APPLICATION OF SHE TO NARMADA FOCUS BASINS

EXPERIENCE WITH DATA COLLECTION
By
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SHE is a deterministic, distributed physically based hydrologic modelling system. It has been developed from partial differential equations describing various processes, viz. overland and channel flow, unsaturated and saturated sub-surface flows, interception and evapotranspiration, etc. The model structure of SHE is able to utilize almost any kind of hydrological information and has large data requirements in its most comprehensive form. Although usual hydrological data bases, particularly in developing countries, might be deficient, seen from a SHE point of view, predictions by use of the SHE Model are likely to be more accurate and reliable in comparison to predictions by simpler models. This is because of the capability of the SHE Model to explicitly utilize any kind of relevant information, e.g. distributed data on topography, soil and vegetation, which a simpler model can not use.

Data Requirement

The application of a distributed hydrological model like SHE requires considerable input of parametric and exogenous data including parameter values that change over time (e.g. crop parameters), to simulate interception, evapotranspiration, overland and channel flow, unsaturated zone and saturated zone components. Some sort of calibration of model parameters is usually needed for selective improvement of initial estimates and also in view of model parameters being average values over a finite grid size in contrast to measured values being point values.

On the basis of discussions held in Bhopal during November-December, 1987, a preliminary selection of six possible catchments for application of SHE Model was made. Further discussions, scrutiny of data availability and field trips in the Narmada catchment carried out by NIH staff and DHI expert led to selection of Kolar, Barna, and Sher basins for use in the simulation studies using SHE Model during training at Danish Hydraulic Institute in 1988, with three more basins (Ganjal, Hiran, and Narmada upto Manot) to be taken up for simulation during 1989 training.

The Kolar river rises in the Vindhya range at an elevation of 450 m and flows 100 km in a southwesterly direction to join the river Narmada, south of Nasrullaganj. Its catchment area upto Satrana gauging site is around 820 km^2. The Barna river also rises in the Vindhya region. It flows south-eastwards to join river Narmada. Its catchment area upto Bareli gauging site is around 1530 km^2. Barna dam near Bari (upstream of Bareli site) was completed in 1976. The Sher river rises in the southern Satpura range at an elevation of 600 m above sea level. Its catchment area upto Belkheri gauging site is around 1395 km^2.

SHE Model requires the specification of several parameters and parametric functions for each component. Broadly, the data required for SHE Model studies and application include the following:

1. Rainfall Data
   (a) Hourly
   (b) Daily
   (c) Location map of raingauge stations

2. River Discharge Data
   (a) Hourly gauge data,
   (b) Daily gauge and discharge data
   (c) Cross section for gauging station
   (d) Rating curve for gauging station
   (e) Information about slope, roughness, velocity, etc.
   (f) Location map of river gauge stations.

3. Evapotranspiration
   (a) Daily panevaporation
   (b) Weekly or monthly pan evaporation
   (c) Weekly or monthly potential evaporation
   (d) Location map of station/observatory

4. Seasonal well observations

    (a) Monthly observations

    (b) Premonsoon and postmonsoon observations

    (c) Location map

    (d) Relevant details of observation well

5. Groundwater abstraction data

    (a) Atleast for monthly periods on block/district basis

6. Soil moisture data - atleast on monthly basis

7. Topographic, landuse and soil maps in 1:50000 and 1:250000 scales

8. Reservoir data

    (a) Hourly/daily levels

    (b) Hourly/daily inflows

    (c) Capacity curve

    (d) Rule curve, etc.

9. Reprts and scientific papers containing relevant information regarding soil properties in the catchment, viz. soil type, soil depth, saturated soil conductivity for saturated and unsaturated zones, vegetation, root zone depth, soil moisture tension versus soil moisture content relationship for each soil, etc.

10. Cropping pattern and vegetation parameters such as leaf area index and its variation with time

11. River longitudinal section and cross sections at different locations, flow resistance coefficient for overland and channel flows, etc.

Data Collected

A data assembly programme was carried out to provide the hydro-meteorological and basin data needed for SHE simulations for three basins. In view of the large number of data collection agencies, both Central and from the State of Madhya Pradesh were approached. With the support and active interest of Shri K N Venkatraman, Secretary, Major Projects, M.P. Irrigation Department, a liaison mechanism was evolved with Shri M S Sohoni, Chief Engineer (Investigation) as Coordinator, not only for data collection but also for discussions and field visit of consultant staff. Various agencies contacted and who have taken a lot of pains to provide relevant data and information to NIH include:

1. M.P. Irrigation Department

    (a) Director, Hydrometeorology

    (b) Upper Narmada Circle

    (c) Superintending Geologist

(d)   Various concerned Circles, Divisions & Sub-divisions

(e)   Bargi Project Circle

(f)   Kolar Project Circle

(g)   Barna Dam Project Circle

2.   Narmada Valley Development Authority

(a) Superintending Engineer, Circle-2

(b) Joint Director (Agriculture)

3.   Central Water Commission

4.   J.N.K.V.V. Agricultural University, Jabalpur

5.   India Meteorological Department, Delhi and its offices
in Pune, Nagpur, and Bhopal

6.   Central Ground Water Board
- North Central Region

7.   Survey of India, Dehradun

8.   Narmada Control Authority, Delhi and Bhopal

9.   All India Soil And Land Use Survey Organisation, New Delhi
and Nagpur

10.   Director, Department of Agriculture, Bhopal and zonal agricultural
research stations at Powerkheda, Khandwa, Adhartal.

11.   M.P. State Ground Water Survey Board, Bhopal

12.   State Forest Research Institute, Jabalpur

13.   College of Agriculture, Indore

14.   Institute of Deciduous Forest, Jabalpur

Besides these organisations, a number of other organisations and individuals have provided useful information, and helped NIH teams and visits of experts. Data was collected for Kolar, Barna, and Sher basins in two stages, viz. upto April 1988 for use in four months training at Danish Hydraulic Institute during 1988, and subsequently after October 1988 to revise simulation studies with improved data base. Brief details of data used in simulation studies being presented at this workshop are as follows:

KOLAR BASIN (1983-88)

1. Rainfall — 5 ORG,(Incomplete record 1978-85)
   4 SRRG (1981/82 to 88)

2. Discharge

   Hourly gauge — Satrana (1983-88 monsoon)
   Lawakheri (1981-86 monsoon)

   Daily gauge and — Satrana (1983-88)
   discharge — Lawakheri (rating curve)

3. Evapotranspirtion — Weekly panevaporation data for Powerkheda
   (1983-88)

4. Groundwater table — At 10 locations in and around the basin, 1983-87
   observations

5. Topographic maps — 55E/4,8
   55F/1, 5, 6

BARNA BASIN (1984-87)

1. Rainfall — 4 ORG §(Incomplete record 1978-83)
   1 SRRG §(Complete record 1984-87)

2. Discharge

   Hourly gauge — Bareli (1984-86 monsoon)
   Sultanpur (1982-86 monsoon)

   Daily gauge and — Bareli (June 85 to May 88)
   discharge — Sultanpur

3. Evapotranspiration — Weekly pan evaporation for Powerkheda
   (1983-87) and daily (for 1987-88)

4. Groundwater table — Nine to ten wells located at periphery of
   observations — of the basin (1983-87)

5. Reservoir data — Barna reservoir (1978-87)

6. Topographic maps — 55E/15,16
   (1:50000 Scale) — 55F/12,13
   55I/3,4,8
   55J/1,5

SHER BASIN (1978-86)

1. Rainfall — 3 ORG (Incomplete record 1980-88)
   1 SRRG (outside)

2. Discharge:

   Hourly stage — Belkheri (monsoon) (1986-88)

   Daily gauge & — Belkheri (1986-87)
   discharge

3.	Evapotranspiration	-	Daily pan evaporation data for Jabalpur
4.	Topographic maps	- -	55N (Scale 1:250000)
			55N/1, 2, 5, 6, 7, 10 (Scale 1:50000)
5.	Ground water table observations	-	Data for some wells

Other Information:

1. Land use maps and soil maps in 1:250000 scale obtained from Narmada Development Authority

2. River cross sections and rating curves available only for basin outlets, viz. Kolar-Satrana, Barna-Bareli, and Sher-Belkheri. Information for river cross sections at different locations upstream not available.

3. Soil moisture and soil depth data - None available

4. Soil and vegetation properties - Mostly in the form of studies on similar soils. Location specific information for concerned basins is not available.

The data collection activity for the three basins was carried out in two stages. For training of three scientists at Danish Hydraulic Institute during May-August 1988, data and information as could be available upto April 1988 was used. There was deficiency of availability of hourly rainfall data, evapotranspiration data and particularly of direct information on soil and vegetation properties. Subsequently, attempts were made to collect further information to improve the data base. Additional information was obtained for rainfall both hourly and daily. Information about reservoir inflows was obtained for Barna reservoir, and groundwater levels in observation wells. A large number of reports dealing with soil characteristics and parameters in Narmada basin were also reviewed. This was utilized to introduce two soil types in the vertical at each column, the upper layer being less permeable than the lower. Simulation studies being presented at the workshop are revised studies carried out at National Institute of Hydrology during Jan.-Oct. 1989 using improved data base and introduction of soil crack component in the model for black clayey soils present in the basins.