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PRESENTATION O THE WEAP MODEL (THE WATER EVALUATION AND PLANNING SYSTEM). CASE STUDY HYDROGRAPHIC BASIN OF THE RIVER BEGA

PREZENTAREA MODELULUI WEAP *(*THE WATER EVALUATION AND PLANNING SYSTEM) PENTRU DETERMINAREA UMIDITĂȚII SOLULUI. STUDIU DE CAZ BAZINUL HIDROGRAFIC BEGA

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Abstract: *WEAP was conceived in 1988 by Paul Raskin, President at Tellus Institute and developed under his supervision. The purpose was to create a flexible instrument, integrated, and transparent to sustainable evaluate the current water demand and supplying models exploring alternative and long-term scenarios. The integrated approach of water management locates the water resource in the context of a dilemma between the demand on one hand and also the problem of water quality and conservation on the other hand. This system is distinguished by the integrated approach for the water system simulation, locating the demand for the water resource, equipment efficiency, re-use, price on the same side with the source, surface and underground flow, water reserves and transfer.*
As data basis WEAP brings a system to maintain the information regarding the water demand and source. As a prognosis instrument WEAP simulates the water demand, source, inflow, generates pollution, treatment and water evacuation. It also evaluates a large range of options regarding water management, taking into consideration the multiple usages of water systems.

Rezumat: *Abordarea integrată a managementului apei plasează sursa de apă în contextul unei probleme a cererii pe de o parte dar şi a problemei calității şi a conservării apei pe de altă parte. Sistemul de evaluare şi control al apei urmăreşte încorporarea acestor valori într-un instrument practic pentru planificarea resurselor de apă. Acest sistem se distinge printr-o abordare integrată pentru simularea sistemelor de apă plasând cererea pentru folosința de apă, eficiența echipamentelor, re-folosirea, prețul şi alocarea pe acelaşi plan cu sursa, debitul de suprafață şi de adâncime, rezervele şi transferul de apă. Ca şi bază de date WEAP furnizează un sistem pentru menținerea informațiilor privind cererea şi sursa de apă. Ca şi instrument de prognoză, WEAP simulează cererea de apă, sursa, debitul şi înmagazinarea, generează poluarea, tratamentul şi evacuarea apei. Deasemenea evaluează o gamă variată de dezvoltare a opțiunilor privind managementului apei considerând multiplele şi complexele folosințe ale sistemelor de apă.*

Keywords: *hydrographical basin, water demand, soil moisture, prognosis, soil quality.*
Cuvinte cheie: *bazin hidrografic, cerere de apă, umiditatea solului, prognoză, calitatea solului.*

INTRODUCTION

WEAP was conceived in 1988 by Paul Raskin, President at Tellus Institute and developed under his supervision. His purpose was to create a flexible tool to evaluate the sustainability of current water demands and the supplying models exploring alternative long-term scenarios. Currently the WEAP software and development belongs to Jack Sieber, Senior Scientist at Stockolm Environment Institute.

A „catchments" or „catchments area" is a schematically surface were we can specify processes like precipitations, evapotranspiration, percolation, irrigation or efficiency on agrarian and non agrarian fields. For a catchments, watershed, we can choose one of the three methods available to calculate the water requirement (from precipitation or irrigation), percolation or infiltration on agrarian land or other usages.

The Soil Moisture Method includes a one dimensional scheme with two compartments to calculate the evapotranpiration, surface and underground flow and deep percolation of the watershed.

This method allows the characterization of the terrain usage and/or the impact of the soil type for various processes. A water unit can be divided in N fractions of surfaces each one representing various usages/soil types. And the water balance is calculated for every fraction from the surface j of N.

This one dimensional, 2-compartment (or "bucket") soil moisture accounting scheme is based on empirical functions that describe evapotranspiration, surface runoff, sub-surface runoff (i.e., interflow), and deep percolation for a watershed unit (Figure 1). This method allows for the characterization of land use and/or soil type impacts to these processes. The deep percolation within the watershed unit can be transmitted to a surface water body as base flow or directly to groundwater storage if the appropriate link is made between the watershed unit node and a groundwater node. A watershed unit can be divided into N fractional areas representing different land uses/soil types, and a water balance is computed for each fractional area, j of N. Climate is assumed uniform over each sub-catchments, and the water balance is given as,

$$Rd_j \frac{dz_{1,j}}{dt} = P_e(t) - PET(t)k_{cj}(t)\left(\frac{5z_{1,j} - 2z_{1,j}^2}{3}\right) - P_e(t)z_{1,j}^{LAI} - (1-f_j)k_j z_{1,j}^2 - f_j k_j z_{1,j}^2 \quad (1)$$

where $z_{1,j}$= [1,0] is the relative storage given as a fraction of the total effective storage of the root zone, Rd_j (mm) for land cover fraction, j. The effective precipitation, P_e, includes snowmelt from accumulated snow pack in the sub-catchments, where m_c is the melt coefficient given as,

$$m_c = \begin{cases} 0 & T_i < T_s \\ 1 \quad \text{if} & T_i > T_l \\ \dfrac{T_i - T_s}{T_l - T_s} & T_s \le T_i \le T_l \end{cases} \quad (2)$$

where T_i is the observed temperature for month *i,* and T_1 and T_s are the melting and freezing temperature thresholds. Snow accumulation, Ac_i, is a function of m_c and the observed monthly total precipitation, P_i, by the following relation,

$$Ac_i = Ac_{i-1} + (1 - m_c)P_i \quad (3)$$

with the melt rate, m_r, defined as,

$$m_r = Ac_i m_c \quad (4)$$

The effective precipitation, P_e, is then computed as

$$P_e = P_i m_c + m_r \quad (5)$$

In Eq. 1, PET is the Penman-Montieth reference crop potential evapotranspiration, where $k_{c,j}$ is the crop/plant coefficient for each fractional land cover. The third term represents surface runoff, where LAI_j is the Leaf Area Index of the land cover. Lower values of LAI_j lead to more surface runoff. The fourth and fifth terms are the interflow and deep percolation terms, respectively, where the parameter $k_{s,j}$ is an estimate of the root zone saturated conductivity (mm/time) and f_j is a partitioning coefficient related to soil, land cover type, and topography that fractionally partitions water both horizontally and vertically. Thus total runoff, RT, from each sub-catchment at time t is,

$$RT(t) = \sum_{j=1}^{N} A_j \left(P_e(t) z_{1,j}^{LAI_j} - (1 - f_j) k_j z_{1,j}^2 \right) \tag{6}$$

For applications where no return flow link is created from a catchment to a groundwater node, base flow emanating from the second bucket will be computed as:

$$S_{max} \frac{dz_2}{dt} = \left(\sum_{j=1}^{N} f_j k_j z_{1,j}^2 \right) - k_2 z_2^2 \tag{7}$$

where the inflow to this storage, S_{max} is the deep percolation from the upper storage given in Eq.1, and K_{s2} is the saturated conductivity of the lower storage (mm/time), which is given as a single value for the catchment and therefore does not include a subscript, *j*. Equations 1 and 6 are solved using a predictor-corrector algorithm.

where A is the watershed unit's contributing area. The stylized aquifer characterizes the height of the water table relative to the stream, where individual river segments can either gain or lose water to the aquifer (see Surface water-Groundwater Interactions).

$$R = \sum_{j=1}^{N} A_j (f_j k_j z_{1,j}^2) \tag{8}$$

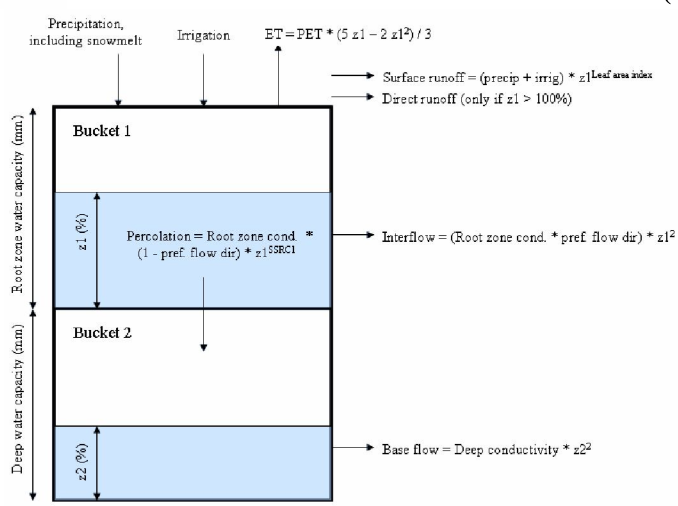

Figure 1. Conceptual diagram and equations incorporated in the Soil Moisture model (WEAP, 2008)

MATHERIAL AND METHODES

CASE STUDY HYDROPHGRAFIC BASIN OF THE RIVER BEGA

Surface: 4492 km^2 =449 200 ha

Effective precipitation 98%

Culture coefficient:	Sept – February	0,9
	March	1,0
	April	1,1
	May	1,4

June – August 1,1

We introduce data regarding the reception basin which include Precipitation and Evapotranspiration.

Results:

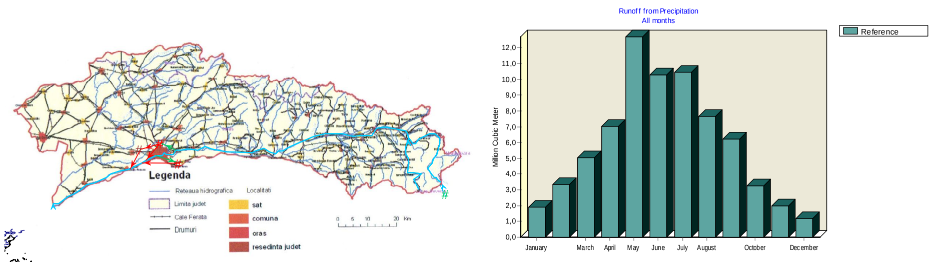

Figure 2. Runoff from precipitation in the Hydrographical Basin of the River Bega

If we will change the status for Agriculture and we will have three types of land usages: irrigations, forests and hayfield. For this we must consider the following data regarding land usage:

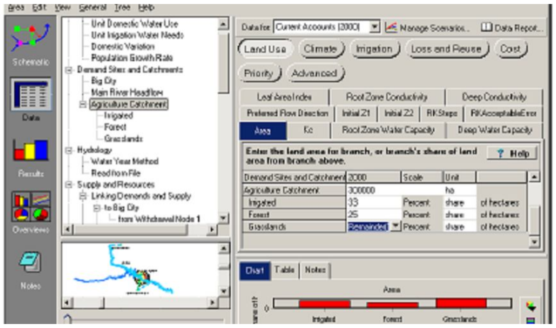

Figure 3. Input data

Surface	total:		200 000 ha
	Irrigated	Forest	Hayfield
Percents	33%	25%	42%
The flowing resisting factors	3,6	3,0	1,7
Root area conductivity (mm/month)	60	35	45
Flow direction	0,15	0,15	0,15
Initial Z1	50%	20%	20%

The following variables have the same values for each usage type:

Initial Z2	20%
Root area water capacity	900 mm
Root area for depth water capacity	35,00 mm
Depth conductivity	240 mm/month

Culture coefficient:	Sept – February	0,9
	March	1,0
	April	1,1
	May	1,4

June – August 1,1

Are introduced the data at the catchment area level, data that include Precipitation and as in the previous model.

Temperature:11ºC

Humidity: 61%

Wind: 1m/s

Latitude: 45º

RESULTS AND DISCUSSIONS

The results for „Land Class Inflows and Outflows” represent in a very detailed manner the water balance for each usage.

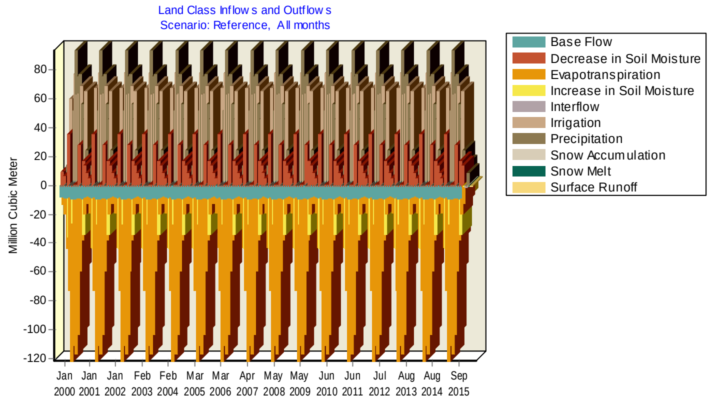

Figure 4. Water balance for each usage

The results for „Land Class Inflows and Outflows – water intakes and discharging” are presented in cubical meter of water.

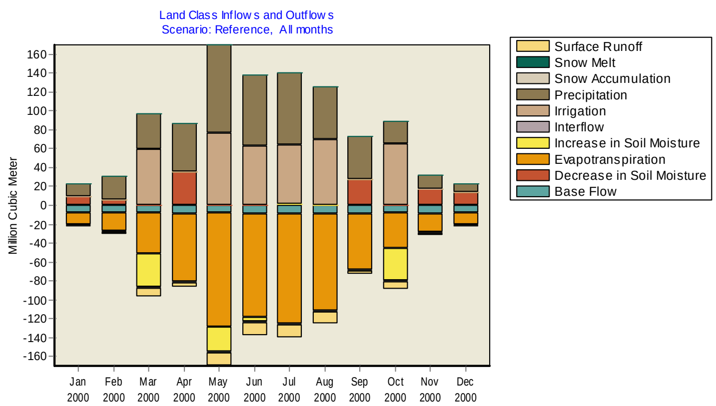

Figure 5. Water intakes and discharging

The same results can be presented in mm which is more useful in examining and validation of the results regarding the catchment area.

For the same entrance data we can obtain results for – Relative Soil Moisture 1%.

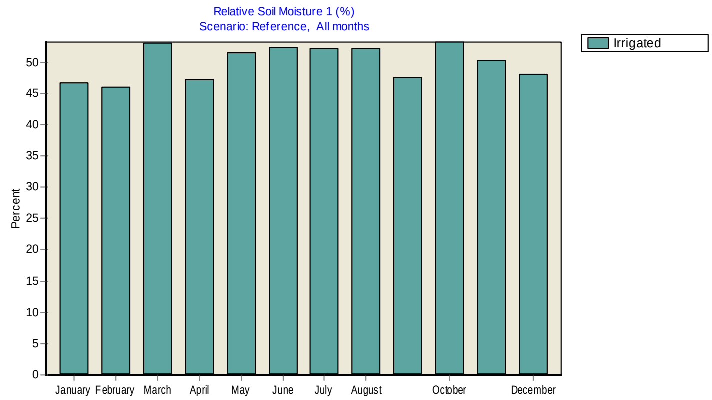

Figure 6. Relative soil moisture

CONCLUSIONS

WEAP is unique in its capability of representing the effects of demand management on water systems. Water requirements may be derived from a detailed set of final uses, or "water services" in different economic sectors. For example, the agricultural sector could be broken down by crop types, irrigation districts and irrigation techniques. An urban sector could be organized by county, city, and water district. Industrial demand can be broken down by industrial sub sector and further into process water and cooling water. This approach places development objectives--providing end-use goods and services--at the foundation of water analysis, and allows an evaluation of effects of improved technologies on these uses, as well as effects of changing prices on quantities of water demanded. In addition, priorities for allocating water for particular demands or from particular sources may be specified by the user.

WEAP scenario analyses can take into account the requirements for aquatic ecosystems. They also can provide a summary of the pollution pressure different water uses impose on the overall system. Pollution is tracked from generation through treatment and outflow into surface and underground bodies of water. Concentrations of water quality constituents are modelled in rivers.

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