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Short communication

Modeling of moisture variability for Savitri basin using RS data

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Soil moisture is an essential variable in climate and hydrological science because it directly makes impact on the energy and water balance system. Knowledge about soil moisture and its spatio-temporal variability is helpful to identify the heterogeneity of different characteristics, such as soil texture, vegetation, topography and meteorological conditions etc. (Mittelbach and Seneviratne, 2012). Vegetation Indices (VIs) are combinations of surface reflectance at two or more wavelengths designed to highlight a particular property of vegetation. They are derived using the reflectance properties of vegetation. Each of the VIs are designed to accentuate a particular vegetation property (Singh *et al*., 2010; Latif, 2014). The vegetation indices are useful for assessing vegetation condition, foliage, cover, phenology, and processes such as evapotranspiration (ET) and primary productivity, related to the fraction of photo synthetically active radiation absorbed by a canopy (Bal *et al.,* 2013; Glene and Huete, 2008). The numbers of vegetation indices developed like Normalized Difference Vegetation Index (NDVI), (Rouse *et al.,* 1974), Soil Adjusted Vegetation Index (SAVI), (Huete *et al.,* 1988); Modified Soil Adjusted Vegetation Index (MSAVI), (Qi *et al.,* 1994) and Normalized Difference Water Index (NDWI) proposed by Gao, (1996) are popularly adopted in recent years for estimating vegetation cove and its changes with time. Wang *et al.*, (2006) designed a method for retrieving evaporative fraction from a combination of day and night LST and NDVI with an increased accuracy. Soil moisture near the land surface affects a wide variety of earth system interactions over a changing spatial and temporal scale. Surface soil moisture plays a critical role in the interaction between land surface and the atmosphere, as well as in hydrological and ecological processes. In present study the moisture variation in different years with season were estimated from remote sensing images of landsat 7 for Savitri basin in GIS environment and compared with actual measured soil moisture at specific pixel value.

Study area and data used

The Savitri river basin is comes under the Western part of Sahyadri ranges belongs to Mahad and Poladpur Tahshils of Raigarh district in Konkan region of Maharashtra state. The latitude and longitude of the study area is 18°20'N to 17°51'N and 73°22' E to 73°41'E respectively and elevation ranges from 6.50 m to 1366.23 m above mean sea level**.**

Cloud free landsat satellite data of 1999, 2000, 2002 and 2003 for the study area has been downloaded from official website of USGS (www.earthexploer.gov.in). All the data were pre-processed and projected to the Universal Transverse Mercator (UTM) projection system. The details of the satellite data collected with band designations are given in the Table 1 and the details of band in Landsat 7 data is given in Tables 2.

Moisture variation by normalized difference water index (NDWI)

The normalized difference water index (NDWI) was calculated using the NIR and SWIR band from Landsat image and it is widely used to flood and drought monitoring. The NDWI method was best approach for determining moisture content in the top layer of the soil. The index image was normalized to 8-bit and classified into the three classes of crop moisture variation as very low moisture, low moisture and moderate moisture. Thresholds DN values were determined by feature physical inspection of the VNIR image. The thresholds DN values for the respective classes are given in Table 3.

For threshold DN value 0-122, the moisture variation is 16 to 34 per cent. For threshold DN value 123-136, the moisture variation is 35 to 59 per cent. For threshold DN value 137-255, the moisture variation is 60 to 72 per cent. It is inferred that, the high moisture percentage was obtained in the year 1999, the threshold DN value for this year was 137-255.

The area under very low moisture, low moisture and moderate moisture were 99.4 sq. km, 298.2 sq. km and 596.4 sq. km, respectively for year 1999. The area under very low moisture, low moisture and moderate moisture were 198.8 sq. km, 298.2 sq. km and 497 sq. km, respectively for year 2000. The area under very low moisture, low moisture and moderate moisture were 248.5 sq. km, 298.2 sq. km and 447.3 sq. km, respectively for year 2002. The area under very low moisture,

Table 1: Details of satellite data collected

Sr. No.	Image Details	Satellite/Sensor	Reference System	Path/Row
1.	November, 1999	Landsat-7/ ETM+	World Wild Reference System –II (WRS-II)	147/47 and 147/48
2.	October, 2000	USGS Earth Explorer	WRS-II	147/47 and 147/48
3.	September, 2002	USGS Earth Explorer	WRS-II	147/47 and 147/48
4.	March, 2003	USGS Earth Explorer	WRS-II	147/47 and 147/48

(www.earthexplorer.gov.in)

Table 2: Band designation in Landsat 7

	Bands	Wavelength (micro-meters)	Resolution (meters)
Landsat 7 Enhanced Thematic Mapper Plus ETM+	Band 1- Blue	0.45-0.52	30
	Band 2- Green	0.52-0.60	30
	Band 3- Red	0.63-0.69	30
	Band 4- Near Infrared (NIR)	0.77-0.90	30
	Band 5- Shortwave Infrared (SWIR) 1	1.55-1.75	30
	Band 6- Thermal	10.40-12.50	60*(30)
	Band 7- Shortwave Infrared (SWIR) 2	2.09-2.35	30
	Band 8- Panchromatic	0.52-0.90	15

(*ETM+ band 6 is acquired at 60 m resolution, but products are resample to 30-m pixels)

Table 3: Thresholds DN values for NDWI image classification

Class	Threshold DN value
Moderate Moisture	137-255 (60 to 70 per cent)
Low Moisture	123-136 (35 to 59 per cent)
Very Low Moisture	0-122 (16 to 34 per cent)

low moisture and moderate moisture were 397.6 sq. km, 248.5 sq. km and 347.9 sq. km, respectively for year 2003. The average area (472.16 sq, km) under moderate moisture availability in the basin is moderate, which is 47.5 per cent of total area of basin, area under low moisture availability was 285.77 sq. km (28.75 per cent) and 236.07 sq. km (23.75 per cent) found in very low moisture availability of the basis during 1999 to 2003. Hence, Moisture variation found in the basin but availability is good with different season for supporting vegetation.

Moisture Variation by VI-LST triangular space method

The vegetation index (VI) – land surface temperature (LST) triangular space method proposed by Lambin and Ehrlich (1996) was used to map the relative variation of crop moisture within a field (Hakan, 2015). The MSAVI created from NIR image was used as VI and land surface temperature from TIR image was used as LST. The MSAVI (RED and NIR bands) image and LST (Thermal band) image were stacked to create a two layer image that was then classified using unsupervised classification method. A feature space image was created using the two layer image. The MSAVI image layer was used along X axis and the LST image layer was used along Y axis. The feature space image was used to identify the signatures of the classified image. The initial classified images were recorded into three classes: normal moisture, low to moderate moisture, low moisture (Table 3).

Land surface temperature (LST) means the temperature of the surface which is observe if directly contact or touches it with. It is also refer as skin temperature of the surface. Land surface temperature is an important parameter for many environmental models. The land surface temperature (LST) of remote sensing imagery for 1999, 2000, 2002 and 2003 of Landsat7 was calculated in ArcGIS environment. It is observed from Table 4 that, the LST value of study area varied from 23.13 to 24.8 ^{o}C, 22.13 to 23.96 ^{o}C, 21.13 to 22.96 ^{o}C and 24.12 to 31.83 ^{o}C for the year 1999, 2000, 2002 and 2003, respectively. The highest value of LST was obtained in the year 2003 in month of March i.e. in summer season.

Table 4: Comparative study of moisture variation

Sr. No.	Year	Area (sq. km) NDWI method			Area (sq. km) VI -LST method		
		Very low moisture	Low moisture	Moderate moisture	Very low moisture	Low moisture	Moderate moisture
1	November, 1999	99.4	298.2	596.4	251.66	334.73	407.61
2	October, 2000	198.8	298.2	497.00	246.33	315.06	432.61
3	September, 2002	248.5	298.2	447.3	231.33	305.06	457.61
4	March, 2003	397.6	248.5	347.9	248.21	533.61	212.20
5	Average	236.07	285.78	472.15	244.39	372.11	377.50

Table 5: Comparison of moisture computed with NDWI and VI-LST and accrual measured at Birwadi station

Sr. No.	Year	NDWI method	VI-LST method	Observed moisture content, at Birwadi Station, per cent (db)
1	September, 2015	31.58 (115)*	28.19 (110)	25.52
2	October, 2015	28.60 (106)	22.19 (95)	20.65
3	March, 2016	22.56 (85)	19.58 (65)	18.85

*value in parenthesis indicates the DN value

Finally the MSAVI image and LST image were stacked to create feature space image. Then feature space image was classified using unsupervised classification method into the three classes of crop moisture variation as very low moisture, low moisture and moderate moisture (Table 3).

The average moisture variation in study area was 22.62 per cent at DN value 15000, the area under very low moisture, low moisture and moderate moisture were 246.33 sq. km, 315.06 sq. km and 432.61 sq. km, respectively for years 2000 (Table 4). This indicates that, most of area (75.21 per cent) comes under low to moderate moisture availability for basin in November 2000. The average moisture variation in study area was 27.95 per cent at DN value 32000. The area under very low moisture, low moisture and moderate moisture were 231.33 sq. km, 305.06 sq. km and 457.61 sq. km, respectively for years 2002. The average moisture variation in study area was 16.60 per cent at DN value 25000. The area under very low moisture, low moisture and moderate moisture were 248.21 sq. km, 533.61 sq. km and 212.20 sq. km, respectively. This indicates that, most of area (75.03 per cent) comes under low to moderate moisture availability for basin in November 2003. This implies that, the moisture variation computed by the VI-LST is best suited for the basis in tropical humid climate of Konkan region.

Comparative comparison of NDWI and VI-LST methods

The comparative performance of all vegetation indices was given in Table 4. From Table 4, it is observed that, the average area comes under very low moisture; low moisture and moderate moisture were 236.07 sq. km, 258.78 sq. km and 472.15 sq. km from NDWI method for study period 1999 to 2003. The average area comes under very low moisture; low moisture and moderate moisture were 244.39 sq. km, 372.11sq.km and 377.50 sq. km from VI-LST method for study period 1999 to 2003. The MSAVI-LST Triangular method (using RED, NIR and thermal bands) has more potential to estimate crop moisture variation more accurately than NDWI method (using NIR and SWIR bands) (Hossain *et al.,* 2006). Hence, it can be concluded that, the VI-LST method is most suitable to compute moisture variation than NDWI method.

Validation of moisture variation with field data

The moisture computed with NDWI and VI-LST methods using RS data were compared with actual measured soil moisture at Birwadi station in Savitri basin presented in Table 5. It is observed that, estimated soil moisture with NDWI and VI-LST method were over estimated over the measured soil moisture. The soil moisture observed as in the range of low to moderate range.

REFERENCES

Bal, S.K., Choudhury, B.U., Sood, A., Saha, S., Mukherjee, J., Singh, H. and Prabhjyot-Kaur. 2013. Relationship between leaf area index of wheat crop and different spectral indices in Punjab. *J. Agrometeorol.,*15(2): 98-102

Gao, B.C. (1996). NDWI - A normalized difference water index for remote sensing of vegetation liquid water from space. *Remote Sens. Environ.,* 58: 257-266.

Glene, E.P. and Huete, A.R. (2008). Relationship between remotely-sensed vegetation indices, canopy attributes and plant physiological processes: what vegetation indices can and cannot tell us about the landscape. *Sensor (Basel),* 8(4): 2136-2160.

Hakan, P. (2015). A software tool for retrieving land surface temperature from ASTER imagery, *J. Agric. Sci.,* 21: 471-482.

Hossain, A.K., Easson, G., and Boken, V.K. (2006). Mapping spatial variation in surface moisture usingre flective and thermal aster imagery for southern Africa, *J. Remote Sen.,* 10: 75-88.

Huete, A.R. (1988) A soil adjusted vegetation index (SAVI), *Remote Sen. Environ.,* 25: 295-309.

Lambin, E.F. and Ehrlich, D. (1997). Land-cover changes in sub-Saharan Africa (1982–1991): Application of a change index based on remotely sensed surface temperature and vegetation indices at a continental scale. *Remote Sens. Environ.,* 61: 181−200.

Latif S. (2014) Normalized difference vegetation index retrieval of Landsat-8 data: A case study of Ranchi district, *Int. J. Engg. Develop. Res.,* 2: 3840-3849.

Mittelbach, H. and Seneviratne, S. (2012). A new perspective on the spatio-temporal variability of soil moisture: temporal dynamics versus time-invariant contributions, *Hydrol. Earth System Sc.* 16:2169–2179.

Qi. J., Chelibouni, A., Huete, A.R., Ker, Y. and Soroosbian. S. (1994). A modified soil adjusted vegetation index (MSAVI). *J. Remote Sens. Environ.,* 48: 119-126.

Rouse J.W., Hass, R.H., Schell, J.A. and Deering, D.W. (1974). Monitoring the vegetations systems in the great plains with ERIS. Proceeding of 3rd Earth Resources Satellite-I Symposium. NASA. Sp-351. Greenbelt. Pp:310-317.

Singh, V.K., Satpathy. A. and Parveen, R (2010). Spatial variation of vegetation moisture mapping using advanced space borne thermal emission and reflection radiometer (ASTER) data, *J. Environ. Prot.,* 1: 448-455.

Wang, K., Li, Z. and Cribb, M. (2006). Estimation of evaporative fraction from a combination of day and night land surface temperatures and NDVI: A new method to determine the Priestley-Taylor parameter. *J. Remote Sens. Environ.* 102, 293−305.

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