Application of SWAT model for Water Resources Management in Kopili River Basin in NE India

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NE Region of India

- The North eastern region of India is a unique region in terms of its terrain, climate and biodiversity.
- North-eastern region of India receives abundant rainfall with annual average rainfall varying from 2000 to 4000 mm.
- The region is characterized by a large number of river networks passing through hills and valley.
- However, the development of water resource is much below its potential in terms of providing irrigation facilities and hydro energy in this region

- Water resource management

- It includes
- (i) assessment of water resources with maximum possible precision,
- (ii) realistic planning for water resource development and
- (iii) implementation of water resource developmental plan.

However, precise assessment of water availability on spatial and temporal level is a key step in effective integrated water resources management.

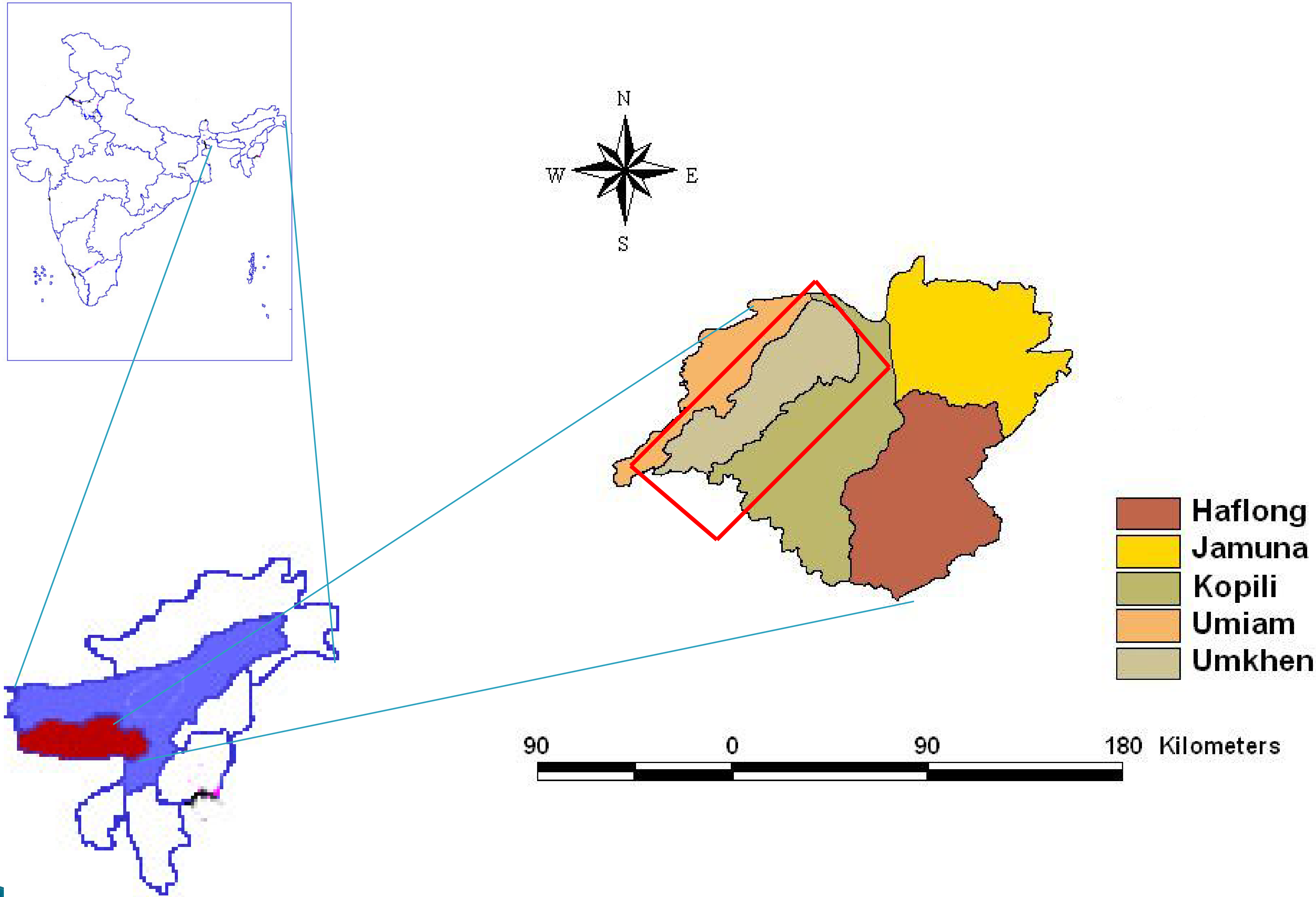
- In the present study SWAT (Soil and Water Assessment tool) model has been used to simulate the various processes going on within a watershed in NE India.
- It is presumed that identification of dominating processes can help in prioritizing sub watershed and suggesting suitable measures for mitigating the impacts of floods and arresting soil erosion in the upper watershed.

Description of Study Area

- Kopili river system is one of the major tributaries of the mighty Brahmaputra in the north-eastern region of India.
- originates from Barail ranges near Jowai in Jaintia hills District of Meghalaya (India) at an altitude of 1800 m above mean sea level.
- The catchment area of Kopili River is 14,670 km^2, which is about 2.44% of the total catchment of Brahmaputra River.

- Umkhen River originates near the South Western slope of the Shillong Peak, at an altitude of 1829 m near Shillong in the state of Meghalaya in India.

- The catchment lies between 25°30΄N and 26°00΄N latitudes and 91°50΄E and 92°35΄E longitudes.
- The total area of the Umkhen watershed till its confluence in Kopili River is 2228 km^2.
- However, for the development of model, the outlet was taken at a downhill distance of 102 km from the origin due to availability of discharge data at the location.
- The catchment area till the selected outlet is 1204 km^2 (Fig 1).


N
W
E
S
Haflong
Jamuna
Kopili
Umiam
Umkhen
90
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90
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Kilometers

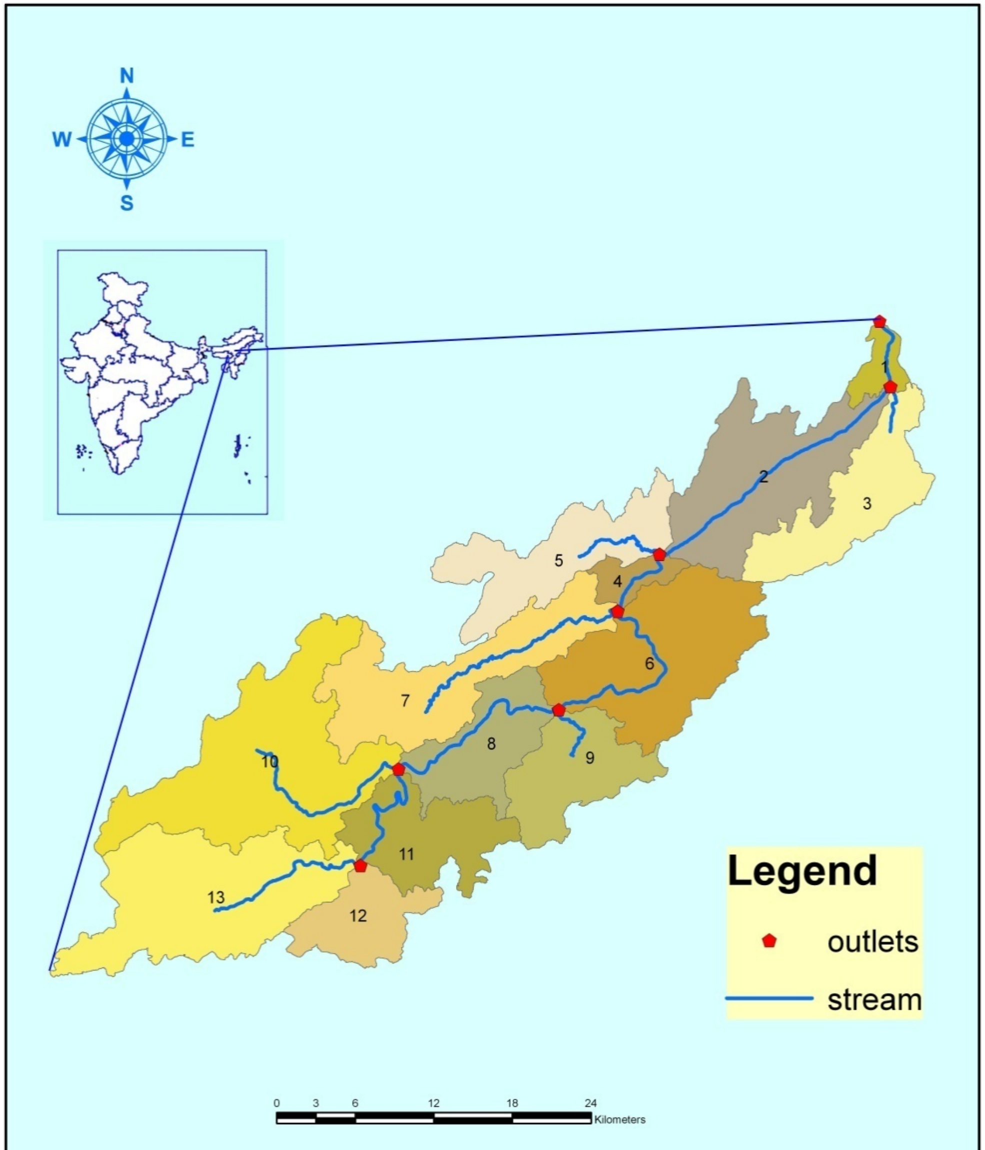


Fig 1: Umkhen watershed showing stream network and sub watsheds

Methodology

- Watershed Configuration :
  - the threshold value was taken as 50 km^2
  - the interface created 13 numbers of sub basins and 32 numbers of hydrological response units (HRU),
- Data requirement

Data requirements

- (i) digital elevation model (DEM): Survey of India toposheet at 1:50000 scale.
- (ii) stream network: Survey of India toposheets
- (iii) soil map: NBSSLUP
- (iv) land use map: Land use map for the Assam portion was obtained from Assam Remote Sensing Application Centre (ARSAC). The land use maps were prepared by interpretation of Landsat TM images taken in the month of March and November 1987.

Climate and discharge data

Sl No	Data stations	Description
1	Shillong	Locations: 25º30´30.09″ N, 91º49´30.02″ E; Elevation above msl : 1598 m
2	Baithalangso	Locations: 25º59´32.83″ N, 92º33´02.57″ E Near outlet of watershed; Elevation above msl : 81 m

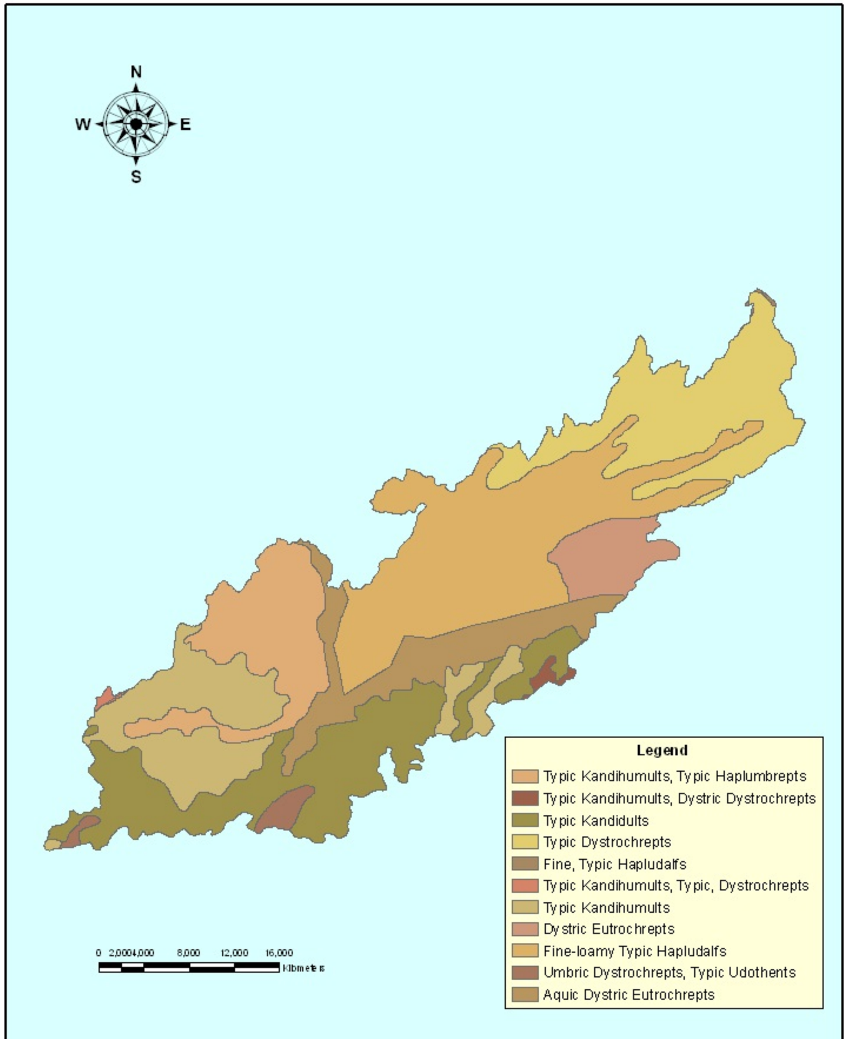


Fig 2: Soil Map of Umkhen watershed

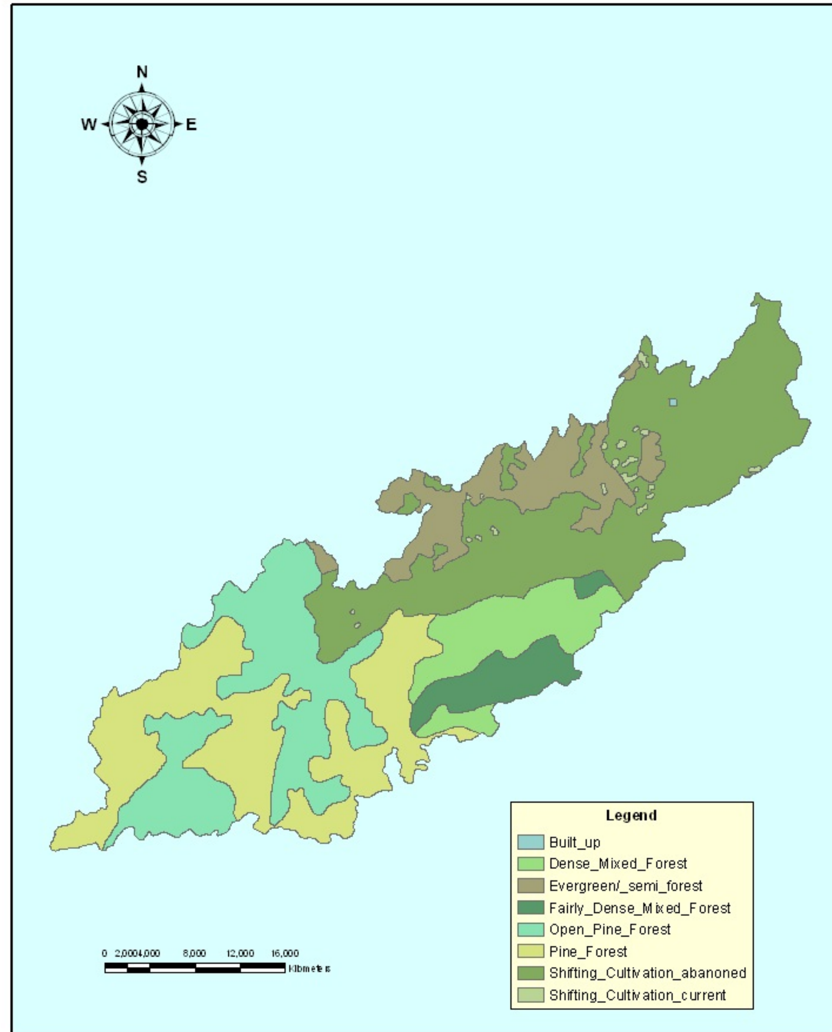


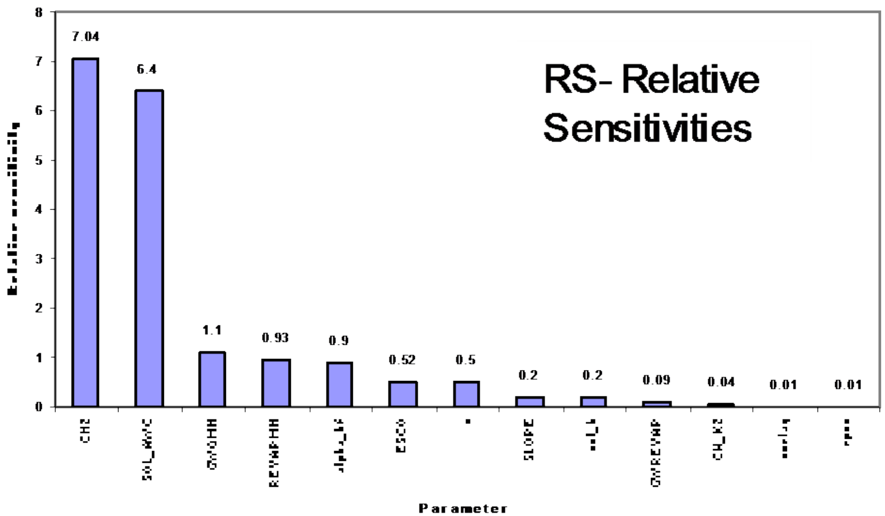
Fig 3: Landuse map of Umkhen watershed

Model outputs

- (i) sensitivity analysis,
- (ii) calibration (1988–1990) and
- (iii) validation (1991–1993)

- Comparison between observed and simulated values were done by the following statistical criteria
- (i) Coefficient of determination (R^2),
- (ii) Nash and Sutcliffe efficiency (*NSE*) and
- (iii) index of agreement (*d*)

- Sensitivity analysis

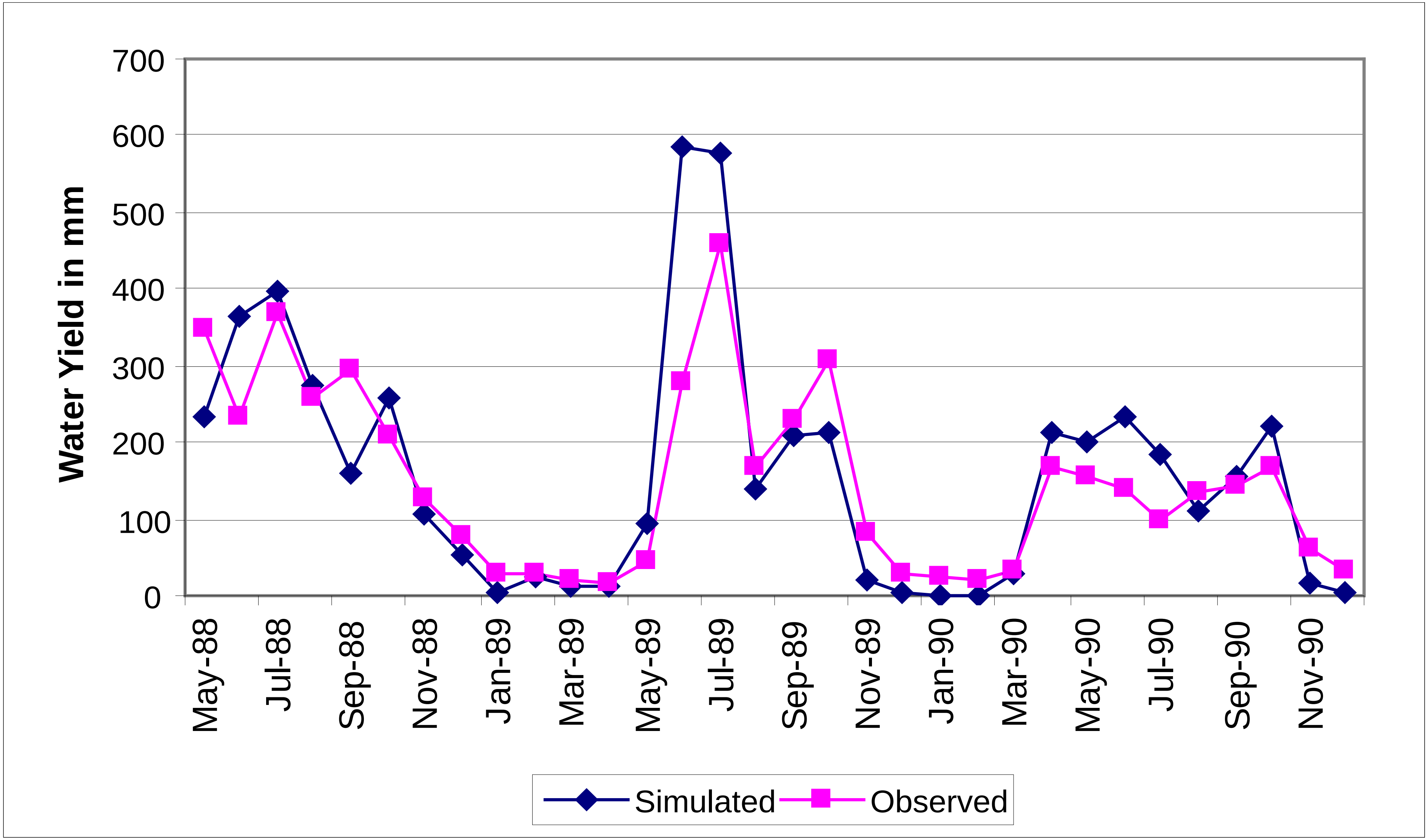


Parameters	Description
CN2	Initial CN II values
SOL_AWC	soil available water flow
GWQMN	threshold water flow in shallow aquifer for flow
REVAPMN	Threshold water depth in the shallow aquifer for flow (mm)
alpha_bf	Base flow recession alpha factor (days)
ESCO	soil evaporation compensation factor
N	Mannings N for tributary channel
SLOPE	average slope seetpness
sol_k	saturated hydraulic conductivity
GWREVAP	Groundwater "revap" coeffcient
CH_K2	channel effective hydraulic conductivity
surlag	surface runoff lag time
epco	plant uptake compensation factor

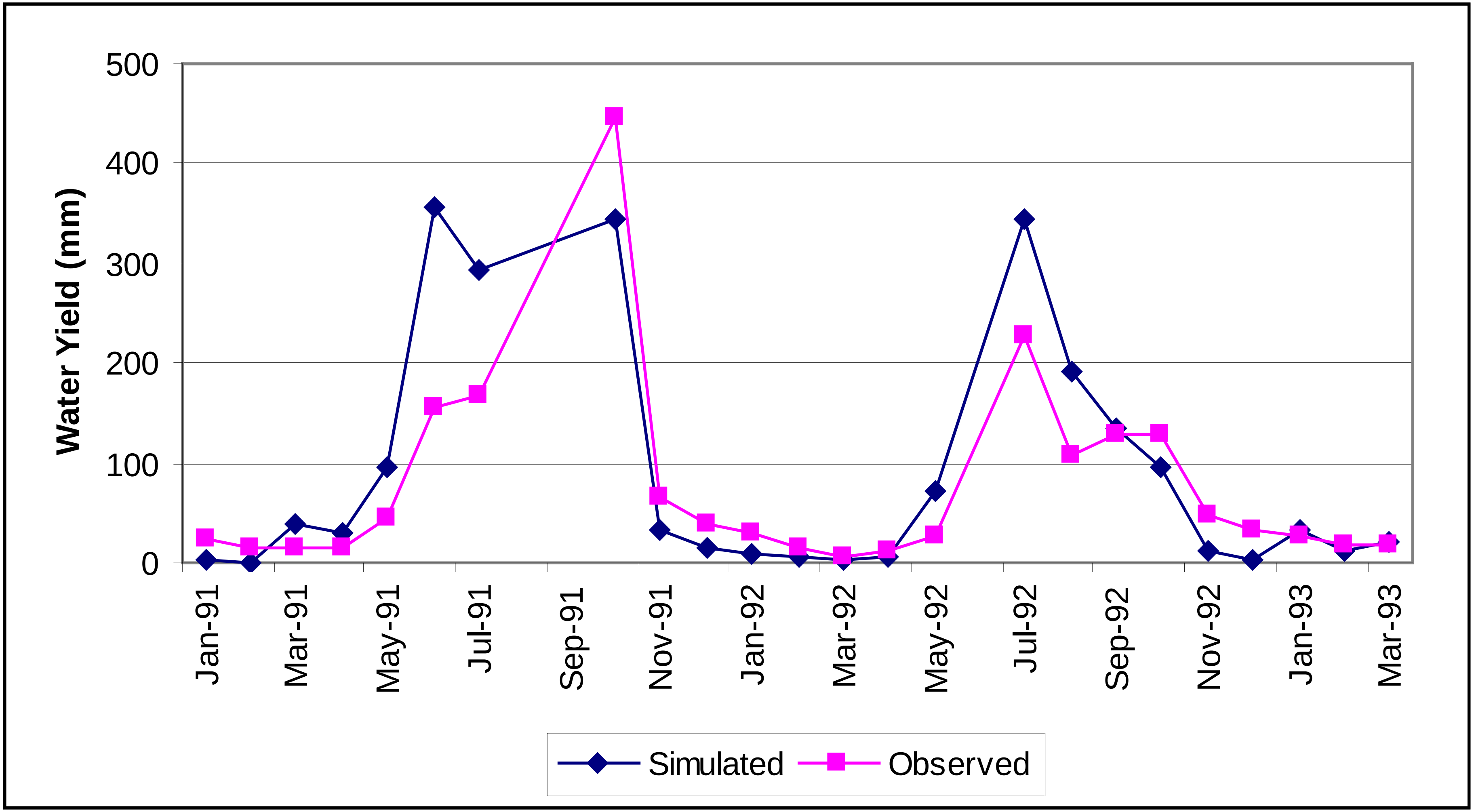
- 7 parameters with higher values were considered for calibration

Table : Parameters used for calibration of SWAT model for Umkhen watershed

Sl	Parameters	Results of calibration	Recommended range
1	Surface runoff curve number (CN2) for land use:		
(a)	Forest Evergreen	52	35-98
(b)	Forest mixed	50	
(c)	Pine	62	
2	Base flow recession alpha factor (days)	0.48	0-1
3	Threshold depth of water in the shallow aquifer	1.0	0-500
4	Soil evaporation compensation factor	0.1	0-1
5	Available water capacity of the soil layer (mm/mm soil)	0.2	0-1
6	Threshold water depth in the shallow aquifer for flow (mm)	20	0-5000
7	Manning 'n' for the tributary	0.1	0.01-0.12



Water Yield in mm
700
600
500
400
300
200
100
0
May-88
Jul-88
Sep-88
Nov-88
Jan-89
Mar-89
May-89
Jul-89
Sep-89
Nov-89
Jan-90
Mar-90
May-90
Jul-90
Sep-90
Nov-90
Simulated
Observed



Water Yield (mm)
500
400
300
200
100
0
Jan-91
Mar-91
May-91
Jul-91
Sep-91
Nov-91
Jan-92
Mar-92
May-92
Jul-92
Sep-92
Nov-92
Jan-93
Mar-93
Simulated
Observed

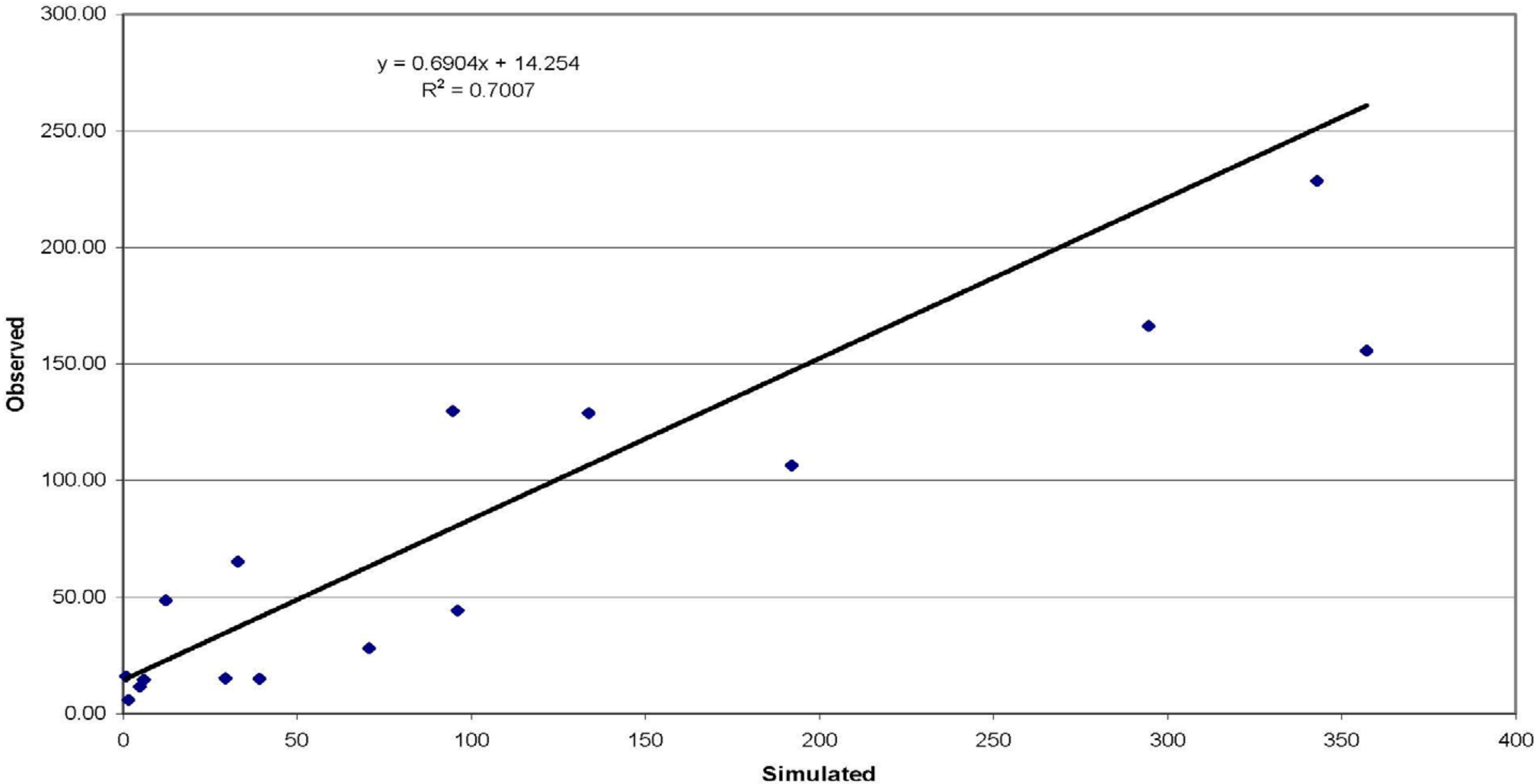


Fig 7: Scatter gram of observed and predicted values of water yield (mm) during validation

Table : Values of validation parameters during different period

Sl No	Validation parameters	Entire period	Rainy period	Non rainy period
1	Coefficient of determination (*R2*)	0.70	0.68	0.93
2	Nash-Sutcliffe Efficiency (*E*)	0.64	0.0	0.86
3	Index of Agreement (*d*)	0.91	0.83	0.96

Predicted water balance components in Umkhen watershed

Water balance component

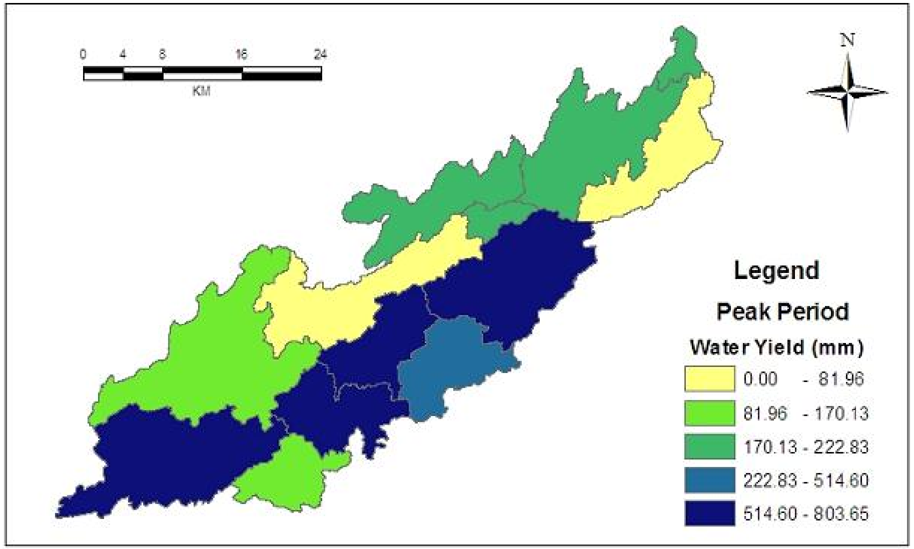
Sl No	Component	Total (mm)
1	Precipitation	2904.00
2	Surface runoff (mm)	715.98
3	Lateral flow contribution to stream flow (mm)	871.45
4	Revap (Shallow Aquifer water returning to root zone)	142.17
5	Deep aquifer recharge	29.55
6	Total aquifer recharge	597.56
7	Total water yield	1581.28
8	Percolation out of soil	619.80
9	Actual evapotranpiration	707.30
10	Potential evapotranpiration	1122.50
11	Transmission losses	6.15

Spatial and temporal variation of water yield

Sub watershed	Watershed size (km2)	Rainfall (mm)	Average water Yield (mm)	Rainfall to run off conversion (%)	ET (%)
SW 1	17.13	1275.14	700.09	54.90	54.84
SW 2	126.98	1275.14	700.62	54.94	54.37
SW 3	82.47	1275.14	406.34	31.87	57.74
SW 4	88.81	1275.14	698.75	54.80	56.35
SW 5	19.09	1275.14	707.49	55.48	53.76
SW 6	119.12	5277.84	3309.82	62.71	10.45
SW 7	138.40	1275.14	379.26	29.74	60.90
SW 8	68.96	5277.84	2795.68	52.97	10.36
SW 9	71.20	5277.84	3047.95	57.75	10.47
SW 10	187.01	1681.94	625.68	37.20	40.15
SW 11	75.66	5277.84	2633.30	49.89	10.71
SW 12	157.05	1681.94	708.57	42.13	39.81

Sub watershed wise water yield during dry and wet period

Sub watershed	Rainfall (mm)	Water Yield for the month of February (mm)	Water Yield for the month of June (mm)
SW1	1275.14	2.67	221.00
SW2	1275.14	2.69	221.38
SW3	1275.14	0.33	81.96
SW4	1275.14	2.74	222.20
SW5	1275.14	2.78	222.83
SW6	5277.84	14.38	790.01
SW7	1275.14	0.33	81.63
SW8	5277.84	10.64	672.17
SW9	5277.84	8.45	514.60
SW10	1681.94	3.30	149.35
SW11	5277.84	7.77	655.32
SW12	1681.94	3.51	170.13
SW13	5277.84	14.15	803.65



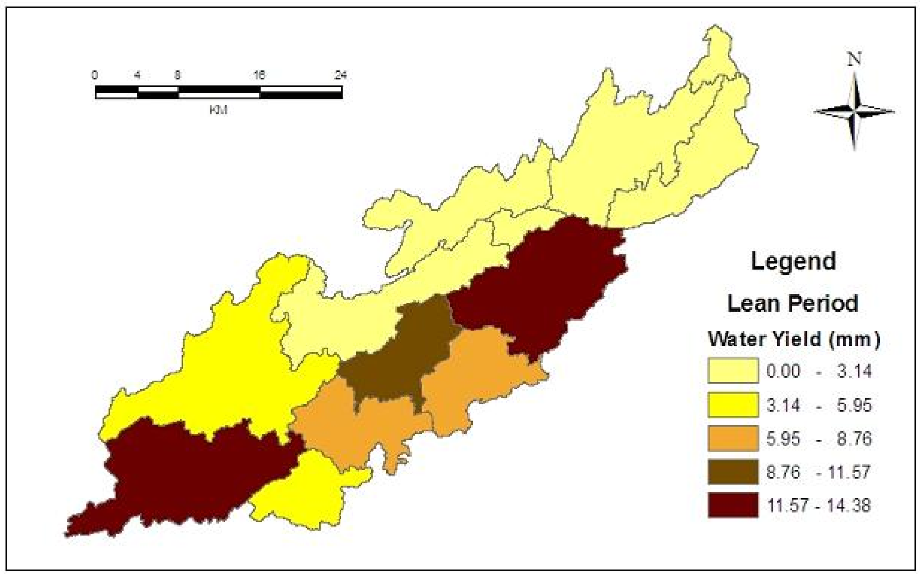


Fig 4: Lean and peak season behaviour of sub watersheds of Umkhen

Conclusion

- (i) SWAT2000 has been demonstrated to simulate water yield in a hilly watershed with the involvement of locally acquired data including observed water yield data.
- (ii) The most sensitive parameters of SWAT2000 watershed modeling of Umkhen are curve number and soil available water.
- (iii) The simulation ability of the Umkhen watershed model has been tested through standard procedure comparing with observed data. The model is capable to simulate water yield with reasonable degree of agreement. Prediction ability of the model is better during non-rainy period then rainy period.
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- (iv) The limitations of the Umkhen watershed modeling are mainly related to data deficiency. Non availability of meteorological data (temperature, rainfall) from a number of closely spaced data stations within the study watershed has been one of the major deficiencies. These aspects might have attributed to simulation error of modeling. Apart from the limitations of the input data, the errors might have been induced during model parameterization. The mis-paramaterization might include non availability of equivalent definition of each parameter for Indian condition particularly the definition of land use and components of curve number methods.
- (v) The variability of input data (soil, land use and weather) has also been found appropriately reflected in model outputs at the outlets of 13 delineated subwatersheds.

THANK YOU