RAINFALL RUNOFF VARIABILITY OVER SEMI-URBAN CATCHMENT MAHARASHTRA (INDIA)

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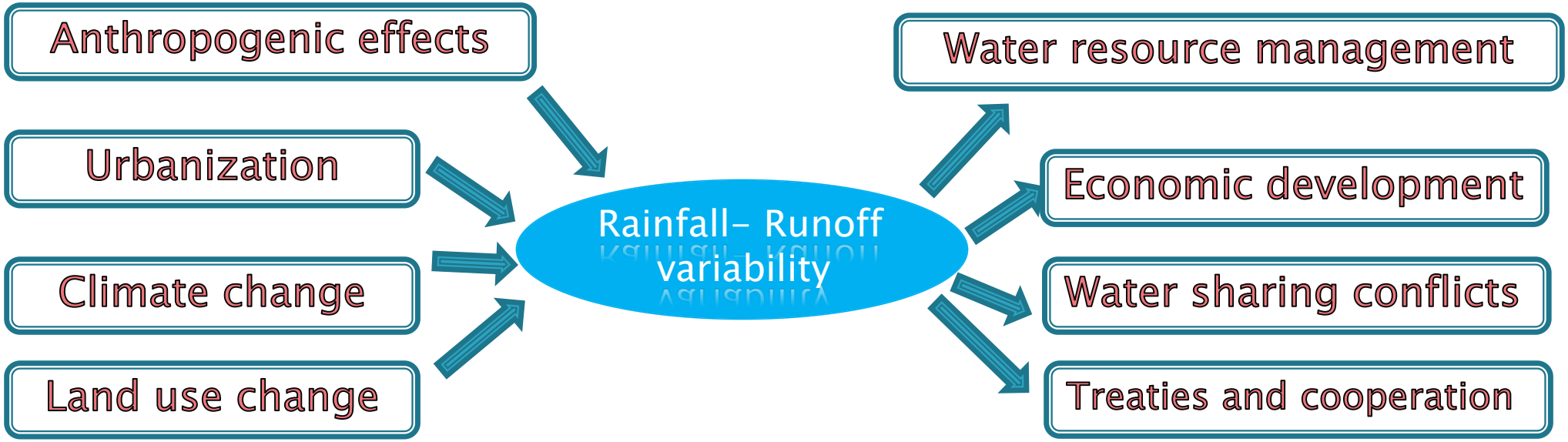
Soil & Water Assessment Tool | SWAT

2012 International SWAT Conference & Workshop
July 16-20, 2012, New Delhi, India

Presentation outline

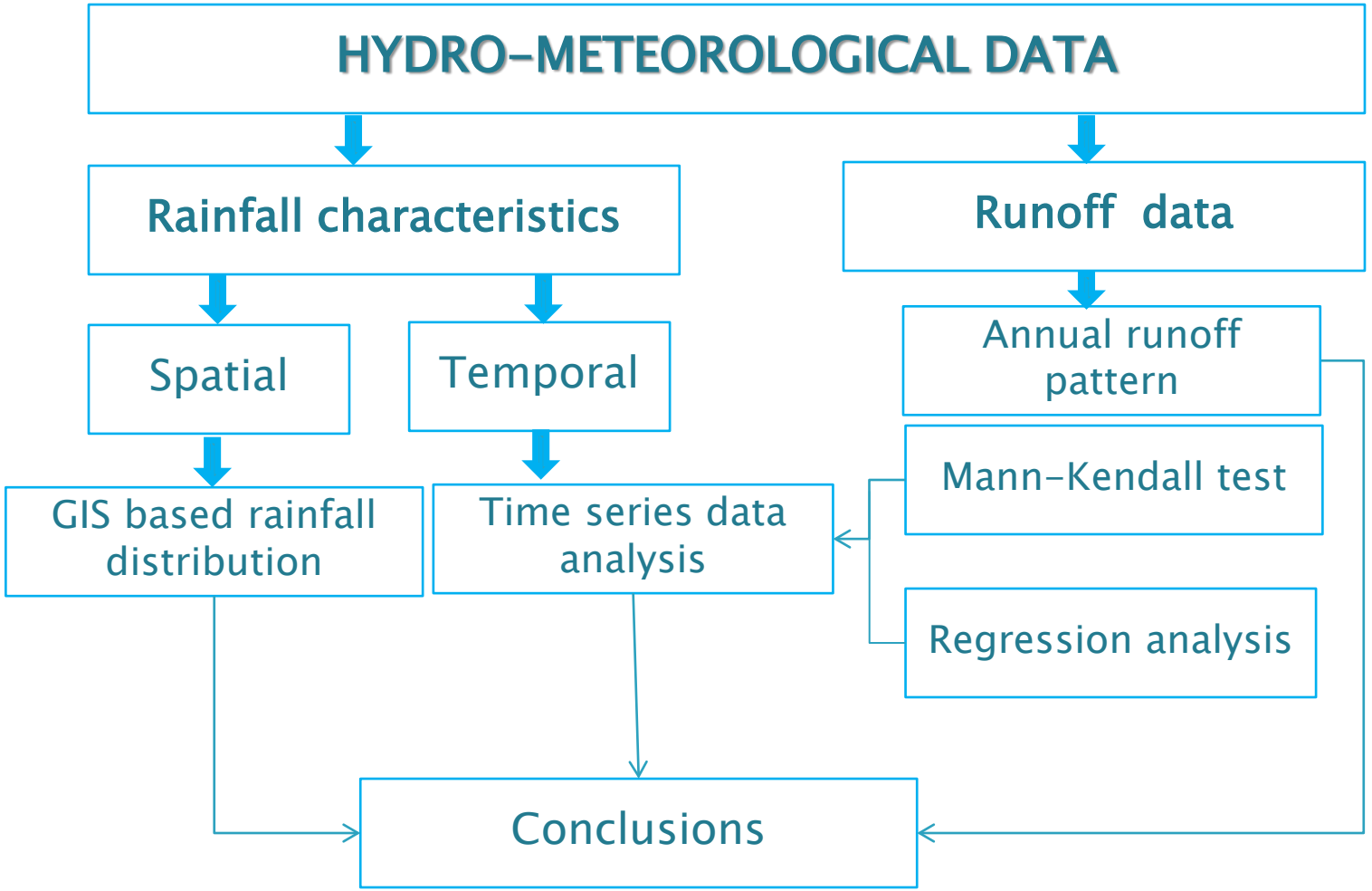
- Brief introduction
- Objectives of the study
- Methodology
- Study area description
- Data base development and work plan
- Rainfall-runoff data analysis
- Important findings
- References


Anthropogenic effects
Urbanization
Climate change
Land use change
Rainfall- Runoff variability
Water resource management
Economic development
Water sharing conflicts
Treaties and cooperation

Objectives

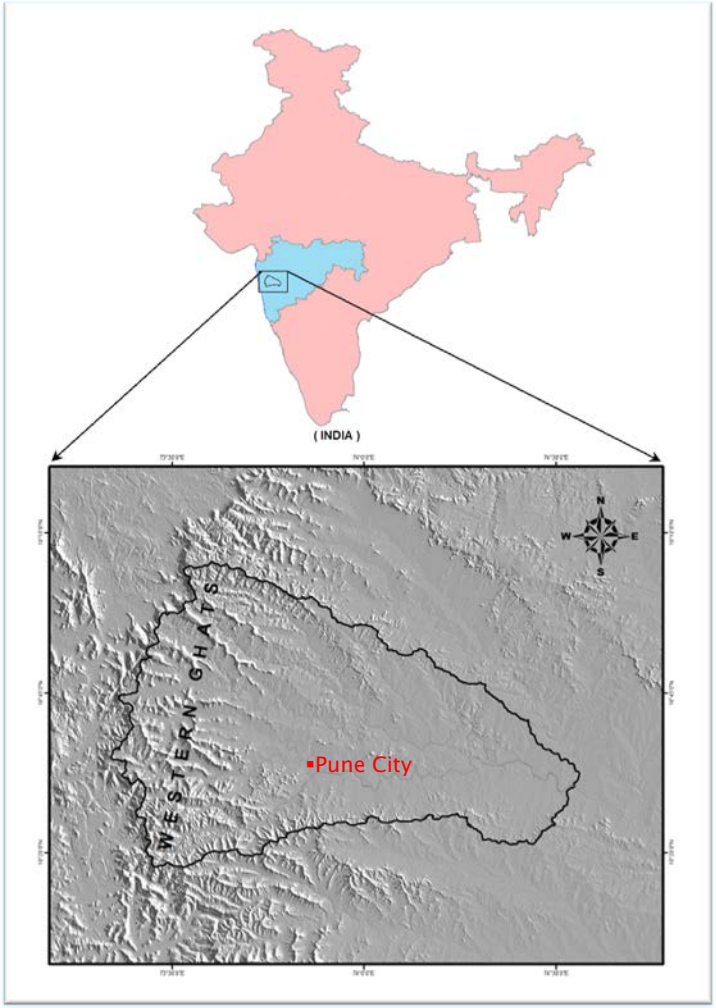
1. Rainfall Characteristics:
   - GIS based spatial rainfall pattern over the catchment.
   - Temporal rainfall pattern during study period (1985-2004) by regression analysis and Mann-Kendall(MK) test.
2. Resulting runoff pattern during study period near catchment outlet.

METHODOLOGY



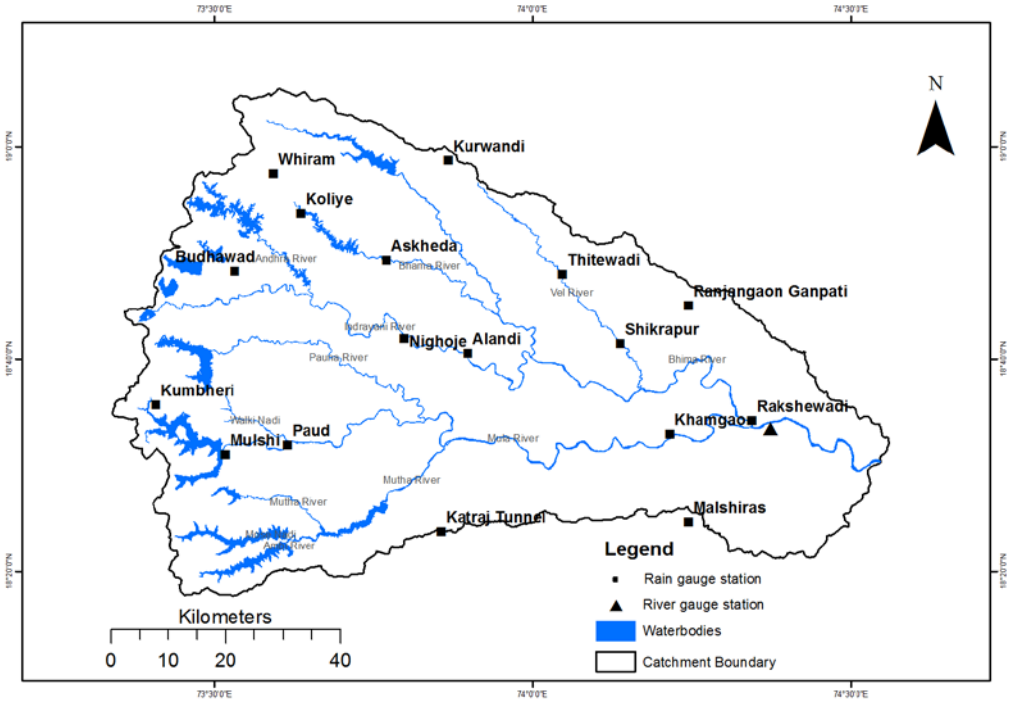
Study Area

- Catchment: Upper Bhima catchment
- Location: Pune District, Maharashtra, India
- Geographical extension: 73° 20′ 11″E- 74° 33′ 42″E
  18° 17′ 38″N- 19° 05′ 26″N
- SOI Toposheet No: 47 E12, 47E16, 47F5, 47F6, 47F7, 47F9, 47F10, 47F11,47F13, 47F14, 47F15, 47J1, 47J2,47J3, 47J5, 47J6, 47J7, 47J10 and 47J11 at 1:50,000 scale.
- Area: 6736 sq. k.m
- Elevation: 499-1298 m.
- Major River: The Bhima river
- Tributaries: Mula-Mutha, Bhama, Vel and Indrayani river.
- Source: Non-perennial
- Major places: Pune city, Lonavala (Hill station)



Data base development & Work plan

Rain gauge and River gauge in study cathchment



No. of rain gauge station: 16

No. of river gauge station: 1

Sl No.	RG stations	Ht of Station(m)	Data availability	Tributary
1	Alandi	575	1985 - 2008	Indrayani
2	Askheda	617	1975 – 2008	Bhama
3	Budhawad	616	1981 – 2008	Kundalike
4	Katraj Tunnel	**955**	1975 – 2008	Mula-Mutha
5	Khamgaon	529	1985 – 2008	Mula-Mutha
6	Koliye	658	1975 – 2008	Bhama
7	Kumbheri	734	1985 – 2008	Mula
8	Kurwandi	857	1975 – 2008	Vel
9	Malshiras	739	1985 – 2008	Bhima
10	Mulshi	651	1985 – 2008	Mula
11	Paud	568	1976 – 2008	Mula
12	Rakshewadi	**526**	1983 – 2008	Bhima
13	Ranjangaon Ganpati	621	1975 – 2008	Bhima
14	Shikrapur	574	1975 – 2008	Vel
15	Thitewadi	646	1985 – 2008	Vel
16	Whiram	698	1975 – 2008	Bhama

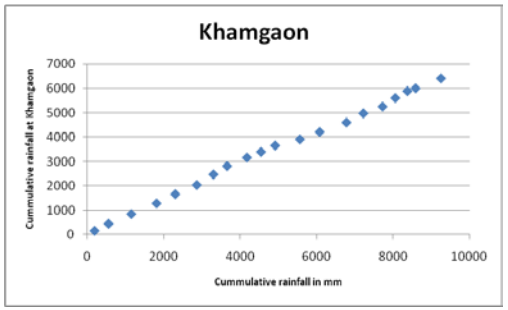
*RG: Rain gauge

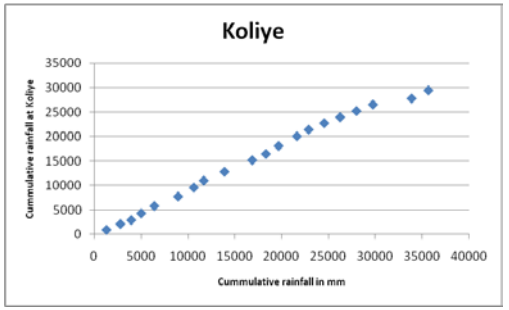
Consistency test for rainfall records

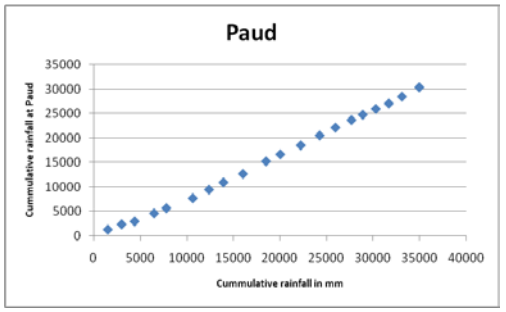
Double mass curve method

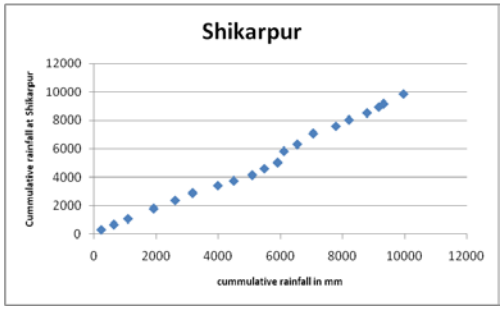
- The consistency of records at the station is tested by double mass curve, plotting the cumulative annual rainfall for a station with the average cumulative rainfall of surrounding stations.

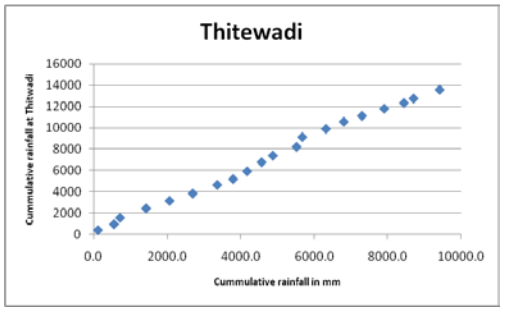
- In case of inconsistency, there is change in slope of the line.

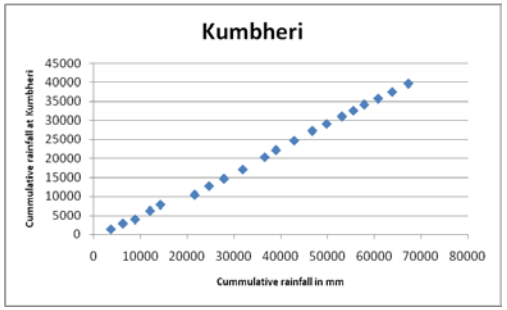






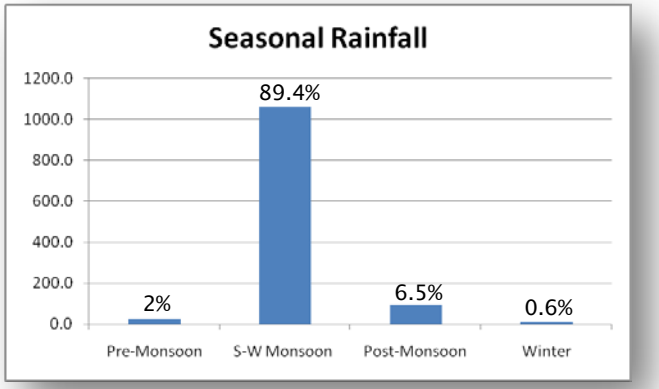






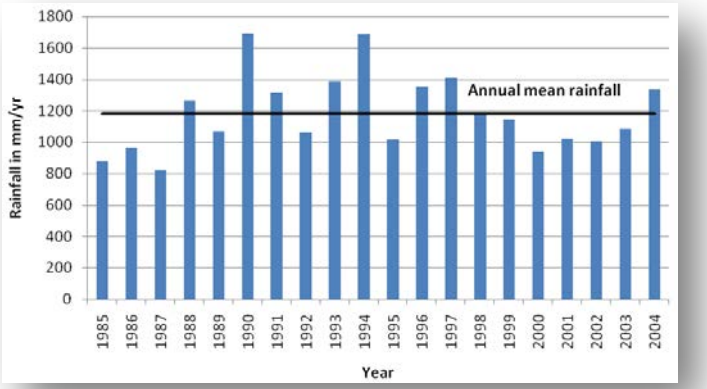
Rainfall characteristics

Seasonal Pattern



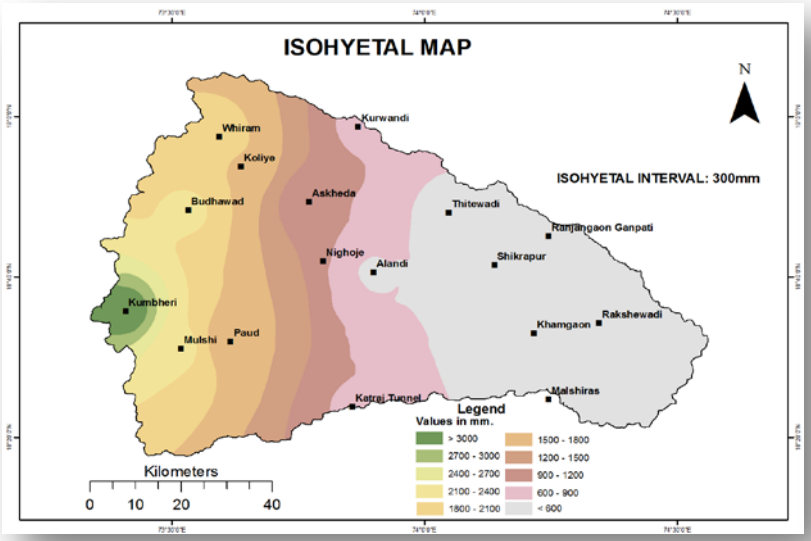
Pre-monsoon (Mar-May)
South-West monsoon (Jun-Sept)
Post-monsoon (Oct-Nov)
Winter (Nov-Feb)

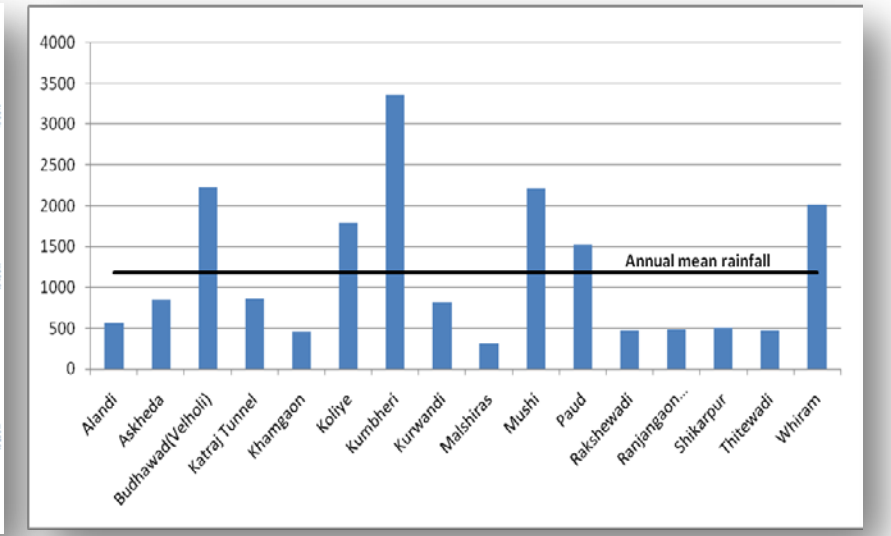
Annual Pattern



Maximum: 1692mm. (1990)
Minimum:820mm. (1987)
Mean:1180 mm.

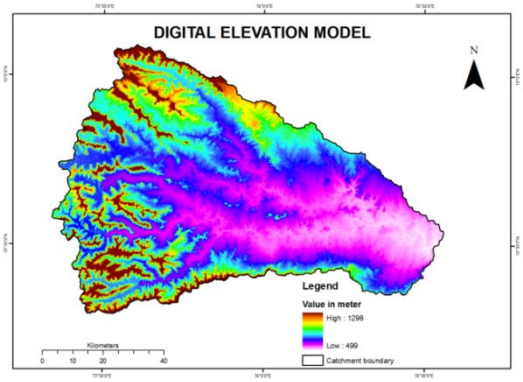
Spatial pattern

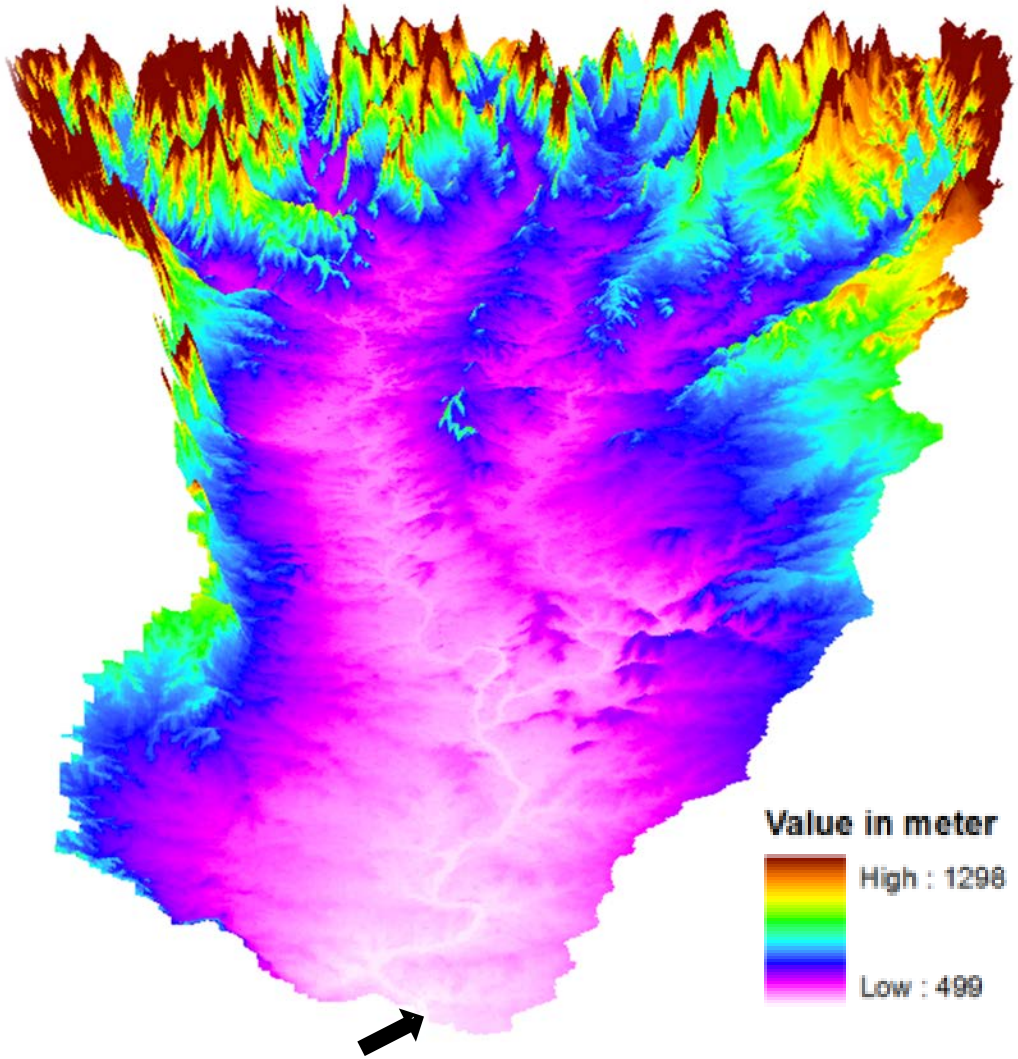




The rainfall throughout the catchment is shown by isohyets. (interpolating the annual avg rainfall over all the station during 1985-2004)

Digital Elevation Model (DEM)





3D View from outlet

Rainfall Trend

Rainfall Trend

- Regression analysis: Annual rainfall is plotted against year and a linear trend line fitted though OLS method. None of these slope value is found to be statistically significant.

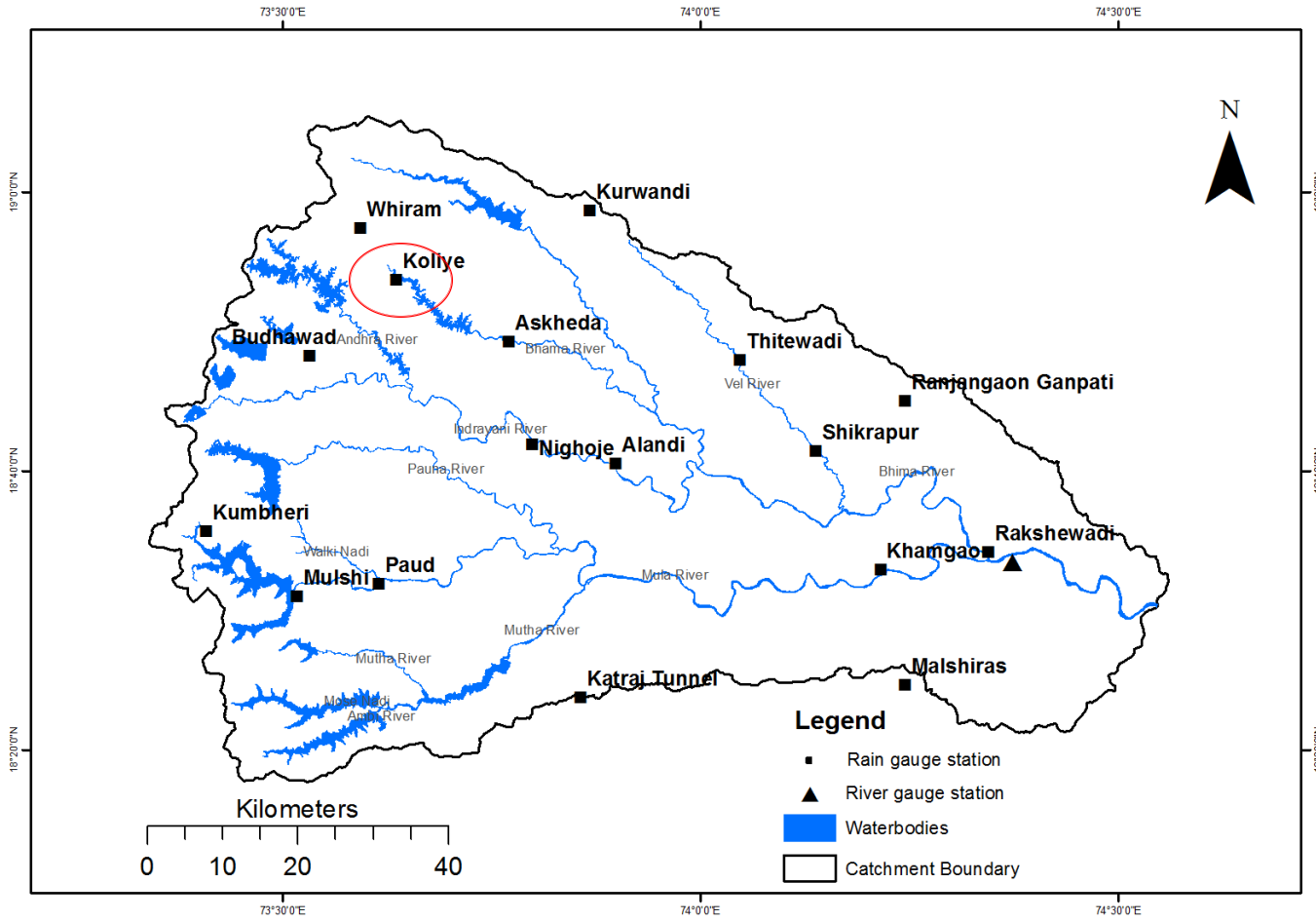
- Mann-Kendall test: It compares the relative magnitudes of sample data rather than the data values themselves (Gilbert, 1987). The data need not to confirm any particular type of distribution.

- The test statistics S is computed as below:

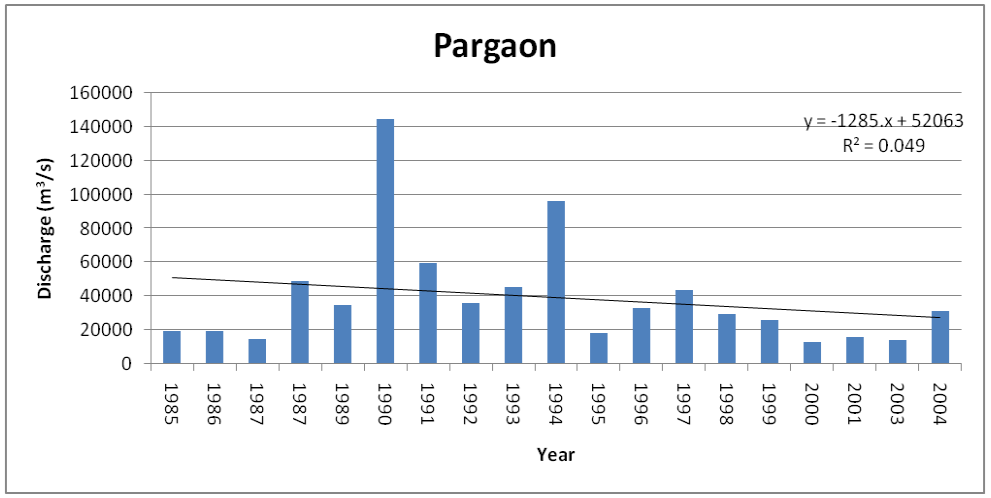
$$S = \sum_{i=1}^{N-1} \sum_{j=i+1}^{N} \text{sign}(Y_j - Y_i) \qquad \text{sign}(Y_j - Y_i) = \begin{cases} +1 \text{ if } (Y_j - Y_i) > 0 \\ 0 \text{ if } (Y_j - Y_i) = 0 \\ -1 \text{ if } (Y_j - Y_i) < 0 \end{cases}$$

  - Where Y_i and Y_j are the sequential data, N is the total number of data in the time series.
  - If a data value from a later time period is higher than a data value from an earlier time period, S is incremented by 1 and vice versa.

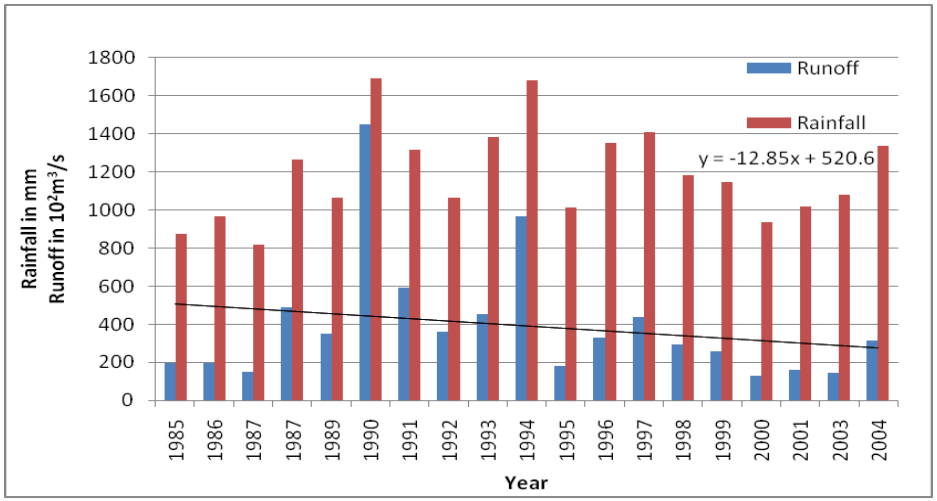
- Variance and probability associated with "S" is computed at certain level of significance(α=5%)
- Only one place has significant trend in the catchment.


73°30'0"E
74°0'0"E
74°30'0"E
19°0'0"N
18°40'0"N
18°20'0"N
N
Kurwandi
Whiram
Koliye
Askheda
Budhawad
Andhra River
Bhama River
Thitewadi
Vel River
Ranjangaon Ganpati
Indrayani River
Nighoje
Alandi
Shikrapur
Pauna River
Bhima River
Kumbheri
Rakshewadi
Khamgao
Walki Nadi
Paud
Mulshi
Mula River
Mutha River
Mutha River
Malshiras
Katraj Tunnel
Mose Nadi
Ambi River
Legend
Rain gauge station
River gauge station
Waterbodies
Catchment Boundary
Kilometers
0
10
20
40

Runoff pattern



(Runoff near catchment outlet)



(Rainfall and runoff in catchment)

Rainfall **Runoff**

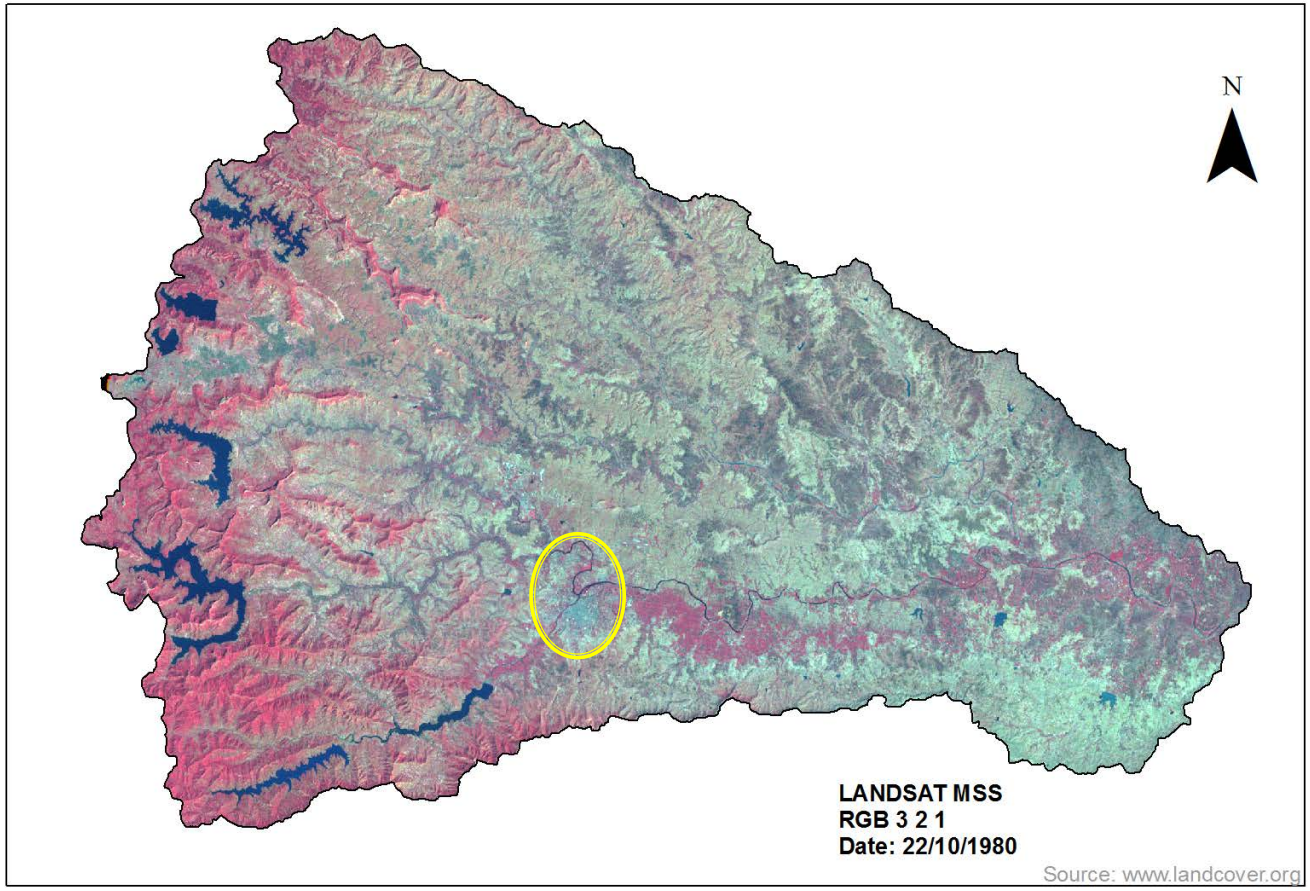
Period D1 (1985–1994): 1213mm. → 52045 m^3/s

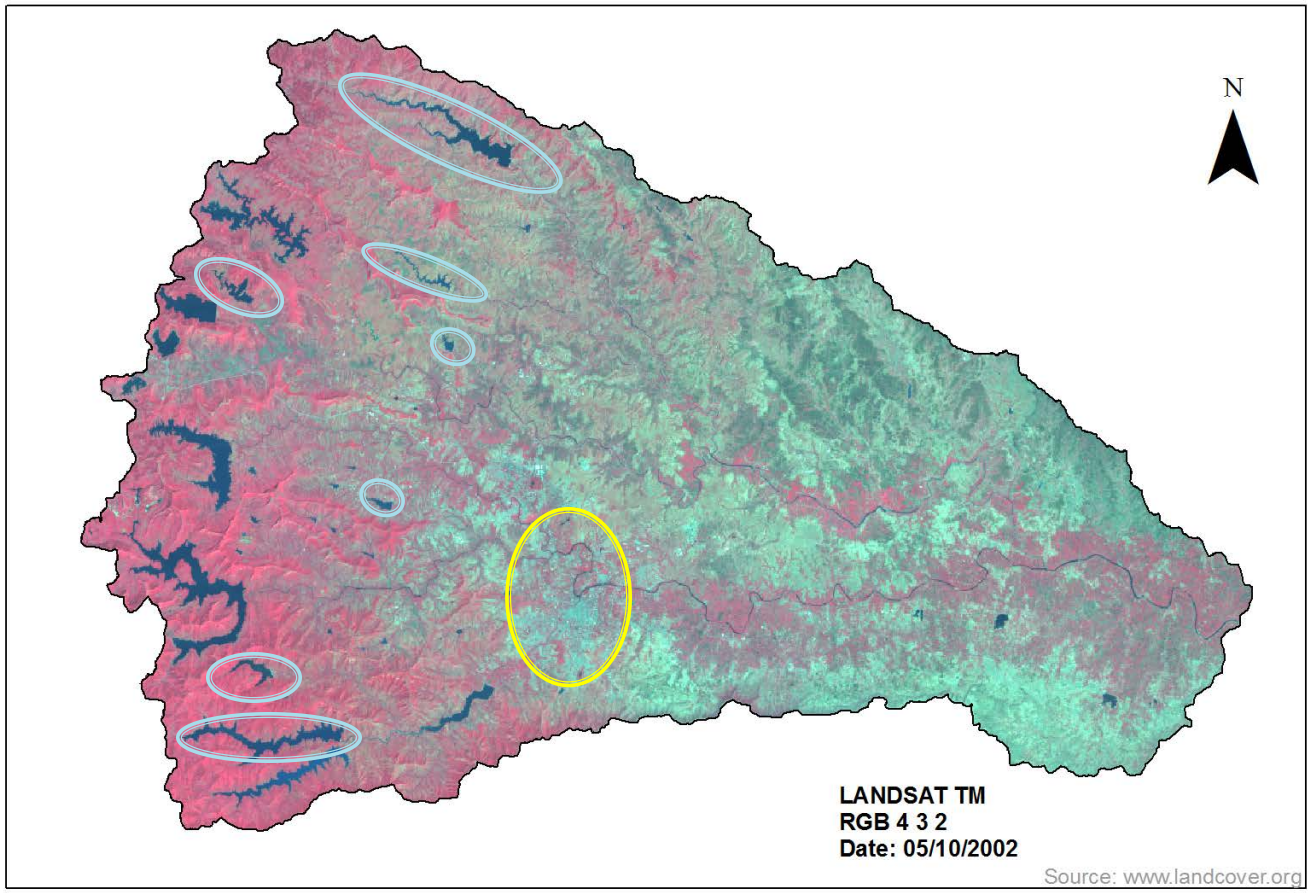
Period D2 (1995–2004): 1164mm. → 24940 m^3/s

Causative Factors

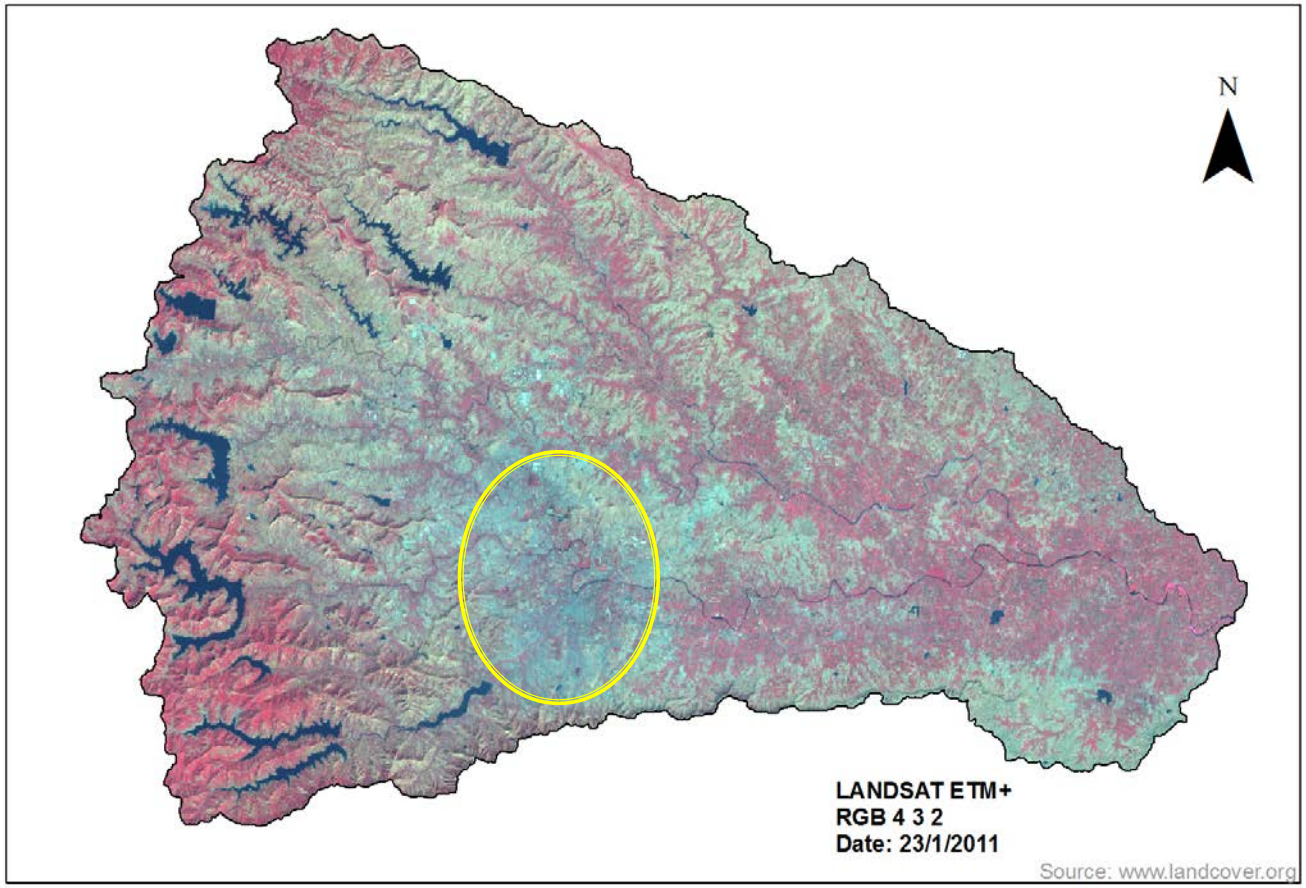
- Construction of dams/reservoirs in upstream areas.
- Increase in agricultural activities in the region.
- Expansion of the Pune city, increase in domestic and industrial water demand in the region.
- Various watershed development programme in the catchment.

Land cover from satellite images


N
LANDSAT MSS
RGB 3 2 1
Date: 22/10/1980
Source: www.landcover.org



Satellite Images cont...


N
LANDSAT ETM+
RGB 4 3 2
Date: 23/1/2011
Source: www.landcover.org

Summery and Conclusions

- Declining runoff pattern in more or less constant rainfall regime in the catchment contradicts expected increase of runoff due to urbanization.
- The declining pattern of runoff is going to affect the down stream areas as most of the water gets stored near source area.
- A single dry year could cause a severe water scarcity problem in the catchment.

Future work

- Rainfall –Runoff simulation using appropriate hydrological model.
- Impact of land use change on runoff in the catchment.
- Climate change scenario in the region.

References

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- Mann, H.B., 1945. Nonparametric tests against trend. Econometrica 13, 245-259.
- Helsel, D.R., Hirsch, R.M., 2002. Statistical methods in water resources. USGS, Book 4, Chapter A3, pp-324.
- Kendall, M.G., 1975. Rank Correlation Methods. Griffin, London, (202pp.).

Thank you