SindhUniv. Res. Jour. (Sci. Ser.) Vol. 51 (01) 141-146 (2019)

http://doi.org/10.26692/sujo/2019.01.25

SINDH UNIVERSITYRESEARCH JOURNAL (SCIENCE SERIES)

Appraisal of Land Cover Changes in the Upper Sindh Through Geo-Informatics Techniques

Z. UR. REHMAN, G. A. MAHAR*, N. H. CHANDIO**, M. J. IQBAL, J. H. KAZMI*

Department of Geography, University of Karachi, 75270, Pakistan

Received 11th July 2018 and Revised 19th November 2018

Abstract: Satellite remote sensing is a useful technique to observe environmental changes which are introduced as a result of man-made activities and physical phenomenon. In this study the land cover patterns of pre-flood period, flood period and post flood period in the year 2015 on upper part of Sindh region have been analysed and difference of vegetation cover, water body and surface temperature before, during and after flood period were observed. Three satellite images of Landsat-8 OLI / TIRS were used in the study acquired on April 11, 2015, August 17, 2015 and October 20, 2015. The land cover classes identify for the study area are healthy vegetation, normal vegetation, wet soil, dry soil and water. Three techniques likelihood supervised classification, Land Surface Temperature (LST) and Normalized Difference Vegetation Index (NDVI) were used to get more precise results. Supervised classification and NDVI showed the spatial increase of vegetative cover. Increasing vegetation also witnesses from LST record of post flood period. This result indicates that land cover classes and socio-economy of the study area is under the dangerous threat of climate change, especially flood. In flood period, many socio-economic and landuse/landcover changes especially water, vegetation, land, animal and house are damages. The flood comes approximately every year in the study area. The mean LST of pre-flood period was 30.5^{0}C , during flood period was 37^{0}C and post flood was 32^{0}C.

Keywords: GIS, Remote Sensing, Natural Disaster, Flood Assessment

1. INTRODUCTION

Landuse and landcover affect the socioeconomy of the people of that land. Natural desasters like Tsunami, Earth quick and flood etc. abruptly change the shape of the landuse and landcover and affect people from all the aspects of life. Monitoring the desasterous conditions of an area, Geomatic technique especially Satellite Remote Sensing (SRS) is an inportant tool for spatial analysis, decision making and even for planning & development. Irregular flooding on the River Indus is a common phenomenon and northern part of the province of Sindh in Pakistan is one of the most vulnerable place in the country which is effected by the flood because of the location of this place on the Indus River System.

Study area is located in the northern part of Sindh which is an important province of Pakistan. The study area is extended to many Districts like Larkana, Shikarpur, western part of Sukkur, northern part of Khairpur, northern part of Nausheroferoze, eastern part of Dadu **(Fig. 1).** This area is famous for its rich productivity, historical background and geomorphologic features, and is most climatic vulnerable zone especially in terms of floods and heat waves (Provincial Monsoon Contingency Plan, 2015),. The main factors of rainfall in this region are monsoon and western distrubance. Monsoon period is in summer season (July to September) and western disturbance mainly occures in winter season. Dust storm also occur during the early summer months with peak in May and June (Snow 2016),

The Indus River lying approximately 750 kms across Sindh (Rapid Assessment Monsoon Rains 2011), The main stream of Indus river comes from Manasarovar lake that is located in the Hamaliyan Mountains. Before the entrance into the province of Sindh, the river receives water from five rivers system at Mithan Kot, that becomes a major cause frequent floods in the Sindh Province. The right and left banks of Indus River in the northern part of Sindh always remain under threat due to riverine flooding in monsoon period. About 60% of land area of Sindh is arid and annual rainfall is 5 inches (https://reliefweb.int/sites/reliefweb.int/files/resources/Full_Report_2021.pdf)

One of the authors is resident of this area who provided the support for field visits and ground truthing but the satellite data is the main source of this study. Satellite Remote Sensing provides different spectral and synoptic assessments of various features on land and water. Remote Sensing and GIS techniques are used for assessment of spatial and temporal changes in land cover and land use (Provincial Disaster Managment Athority Government of Sindh),. Land use/Land cover changes are valuable components of the worldwide environmental changes. These are the main tools used in this study.

++Corresponding author e-mail: goharmahar@gmail.com

*Federal Urdu University of Arts, Sciences and Technology, Gulshan Campus, Karachi, Pakistan

**Shah Abdul Latif University, Khairpur, Pakistan

The location of this study area is unique and centralized with respect to surrounding regions. Western area is bounded by hilly areas of Balochistan and eastern area is covered by Arror hill and beyond this is covered by desert of Rajhastan. North and south of study area is a part of Indus flood plain. After merginig of five major rivers in Panjab province, a big volume of water is entrered into the flood plain of Sindh province through the study area which is from both sides (west and east) is bounded by hills that makes this area more vulnerable in flood season. Although the Guddu and Sukkur barrages have been constructed in 20th century for irrigation purpose but these barrages could not stop big volume of water in flood season. These conditions have affected most of the landuses of this area during the flood period. Not only agriculture but forest area is also affected during flood period. This scenario and its hazardous conditions that frequently occur in this area consequently effected socioeconomic conditions of the people of this area.

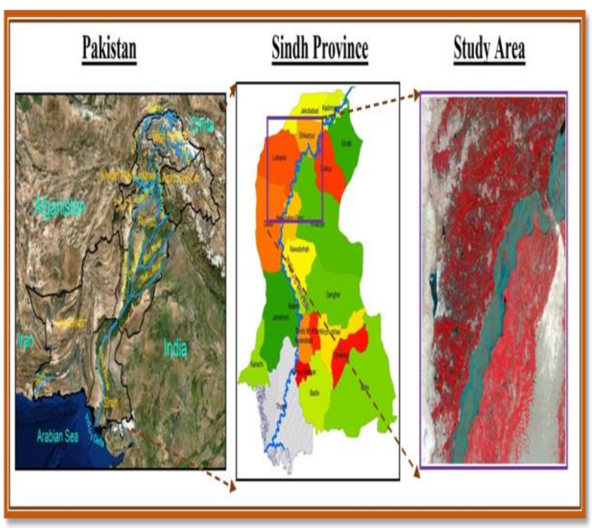

Fig. 1. Map of Study area.

Objectives

- To analyze the change land cover patterns in pre-flood, during flood and post flood period northern part of Sindh Province with the help of Satellite Remote Sensing (SRS) data.
- To observe the change in Land Surface Temperature (LST) and Normalized Difference Vegetation Index (NDVI) during the study period.
- To observe how the reflectance of different features of earth's surface give different values in terms of Digital Number (DN).

2. METHODOLOGY

The methodological framework of the study area as shown in **(Fig. 2)** is based on SRS data. Satellite data is downloaded from official Earth explorer USGS distribution website (*earthexplorer.usgs.gov)* **(Fig. 3 Table-2).** The collected data was in separate bands and orthorectified. All bands had been given projection of Universal Transverse Projection (UTM) on the datum of WGS-1984. So only layer staking was performed to make a composite image. Later the enhancement and extraction of area of interest from the image was performed.

Three analyses were performed to obtain the results.

1- Supervised Classification
2- Land Surface Temperature (LST)
3- Normalized Different Vegetative Index (NDVI)

Supervised classification is processed informally by using samples of known identity to classify pixels of unknown identity (Zaki *et al.,* 2011) Selected samples of known objects are pixels located within training regions *(*Campbellm *2002),* After the selection of training regions, the image processing software is used to find out the statistical parameters for each information class. Supervised classification of acquired images was carried out with the help of ERDAS Imagine, USA, 2013.

Land surface temperature (LST) is the main aspect of measuring factor determining energy exchange and surface radiation (Sohail 2012) (Bobrinskaya 2012),, Land Surface Temperature (LST) is one of the major components of this study. LST was performed to evaluate the temperature of each location. LST also refer to the air temperature of the environment. This method also gave an important correlation with the vegetation and other classes found in the image.

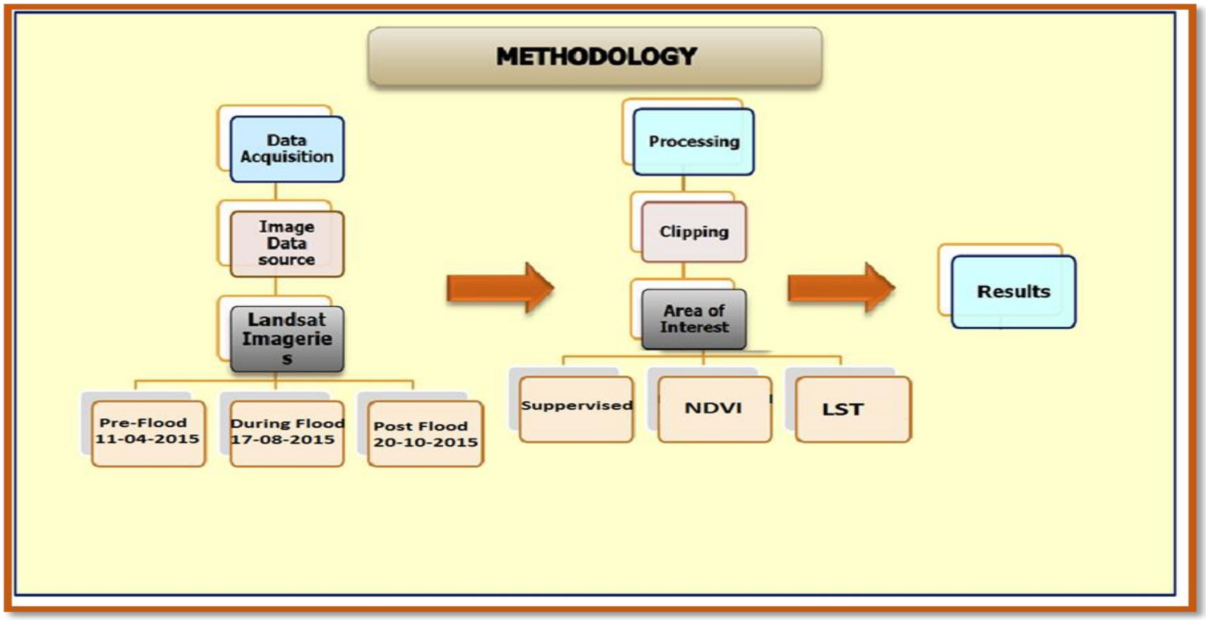

Fig. 2. Methodological framework of the study.

Table.1.Details of Lands at data collected.

Sr. No.	Period	Date of Data Acquisition	Satellite	Sensor	Bands	Resolution (m)
1	Pre-flood	11-04-2015	LANDSAT-8	OLI / TIRS	11	30
2	During-flood	17-08-2015	LANDSAT-8	OLI / TIRS	11	30
3	Post-flood	20-10-2015	LANDSAT-8	OLI/TIRS	11	30

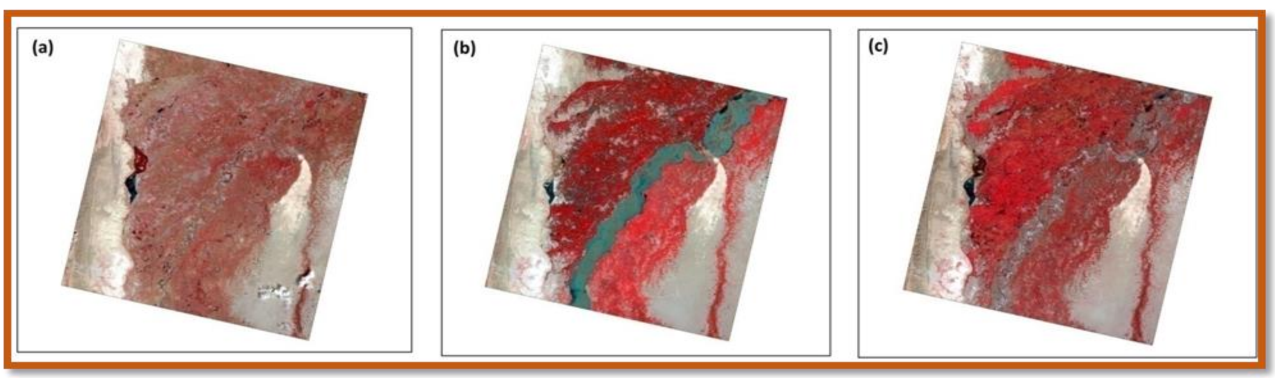

Fig.3. Upper part of Sindh region on (a) 11-04-2015 (b) 17-08-2015 & (c) 20-10-2015

Normalize Difference Vegetation Index (NDVI) technique was performed to compare the vegetation density, vegetation stress and vegetation types (Karnieli *et al.,* 2010). *(*Karnieli *et al.,* 2010) NDVI gives more precise result of seasonal variation of vegetation. It is calculated as a ratio between major reflectance in the red (Red) and Near Infrared (NIR) spectral bands of image by following formula.

NDVI = Near Infrared – Red Band ╱Near IR band + Red Band

3. <u>RESULTS</u>

Land cover of the study area is divided into five different classes namely Healthy Vegetation, Normal Vegetation, Wet Soil, Dry Soil and Water body. The Land cover classified images of years 11-04-2015, 17-08-2015 and 20-10-2015 have been prepared. The temporal analyses between these classes were identified through graphical values of pre-flood period, during flood period and post flood period.

The total land cover area of pre-flood period is 2112130 ha, which showed minor decrease of one hectare during flood period and again showed reduction around 7 hectare in post flood period. Results extracted from the satellite images in pre-flood, post flood and during flood period shows that healthy vegetation covered about 34166 ha (1.6%) in pre-flood period and increase 161368 ha (7.64%) during flood period and little increase 163611 ha (7.75%) in post flood period. Normal vegetation is covered about 1462480 ha (69.24%) in pre-flood period, 1127190 ha (53.37%) in flood period and increased 1170340 ha (55.41%) in post flood period **(Fig. 4)**. The reason of decline during flood period is the heavy water flow in river Indus. Wet Soil cover is about 360951 ha (17.09%) in pre-flood period, increase 405434 ha (19.20%) during flood period and again increase 555122 ha (26.28%). Dry Soil is cover about 166963 ha (7.9%) in post flood period, increase 182126 ha (8.62%) during flood period and little decrease 173505 ha (8.21%) in post flood period. Water body is covered about 87570 ha (4.15%) in post flood period and increases during flood period i.e. 236011 ha (11.17%), decreased 49545.7 ha (2.35%) in post flood period. The overall classification accuracy assessment results showed 84% with Kappa statistics 0.8372, 89% with 0.8273 and 76% with 0.7309 for pre-flood, during flood and post flood period dated 11-04-2015, 17-08-2015 and 20-10-2015 respectively.

In short, flood increases the fertility of soil in the area. These phenomena changed the whole scenario of the study area. These changes in vegetation and other land cover are remarkable due to influence of heavy rainfall and flood. Figure 4 shows the good comparison of different land-cover classes of pre-flood, during-flood and post-flood period. It also artistically delineates the land water boundary of Indus River and shows the danger of flood during-flood period image.

Land Surface Temperature (LST) ranged from 10^{o} C to 5^{o} C with a mean of 30.5^{o}C (**Fig.5**). It was observed that light blue and light green color in the image highlighted the temperature range 20^0C to 30^0C shows water body. The temperature range between 30^0C to 35^0C shows vegetation in green colour in the image. Other temperature ranges 35^0C to 40^0C shows wet soil in yellow color. The highest temperature range 40^0C to 51^0C shows dry soil in light brown and brown colour.

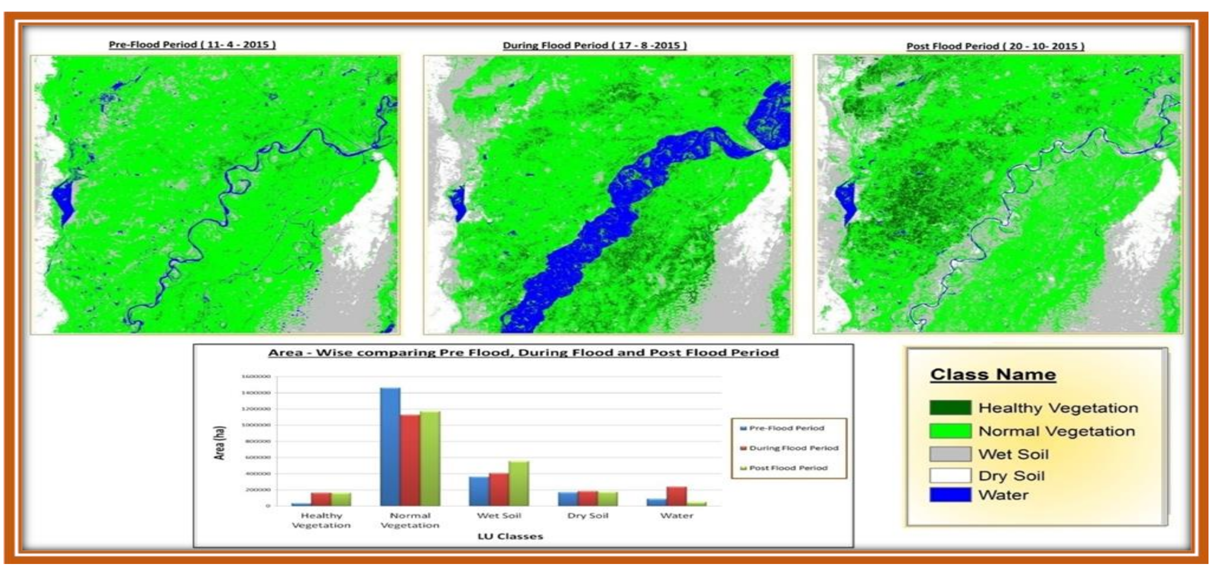

Fig. 4. Comparing of different Land cover of Pre-Flood Period, during-flood period and Post-Flood Period.

LST recorded from satellite image in the flood period ranged from 28^0 C to 46^0 C with a mean of 37^0C (**Fig.5**). It was observed that pink colour in the image highlighed the temperature range 28^0C to 30^0C show water body. The temperature range between 30^0C to 34^0C shows vegetation in blue and sky blue colour in the image. Other temperature ranges 34^0C to 39^0C shows wet soil in green and yellow color. The highest temperature range 39^0C to 46^0C shows dry soil in light brown and brawn colour.

LST recorded from satellite images in post flood period ranged from 20 ^{0}C to 44^0C with a mean of 32^0C (**Fig. 5)**. It was observed that light blue and light green color in the image highlighted the temperature range 20^0C to 30^0C shows water area and some area of vegetation. The temperature range between 30^0C to 35^0C shows vegetation in yellow colour in the image. Other temperature ranges 35^0C to 40^0C shows wet soil in orange color. The highest temperature range 40^0C to 44^0C shows dry soil in brown colour.

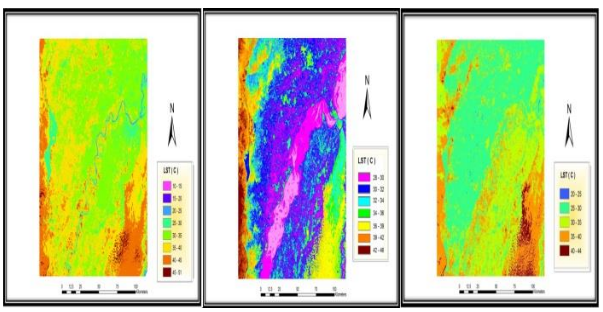

Fig. 5. LST of upper Sindh (from left to right) Pre-flood, during-flood and Post-flood Period.

Fig. 6 shows the NDVI (pre-flood period) ranged from -0.24 to 0.46 with a mean of 0.35. It was observed that light blue colour in the image highlighed the NDVI range -0.24 to -0.02 shows water body. The NDVI range between -0.02 to 0.05 show dry soil in dark grey colour in the image. Other NDVI ranges 0.05 to 0.11 shows wet soil in yellow color. The NDVI range 0.11 to 0.18 shows normal vegetation in orange color. The highest NDVI range 0.18 to 0.46 shows healthy vegetation.

Fig. 6 shows the NDVI (Flood period) ranged from -0.25 to 0.53 with a mean of 0.39. It was observed that blue colour in the image highlighed the NDVI range -0.25 to -0.04 shows water body. The NDVI range between -0.04 to 0.09 shows dry soil in dark grey colour in the image. Other NDVI ranges 0.09 to 0.19 shows wet soil in yellow color. The NDVI range 0.19 to 0.30 shows normal vegetation in orange color. The highest NDVI range 0.30 to 0.53 shows healthy vegetation.

Fig. 6 shows the NDVI (post flood period) ranged from -0.27 to 0.51 with a mean of 0.39. It was observed that blue color in the image highlighted the NDVI range between -0.27 to -0.03 shows water body. The NDVI range between -0.03 to 0.08 shows dry soil in dark grey color in the image. Other NDVI ranges 0.08 to 0.17 shows wet soil in yellow color.The NDVI range 0.17 to 0.27 shows normal vegetation in orange color. The highest NDVI range 0.27 to 0.51 shows healthy vegetation.

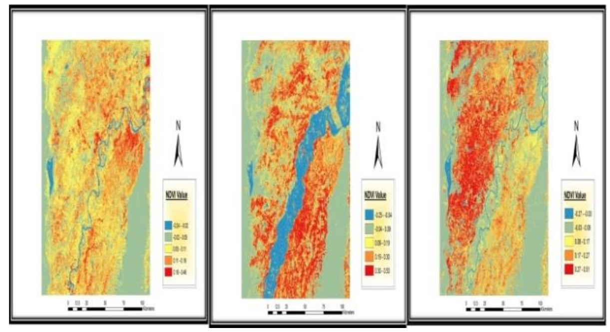

Fig. 6: NDVI of upper Sindh (from left to right) in Pre-flood Period, during-flood and Post-flood Period

4. DISCUSSION

The phenomenon of temporal study of pre-flood period to post-flood period using the geo-informatics technology shows some hazardous results of destruction and deterioration of crops with other infrastructure and it also provides some beneficial information like refreshing of fertile soil by flooded water. Covered area of flooded has not only been studied in this research that has provided the delineated figure of spatial sprawl of flooded area and it's consequent impact on crops destructions. Wet soil and fresh soil with temporal change has also been studied and it has been found that fresh soil was increased after the flood. This is an improvement in the cultivated area because silt provided by the flood water is fresh or fertile soil and spread over the flood plain area.

Land Surface Temperature (LST) extracted from different object provided temperature as albedo is not always same from different objects and in different time period found on the earth surface (Frederick 1982). LST extracted from different image for temporal has provided varying results. Climatic phenomenon does not remain same before, during and after flood in a place. Using the geo-informatics techniques, varying weather conditions before, during and after flood have also been found.

Spectral characteristics of vegetation have also been studied and its reflectance in pre-flood and post-flood period has been observed. It is also analyzed from the study that reflectance was found increased in post flood period. After the calculation of NDVI in the flood and post flood period it is concluded that fresh vegetation in clear sky gives more reflectance from vegetation and increases its digital number (DN).

4. CONCLUSION

For analysis of LULC patterns and changes, GIS found to be an affective techniques for mapping and analyzing of these patterns. These techniques give good comparison of the historical and present environmental condition in the study period. The northern districts of Sindh province along the Indus River are risk and threats of LULC changes due to flood. Flood irregularly occurs during monsoon period. The land cover changes of the study area are water body, wet soil, vegetation, animal, house damages/destroyed. Wet soil increases continuously and normal vegetation slightly decreased. On the basis of correlative study of supervised classification, LST and NDVI, following concluding out comes are found.

On the basis of classification, healthy vegetation and wet soil are increased gradually, while normal vegetation and dry soil are declined in flood period, but little increase in post flood period. Water body is increased in flood period as compared to pre & post-flood period.

i. On the basis of land surface temperature analysis (LST) from Landsat data, highest LST is around 37ºC to 51ºC of dry soil and wet soil. LST of normal and healthy vegetation are around 30 C to 36 C.
ii. On the basis of NDVI analysis, highest NDVI value is about 0.53, that is in flood period.
iii. The relationship between LST & NDVI with land cover classes, on the bases of analysis, all land cover of pre-flood, during-flood and post-flood periods excluding water body is negative correlation because when LST is high the NDVI values decline, for example LST of dry soil and wet soil are about 37 C to 51C, and NDVI values of these land cover classes are about -0.24 to -0.05. It clearly indicates that relationship is negative.

REFERENCES:

Bobrinskaya, M. (2012), Remote Sensing for Analysis of relationships between Land Cover and Land Surface Temperature in Ten Megacities. Master's of Science Thesis in Geoinformatics, TRITA-GIT EX 12-008, School of Architecture and the Built Environment, Royal Institute of Technology (KTH), Stockholm, Sweden.

Campbell B. J. (2002), Introduction to Remote Sensing. (3rd ed.) London. -Taylor and Francis

Frederick K. L. And J. T. Edward (1982). The Atmosphere: An Introduction To Meteorology. Prentice-Hall International, Inc. Englewood Cliffs, N.J. 07632, London, Uk.

Gillies R. R., T. N. Carlson J. Cui W. P. Kustas and K. S. Humes (1997), A verification of the 'triangle' method for obtaining surface soil water content and energy fluxes from remote measurements of the normalized difference vegetation index (NDVI) and surface radiant temperature. International Journal of Remote Sensing 18 3145–3166.

https://reliefweb.int/sites/reliefweb.int/files/resources/Full_Report_2021.pdf

Kustas W. and M. Anderson (2009), Advances in thermal infrared remote sensing for land surface modeling. -Agricultural and Forest Meteorology; 149: 2071–2081.

Karnieli A., N. Agam, R .T. Pinker, M. Anderson (2010) Imhoff Use of NDVI and land surface temperature for drought assessment: Merits and limitations. - Journal of Climate; 23: 618–633.

Provincial Monsoon Contingency Plan, (2015), Provincial Disaster Managment Authority, Government of Sindh.

Provincial Disaster Managment Athority Government of Sindh, Rehabilitation Department, Multi Hazard Contingency Plan 2013, http://pdma.gos.pk/MHCP%202013%20part%202.pdf

PMD, (2014), Pakistan Meteorological Department, Govt. og Pakistan. Website available from URL http://www.pmd.gov.pk/rnd/rndweb/rnd_new/climchange.php cited dated: 21 August s2014.

Rapid Assessment Monsoon Rains (2011), Health & Nutrition Development Society, Web site:

Snow L., (2016), Web Site availabe from URL http://snowland.com.pk/weather-pakistan/ cited dated: 1st September-2017.

Sohail A. (2012), Mapping Landcover / Landuse and Coastline Change in the Eastern Mekong Delta (Viet Nam Master's of Science Thesis in Geoinformatics, School of Architecture and the Built Environment, Royal Institute of Technology (KTH), Stockholm, Sweden.

Weng Q. and C.P. Lo (2001), Spatial analysis of urban growth impacts on vegetative greenness with Landsat TM data.Geocarto International 16 (4), 17–25.

Zaki R., A.Zaki, and S. Ahmed (2011), Land Use and Land Cover Changes in Arid Region: The Case New Urbanized Zone, Northeast Cairo, Egypt, Journal of Geographic Information System, 3, 173-194, doi:10.4236/jgis.2011.33015.

Zhang R., J. Tian, H. Su, X. Sun and S. Chen (2008), Two improvements of an operational two-layer model for terrestrial surface heat flux retrieval. Sensors; 8: 6165-6187