water Supply Company (R-WSC)

Objective:	★ profit through effective and efficient public water supply.
Activities:	★ groundwater provision (abstraction permit), ★ water treatment and distribution, and sewerage, ★ waste water treatment and effluent discharge;
O&M:	★ surface water supply canal C1 and gw production wells PW1, ★ treatment plant TP1 and storage tank ST1, ★ distribution and sewerage networks DN+SN1, ★ waste water treatment plant WTP1 (optional), ★ drainage canal DC1;
Developments:	★ groundwater abstraction capacity, ★ treatment and a storage capacities, ★ stand pipes and private connections, ★ waste water treatment capacity (optional).
Mandates:	★ represented in the R-BWC, ★ pricing (potable water, industrial waste water treatment), ★ information purchase (optional).
Income:	★ initial capital for system's upgrade, ★ loans from the government (optional), ★ potable water sales - urban households and offices, AIF, ★ industrial waste water treatment bill - AIF (optional), ★ effluent discharge bill - AIF, F1, F3;
Expenditures:	★ operation costs (fixed and variable), ★ maintenance costs, ★ investments in system developments, ★ interests and debts discharges, ★ surface and groundwater tariffs - WA, EPA, ★ non-compliance fees (groundwater abstraction permit) - EPA, ★ pollution charge and penalty bills - EPA, ★ information purchase (optional).
State variables:	★ initial value of the system (development level), ★ present value of the system (maintenance level) ★ capital;
Performance criteria:	★ coverage rate (standpipes and private connections), ★ supply effectiveness (shortages), ★ supply efficiency (potable water rate).
Decision variables:	★ surface water treatment, ★ groundwater abstraction, ★ potable water rate, ★ industrial waste water treatment rate (optional), ★ maintenance level and investments in developments .

The Agro-Industry Factory (AIF)

Objective:	★	profit through industrial production.
Activities:	★	industrial production -->
	☆	potable water consumption,
	☆	solid waste generation,
	☆	industrial waste water generation;
O&M:	★	three units of the factory,
	★	storage tank ST11 (optional),
	★	waste water treatment plant WTP11 (optional);
Developments:	★	production capacity - three units,
	★	storage capacity (optional),
	★	waste water treatment capacity (optional).
Mandates:	★	represented in the R-BWC,
	★	production,
	★	technology,
	★	waste water treatment alternative.
Income:	★	initial capital for rehabilitation,
	★	product sales;
Expenditures:	★	operation cost (fixed and variable),
	★	maintenance costs,
	★	investments in system developments
	★	investment in technology (including recycling technology),
	★	energy, raw materials and labor,
	★	solid waste collection tariff,
	★	water tariff - R-WSC,
	★	waste water treatment tariff - R-WSC, or pollution charge and penalty tariffs - EPA,
	★	effluent discharge tariff - R-WSC.
State variables:	★	initial value of the system (development level),
	★	present value of the system (maintenance level)
	★	capital;
Performance criteria:	★	profit,
	★	efficiency - water use and pollution control.
Decision variables:	★	production - type and amount,
	★	labor hired,
	★	maintenance level,
	★	investment in developments,
	★	investment in technology.

The Farmer groups (F1..F3)

Objective:	★	maximize family income trough crop production.
Activities:	★	irrigated agricultural production -->
	☆	surface water consumption,
	☆	agricultural effluent generation;
O&M:	★	tertiary irrigation and drainage canals.
Developments:	☆	
Mandates:	★	cropping pattern,
	★	use of fertilizers and pesticides.
Income:	★	initial capital for rehabilitation,
	★	credit from the government (when needed),
	★	product sales,
	★	excess labor sales (only for F3);
Expenditures:	★	operation cost (fixed),
	★	maintenance costs,
	★	interests (for credits),
	★	labor (optional),
	★	inputs for crop production - seeds and chemicals,
	★	water tariff (subsidy) - WA,
	★	pollution charges (subsidy) and penalty tariffs - EPA,
	★	effluent discharge tariff (subsidy) - R-WSC (F1, F3).
State variables:	★	present value of the system (maintenance level),
	★	capital;
Performance criteria:	★	crop yield and production.
Decision variables:	★	cropping pattern,
	★	inputs - seeds and chemicals,
	★	labor hired or sold (only for F3),
	★	maintenance level.

The Tana Water Supply Company (T-WSC)

Objective:	★	profit through effective and efficient public water supply.
Activities:	★	surface water appropriation,
	★	water treatment and distribution, and sewerage,
	★	waste water treatment (optional),
	★	effluent discharge;
O&M:	★	diversion structure DS2 and surface water supply canal C2,
	★	treatment plant TP2 and (optional) storage tank ST2,
	★	distribution and sewerage networks DN+SN2,
	★	waste water treatment plant WTP2 (optional),
	★	drainage canal DC2;
Developments:	★	treatment and (optional) storage capacities,
	★	stand pipes and private connections,
	★	waste water treatment capacity (optional).
Mandates:	★	represented in the R-BWC,
	★	potable water rate in Tana,
	★	information purchase (optional).
Income:	★	initial capital for system's upgrade,
	★	loans from the government (optional),
	★	potable water sales - urban households;
Expenditures:	★	operation costs (fixed and variable),
	★	maintenance costs,
	★	investments in system developments,
	★	interests and debt discharges,
	★	surface water tariff - WA,
	★	pollution charge and penalty tariffs - EPA,
	★	information purchase (optional).
State variables:	★	initial value of the system (development level),
	★	present value of the system (maintenance level)
	★	capital;
Performance criteria:	★	coverage rate (standpipes and private connections),
	★	supply effectiveness (shortages),
	★	supply efficiency (potable water rate).
Decision variables:	★	surface water treatment,
	★	potable water rate.
	★	maintenance level,
	★	investment in developments.

National Water Council and Central Government

Objective:	★	economic and social development.
Activities:	★	standardization:
	★	regulation,
	★	financial assistance:
	☆	loans for the WSCs,
	☆	subsidies for poor farmers,
	☆	credits for all farmers;
O&M:	☆	(not relevant);
Developments:	☆	(not relevant).
Mandates:	☆	(not relevant).
Income:	☆	(not relevant).
Expenditures:	★	subsidies for:
	☆	irrigation water - F2..3,
	☆	pollution charges - F2..3,
	☆	effluent discharges - F3,
	★	credits - Fs.
State variables:	☆	(not relevant);
Performance criteria:	☆	(not relevant).
Decision variables:	★	fresh water bodies quality standards (rivers),
	★	non-fresh water bodies quality standards (drains),
	★	effluent waters quality standards.
Existing regulations:	★	absolute priority for pws in surface water allocation,
	★	groundwater abstraction right are given only for pws purposes,
	★	pollution penalties for farmers are not subsidized by the Government.
	★	the NWC representant in the R-BWC has veto rights,
	★	the private WSCs are subject to control by state, through the NWC and BWC, and must follow their guiding directions towards:
	★	increasing coverage in pws,
	★	service reliability (shortages),
	★	pricing (affordable prices).

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