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Budgeting of Water in a Watershed

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Methods of Water Budgeting of Watershed

- A water budget is a basic tool that can be used to evaluate the occurrence and movement of water through the natural environment. Water budgets provide a foundation for evaluating its use in relationship to other important influencing conditions such as ecological systems and features and social and economic components.
- It is a process that can encompass various levels of assessment, which start simple and grow more complex if there are concerns about how much water is available at any level.
- The higher the ‘tier’, or level, the more complex the science involved and the narrower the geographic focus.
- Water budget studies consider the volumes of water within the various reservoirs of the hydrologic cycle and the flow paths from recharge to discharge. It need to consider this information on a variety of spatial and temporal scales.



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Some of the main hydrological application fields of remote sensing are:

Topography

Water bodies

Vegetation

Spatial rainfall patterns

Evaporation and soil moisture

Snow cover extent

Groundwater assessment



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Geographical Information System (GIS) is often utilized in hydrological studies by coupling it with hydrological models. Two types of approaches are possible for this purpose.

In the model driven approach, a model or set of models is defined and thus the spatial (GIS) input for the preparation of the input data and output maps are required.

The other approach is the data driven approach. It limits the input spatial data to parameters which can be obtained from generally available maps, such as topographic maps, soil maps etc.

The possibility of rapidly combining data of different types in a GIS has led to significant increase in its use in hydrological applications.



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It also provides the opportunities to combine different data types from different sources.

One of the typical applications is use of a Digital Terrain Model (DTM) for extraction of hydrologic catchment properties such as elevation matrix, flow direction matrix, ranked elevation matrix, and flow accumulation matrix.



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Measurements

In simple terms a water budget for a given area can be looked at as water inputs, outputs and changes in storage. The inputs into the area of investigation (precipitation, groundwater or surface water inflows, anthropogenic inputs such as waste effluent) must be equal to the outputs (evapo-transpiration, water supply removals or abstractions, surface or groundwater outflows) as well as any changes in storage within the area of interest.

In the simplest form this can be expressed as:

Inputs = Outputs + Change in Storage

$$P + SWSW_{in} + GW_{in} + ANTH_{in} = ET + SW_{out} + ANTH_{out} + \Delta S$$



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Where;

P = Precipitation

SW_{in} = Surface Water Flow in

GW_{in} = Ground Water Flow in

$ANTH_{in}$ = Anthropogenic or Human Inputs such as Waste Discharges

ET = Evaporation and Transpiration

SW_{out} = Surface Water Flow out

GW_{out} = Ground Water Flow out

$ANTH_{out}$ = Anthropogenic or Human Removals or Abstractions

ΔS = Change in Storage (Surface Water, Soil Moisture, Ground Water)



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Modeling Approach

A conceptual water budget model is first developed to obtain a basic understanding of the physical flow system. An initial synthesizing of the available data can be used to gain an appreciation of the various fluxes in the watershed. This initial work may indicate, where critical data gaps exist.

The use of numerical modeling can provide a more refined understanding of the flow system including both surface and groundwater. Numerical models are tools used to simplify the representation of these processes and enable quantification and evaluation of the hydrologic system at various levels – watershed, sub-watershed and site scale.

The most appropriate model for water budget analysis will depend primarily on the dominant flow processes (surface water or groundwater).

If changes in the groundwater discharge will significantly affect the flow of a river, then the model used should simulate the complexities of the groundwater system. If flow in the river is most affected by surface runoff and through flow during and following storm events, then the model must be able to simulate the complexities of the surface water processes.



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The three basic types of numerical models that are built and used for water budget analysis are:

Surface Water Models

Ground Water Models

Conjunctive or Integrated Continuum Models



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Effective Application of a Numerical Model for Water Budget Analysis Requires:

- definition of specific objectives of the analysis at the start
- identifying the characteristics of the hydrologic system through development of a conceptual model (review existing reports: size, spatial variations, land use variability, topography, geologic structure, etc.)
- determination of the scale of the problem or the level of detail that needs to be included (e.g. micro-watershed versus large river basin)
- determination of the appropriate time scale
- collection or compilation of sufficient data to evaluate each process
- suitability for linkage to GIS
- effective calibration and validation