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SPATIO-TEMPORAL CHANGE ASSESSMENT USING NORMALIZE DIFFERENCE VEGETATIVE INDEX AND SPECTRAL ANALYSIS TECHNIQUES FOR VEGETATION COVER ON WADI AURANAH

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ABSTRACT

Wadi Auranah is one of the potential wadis in respect of land use, located on the western shield (Hijaz escarpment) of Saudi Arabia. A spatio-temporal change assessment of this wadi (valley) was conducted with the help of landsat data. The results of the spectral analysis and NDVI for vegetation changes assessment reveals a continuous increasing trend of land cover biomass in specific parts of the wadi. Geological review of geologic map supports soil fertility. It is observed from field assessment of the study area that has potential for more land more to be cultivated. About 73 km^2 of vegetation land cover has been increased in the last 20 years. Treated wastewater is the main source of water supply that is used for afforestation and cultivation purpose.

Keywords: NDVI, Spectral enhancement, Spatio-temporal, Satellite Image, Wastewater Treatment

1. Introduction

Saudi Arabia is located in arid and semi-arid climatic conditions where availability of water resources is largely limited to groundwater because of the short and erratic period of rainfall (Rudolf, 2012). This region provides a network of semi-perennial rivers in the east, northeast and north of the country; but the intensity and continuity of rainfall and consequently groundwater resources differ from one region to another due to the varying spatio-climatic conditions and difference in geologic and geomorphic environment (M. Al-Saud, 2009). Groundwater resources are not only naturally dynamics but also change with time (Alley *et al.*, 2002) in response to climate change and anthropogenic activities (Seeboonruang, 2014). Structural and hydrological potential efficiency of watershed in the western shield of Saudi Arabia is correlated with the morphometric parameters (Ali, 2010), supporting the availability of groundwater in several parts of the Wadi. Moreover, the importance of wadi system is also recognized as physiographic, ecological and environmental significance (Abdulrahman, 2012).

Geographical Information System (GIS) and Remote Sensing (RS) have played a vital role in vegetation coverage classification, watershed management and soil mapping (Nahry *et al.,* 2011; Papadavid *et al.,* 2013; Papadopoulos *et al.,* 2014). Satellite Remote Sensing (SRS) due to its respective multi-spectral and synoptic nature provides a unique view to recognize various features on Earth surface and this technique also provides larger area for land biomass study and atmospheric gases (Ortega, 2014). For groundwater appraisal, this study provides the indirect approach to extract the data on larger area even where accessibility is difficult. Image processing and data extraction techniques in remote sensing account for less time-consuming and more cost effective method but these techiques replace field investigation (Eirini, *et al.*, 2011). Normalized difference Vegetative Index (NDVI) and spectral enhancement are techniques those are used in remote sensing data to assess the variation in vegetation. NDVI is calculated as a ratio difference between measured canopy reflectance in the red and near infrared bands, respectively. It is also one of the significant index of the growth and types of vegetations and has a linear correlation with the vegetation coverage density. (Yang *et al.,* 2011). NDVI is mainly used to measure crop health application. In poor spatial coverage, vegetation species can be distinguished spectrally by NDVI (Pérez González *et al.,* 2006).

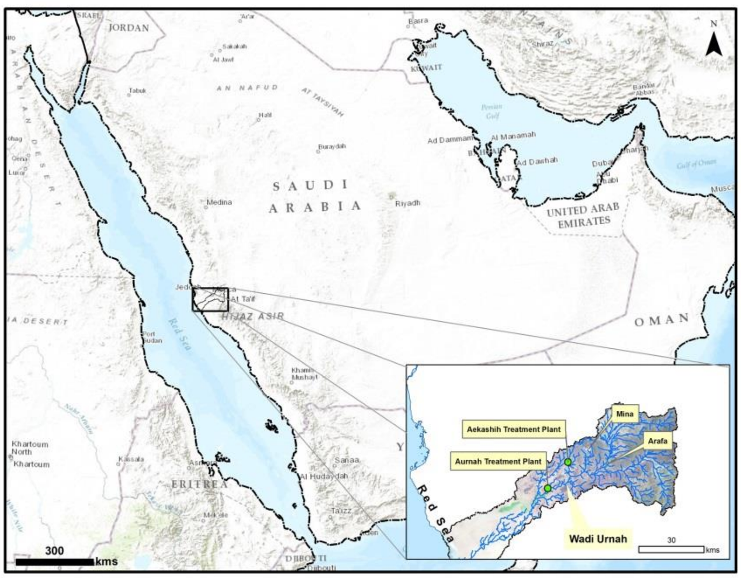

Figure 1. Index Map of Wadi Auranah with locations of Wastewater Treatment Plants

Time-series vegetation index data are recommended to describe vegetation growth well and the shape of vegetation growing profiles depicted by time series vegetation index contained vegetation type information (Brown *et al.*, 2013; Xiao *et al.*, 2002). A study was conducted in north China region to improve the forest cover classification changes by using the landsat Enhanced Thematic Mapper (ETM+) data appending with time series MODIS NDVI data to improve the potential of time series NDVI features (Jia *et al.,* 2014). In the region of Castilla La Mancha (Spain), research was carried out to determine the saline soil using the satellite data. Landsat Thematic Mapper (TM) and ETM data were used to identify the saline soil. In this study, use of NDVI was helpful to detect the saline soil and vegetation that is under stress. (Pérez González *et al.,* 2006). A study was conducted in the Da'an, north China to evaluate the spatial heterogeneity of the land surface. Near Infra Red (NIR), Red band and NDVI were used to detect the spatial heterogeneity of vegetation cover. NDVI shows greatest heterogeneity in early stage of vegetation cover (Ding, 2014). Another study was carried out to classify the climatic regions using the Advance Very High Radiometric Resolution (AVHRR) NDVI data in the Mongolia Plateau (Cui, 2012). In the study, many regions have been classified, based on NDVI value those range from 0.09 (Arid region, medium temperature zone) to 0.83 (Humid region, cold temperate zone). Accuracy and improvement in the results of vegetation cover using the different values of threshold of NDVI for extraction of different features in a study carried out in the Jabalpur city of India (A.K. Bhanderi, 2012). Temperature and vegetation are co-related with each other. An understanding of relationship between temperature and vegetation is important to monitor the changes. Satellite derived data of NDVI and Land Surface Temperature (LST) developed Summer Warmth Index Index (SWI) to generate the temperature gradient that shows the similar trend of NDVI in Arctic region (Raynolds *et al.,* 2008). In another study in Arctic region, increasing temperature and early melting have prolong the growing season of vegetation. Study of NDVI has detected that lower wetter regions are dominated by vegetation cover, are more productive than higher drier regions (John, 2013).

The objectives of this study are to better quantify the spatial and temporal dynamics of vegetation productivity in response to changing cultural or natural environment. In this case, NDVI (an optical index of vegetation greenness), was used as a proxy for productivity based on observations of correlations between NDVI (Goswami, 2011), ground biomass (scattered and dense) for basin study of arid environment.

2. Auranah Wadi (Valley)

Wadi Auranah is located in a unique place of western Arabian Shield of the country which is also called Hijaz escarpment. The catchment area of the wadi is between the two historically famous cities: Makkah and Taif. It flows in the southwest direction and discharges into the Red Sea near Jeddah (Figure 1). Major feature observed from satellite data are classified in image as Mountains, Vegetation, Alluvial and Aeolian sediments deposits (Figure 2).

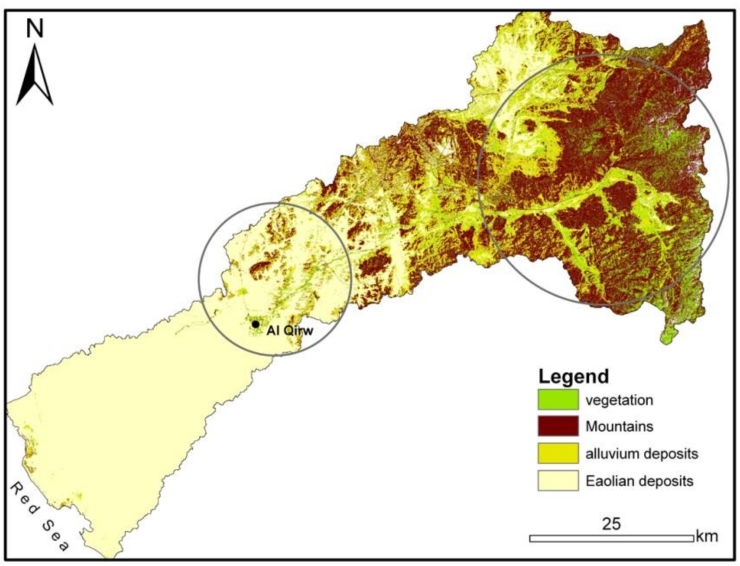

Figure 2. Classified image of Wadi Auranah with natural land cover

Several studies support the potential of biomass production in the Wadi. Morphometric setting of the drainage pattern and its correlation of the interrelated tributaries support the high density of drainage system especially in the middle of the Wadi (Al-Saud, 2009). The overall relief of the catchment area of the Wadi is low to moderate. This creates the low runoff with sufficient time lag for evaporation and infiltration in the Wadi, and accelerates the growth of vegetation in rainfall season. Lineaments features consisting of joint, fractures, fissure and faults in the Wadi are well defined by Al-Saud (2008; 2009). Lineaments extracted from satellite data found that the catchment area of the Wadi has several fault systems while many patches of fracture zones with high density are found in the middle of the Wadi. Potential of groundwater resources in the Wadi is also supported by the hypothesis that the intensive fracture system is found in this area (Al-Saud, 2010, Aburizaiza, 2012).

3. Methodology

This study mainly consists of satellite data. The main objective of the study is to detect the temporal difference of vegetation developed in Al-Qirw area located on the Wadi. Images of the landsat Thematic Map (TM) dated 1990, Enhanced Thematic Map Plus (ETM+) dated 2000, ETM+ dated 2010 and Operating Land Imager (OLI) dated 2013 have been collected to detect the temporal variation of vegetation cover in the Wadi. DEM data for this area has also been collected and used to delineate the boundary and drainage pattern of Wadi in the shape file format.

Two scenes of all the sensors were required to complete the Wadi map and False Color Composite (FCC) of each scene has been developed. Both sets were mosaic with histogram matching. With the help of the boundary of the Wadi, each set of landsat images have been cropped to make the boundary image of the Wadi. On each image following processes have been carried out to evaluate the results.

1. A supervised classified image of the study area was developed to have the overview of the study area and to enhance the salient features in the Wadi.

   Drainage pattern of the Wadi has been delineated with the help of Digital Elevation Model (DEM) of 30 meter resolution of ASTER data.

2. Spectral band combination for each sensor was set. 4, 3, 2 bands for TM and ETM+ of year 1990, 2000 & 2010 was set and 5,4,3 was set for OLI dated 2013. This combination of specified satellite images enhances vegetations and land biomass.

3. NDVI for each image was also developed to enhance the vegetation. The following formula was applied to enhance the images:

   NDVI = (Infrared) – (Red**/**Infrared) + (Red)

   The images of the 1990, 2000, 2010 and 2013 were enhanced by NDVI. Al-Qirw area in the south was focused to get the spatial difference of vegetation.

4. For the study of the geology of the Wadi, the Geological map collected from the Saudi Geological Survey, was digitized to enhance the structural features.

5. Several field visits were conducted during the work of image processing. from catchment area to downstream area of the Wadi. Global Positioning System (GPS) was used for ground truth and correlated verification.

4. Spectral Enhancement Study

This study basically depends on processed satellite data to understand the temporal variations of vegetation cover in cultivated area and in naturally grown vegetation area. Four selected satellite images of different periods (1990, 2000, 2010 & 2013) have been processed for the spectral study in Arc map program. Spectral analysis of 4, 3 & 2 bands combinations have been made to observe the vegetation study in the satellite imageries of 1990, 2000, 2010 and 2013. This combination enhances the vegetation patches in the images. The band combination of 5, 3, and 2 was applied on landsat image of 2013 (Figure 3). Both the combinations enhance the water and the vegetation on the land surface.

Two areas of Wadi Auranah have been selected for observation. One is the upper catchment area, covered by big circle and the other is the lower area of the wadi covered by a small circle. The catchment area is almost covered by natural vegetations but some patches near the river side seem to be covered by natural and cultivated land from different images. The FCC satellite image of 1990 shows some sparse vegetation (in red color) in the upper catchment area, but on the main wadi Naaman many small parcels of cultivated land were identified (Figure 3A). Similar trend is also observed on this Wadi coming from the north. This shows the historical presence of settlements over there and potentiality of land. A tilted D-shaped vegetation cover in this area is the place of Arafah. This place is religiously very important for Hujj performance. After the survey conducted in this area, it was observed that Neem trees were planted in Arafat in 1980s for convenience of pilgrims during Hujj. The lower wadi area shows very small vegetation from this spectrally enhanced satellite image taken in 1990.

Spectrally enhanced False Color Composite (FCC) image of 2000 with 4, 3, 2 band combination shows a similar trend in the catchment area (Figure 3B). In the mountain area, sparse vegetation is found while on the Wadi courses and on upper interflows, more vegetation is found. In comparison with image 1990, the image of 2000 shows more dense vegetation in the catchment area. In Wadi Nauman and Wadi Auranah, similar trends of continuous land parcels are shown. Lower wadi area marked with small circle shows a noticeable difference from the image of year 2000. Cultivation was started in this area during this period. Light and medium red colors in the image show the area used for cultivation, while dark color along the course of the Wadi shows dense vegetation.

The ETM+ image of the year 2010 has Scan Line Corrector (SLC) off data. This is an instrumental malfunction on board on ETM+ satellite since 31 May, 2003. This is caused by the failure of the SLC, which compensates for the forward motion of the satellite (NASA, 2013). This malfunction causes the missing of the alternate scan lines of the image. The missing lines could be filled by merging with the alternate image but for temporal study the process of filling lines deteriorates the actual result. Moreover, the developed image is not that much enhanced. Therefore, it was decided to make the composite image from the actual data for the study.

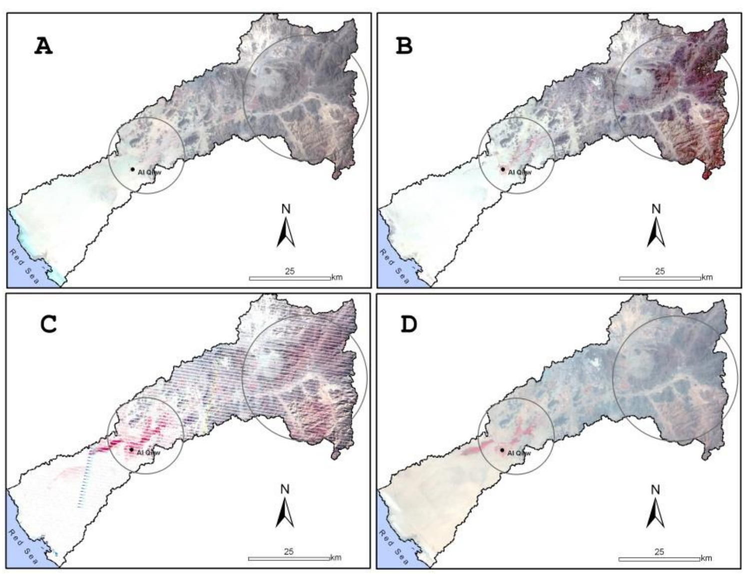

Figure 3. Spectral enhancement image of Wadi Aurnah to detect the temporal changes. Image ‘A’ represents data of 1990, image ‘B’ 2000, image ‘C’ 2010 and image ‘D’ represents data of 2013

While observing the ETM+ image of 2010 to study this area, similar trends in the upper area were found (Figure 3C). Spectral bands combination of 4, 3 and 2 of image shows cultivated land along the valley on the image while the mountainous area seems to be sparsely vegetated area. While observing the lower part of the wadi, a remarkable increase in vegetative area has been found from this image. It shows that during the period from 2000 to 2010, special attention was given to increase the cultivation in this area.

The last processed image of year 2013 was taken for analysis (Figure 3D) because its spectral range is different. Therefore, 5, 3, 2 band combination was taken from this data. Red color in FCC image is more enhanced from this image. Upper catchment area shows scattered vegetation in this image, while lower catchment area within the circle is denser. This shows that with the passage of time, lower valley cultivated area is increasing.

5. NDVI Study

NDVI is the common method of measurements of vegetations over the globe. It helps to determine the density of the green vegetation on the surface. The signature made on the images by the visible and near infra-red wavelength of the sunlight reflected by the plants is processed to get the NDVI image. For the study of the Wadi Auranah, a set of four images of NDVI is extracted from visible and near infra-red wavelength bands of the FCC landsat image of year 1990, 2000, 2010 and 2013 (Figure 4).

NDVI developed from Image 1990 does not show the remarkable larger area where cultivation is found, but after the catchment on the Wadi Naaman, many small plots are observed (Figure 4A). This image shows the upper catchment and the lower wadi area covered by natural vegetation. NDVI developed from the landsat 2000 gives perfection in extracting vegetation areas (Figure 4B). Upper catchment area shows the vegetation with more visible enhancement. Lower vegetation area shows increased area. About 23 km^2 of the area has been extracted with the help of NDVI of image 2000 marked by small encircled vegetation cover (Figure 4B & Table 1).

Table 1. Temporal increase in vegetation in Al Qirw, south of Wadi Auranah

Date	**Area (km^2)**	**Percentage**
1990	3	0
2000	23	2000%
2010	61	122%
2013	73	20%

Similarly the NDVI study of image 2010 shows the same trend of increasing the natural vegetation and cultivated area in the smaller encircled area and about 61 km^2 area has been calculated while upper area shows the same trend of natural vegetation (Figure 4C). NDVI developed from the image 2013 also shows the increasing trend in the middle wadi with small encircled area (Figure 4D). Vegetation seems to have increased in this wadi area in 2013 to about 73 km^2. This image not only shows the increasing area of cultivation in Al Qirw area but cultivated area was developed around the river course of the Wadi Nauman.

6. Geological review

The rocks in Wadi Auranah are of Precambrian periods, upper Tertiary Formation (Shumasi Formation of Miocene to Pliocene) and Quaternary periods of about 1.6 Million years (Figure 5).

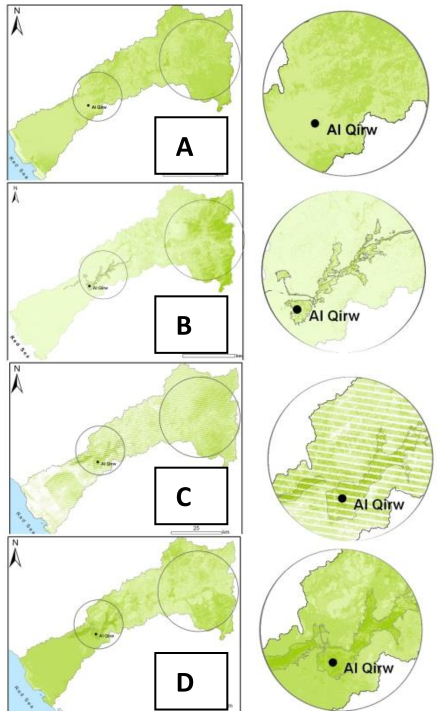

Figure 4. NDVI of image 1990 (A), 2000 (B), 2007 {(C) and 2013 (D) with enhanced and enlarged encircle area.

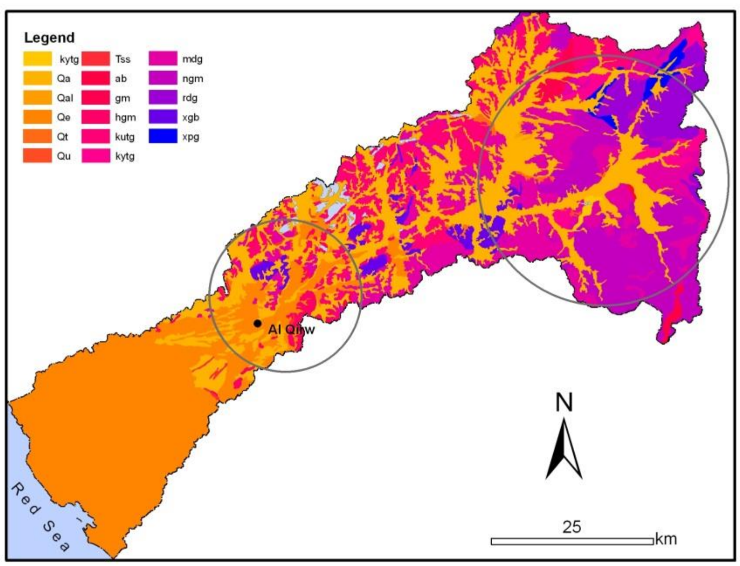

Figure 5. Geological Map of Wadi Auranah: Abbasah Formation-mafic to felsic metalavas and volcaniclastic rocks hgm: monzogranite (ab/abq); Monzogranite (gm); trondhemite (kytj); tonalite to grandodiorite (kytg); hornblende tonalite to grandodiorite (kutg); Alluvial Fan Deposits (Qa); diorite and gabbro (mdg); Nu'man Complex-massive to foliated biotite monzogranite (ngm/ngd); Wadi and Alluvial Fan Deposits grading to gravel, sand, and silt on coastal plain mixed with fluviatile and eolian origin (Qal); Alluvial Fan Deposits, sand and gravel (Qat); Eolian Sand Dunes and Sheets (Qe/Qes); Beach Sand-Shell-bearing (Qs); Scree Debris-Boulders to gravel (Qu); Tallus Deposits (Qt); Dumah granodiorite-Granodiorite rdg/rdd; Paragneiss and schist (xpg); gabbro, anorthosite, amphibolite and schist (xgb)

The Precambrian lithological structures along with Pleistocene sediments deposits present the shape of the valley as shown by the geological map. Precambrian structure was mainly composed of igneous rocks consisting of diorite, gabbro minor granodiorite monzogranite granodiorite, while in some places foliated biotite monzogranite and gneissic are also found. Upper Wadi area from catchment to middle wadi area is covered by alluvial deposits. During the field survey of thearea, it was observed that this area has many sediment deposits features like alluvial fan, tallus and debris. Deposited material contains silt, sand, gravel and even boulders. The southwestern lower part of the Wadi is covered by Aeolian deposits in the shape of sheet and dunes and upper Wadi area is covered by the igneous and sedimentary rocks. Deposited aeolian and Alluvial silt support the potentiality of land for agriculture, natural vegetation and afforestation of the area.

7. Field Study

It was observed from the satellite image study that the middle part of the Wadi, near the Al-Qirw district, the vegetation area has increased each year. It was decided to conduct a field survey of the Wadi for the verification and ground truth of biomasses observed from the satellite data. GPS device was used to get the positions of different places of the studied area to correlate with the image. These verified locations were marked on the image for correlation. It was observed during the field visits that middle part of the Wadi is covered by lush vegetation. Some part of the Wadi near the course is covered by cultivated land while other part is by natural vegetation. From the field survey, it was observed that this green area is going to increase each year, is due to treatment plants located near this area. One is Auranah treatment plant and the other one is Aekashish that has been demolished.

Aekashih treatment plant was located south of the city of Makkah, about 15 km from the center of the city, where Al-Haram mosque is located, this treatment plant was developed in two phases, the first phase was developed in the early seventies and the second phase was developed in the early nineties of the last century. The total capacity of the first phase was 20000 m^3/day and second phase was 24000 m^3/day. The final capacity of this plant was 180000 m^3/day. The plant processes the amount commensurate with the design capacity, and the rest was transferred via pipeline to Auranah treatment plant. This treated wastewater was sent to the tank's project of forestation of the Mina and Arafa (Ahmed Abdelwareth, 2004).

Table 2. Results of the analysis of effluent Auranah wastewater treatment plant (2008)

Standard	minimum	maximum	average
PH (pH)	7.2	7.7	7.52
Chemical Oxygen Demand (COD) [mg l^{-1}]	17.6	42.1	29.7
Bio Oxygen Demand (BOD) [mg l^{-1}]	5.8	13.1	9.1
Total outstanding materials (TSS) [mg l^{-1}]	3.6	13.2	7.6
Total nitrogen (Total Nitrogen) [mg l^{-1}]	11.0	32.0	24.1
Ammonia - Nitrogen (Ammonia-N) [mg l^{-1}]	0.13	2.28	1.02
Nitrates - nitrogen (Nitrate-N) [mg l^{-1}]	2.3	3.78	3.03
Nitrite - Nitrogen (Nitrite-N) [mg l^{-1}]	0.02	0.1	0.05
Phosphates - phosphorus (Phosphate-P) [mg l^{-1}]	5.61	9.72	7.15
Turbidity (Turbidity) [unit turbidity Nfelhumicria]	3.0	7.0	5.0

Source: Ministry of Water and Electricity, General Directorate of Water in Makkah.

Auranah WastewaterTreatment Plant is located in southern Makkah, (Figure 1). The station is a modern construction and was designed for tertiary treatment; capacity of the plant is between 125,000 - 375,000 m^3/day. The treated wastewater from this plant is also used for the forestation of the holy sites (Mina and Arafah). The rest of unused treated wastewater is sent to the lower wadi through the course of Auranah. This mechanism increases the surrounding groundwater level of the lower wadi area. This is the reason of remarkable appearance of lush vegetation on recent images. The Auranah wastewater treatment plant produces high quality water (Table 2) and can be used for many purposes like land cultivation, forestation and industry etc.

8. Discussion

Spatiotemporal variation of natural biomass including cultivated area of Wadi Auranah has been identified in this study. Temporal study of NDVI and spectral assessment with the help of landsat images of 1990, 2000, 2010 and 2013 present the natural phenomenon in the catchment area. This study discovers the continue increasing trend of natural and cultivated land in the middle of the Wadi that is the south of the Makkah city. NDVI was developed from all these images to get the precise level of vegetation cover.

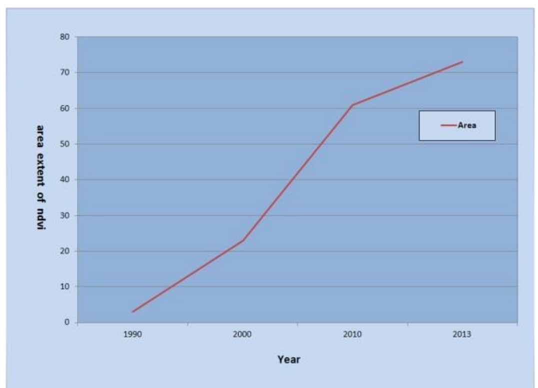

Figure 6. Plotting shows the increasing trend of vegetation area (in km) which is measured from the vegetative Index

The TM image of 1990 shows very little vegetation and cultivated land but from the ETM+ image 2000; It was found that green area was created and spread over 23 km^2. The vegetation area increased to 61 km^2 in 2010 that is about 122% of the previously calculated area of 2000. In 2013, the green area was about 63 km^2 that about 20% more than the area calculated in 2010. Increasing trend is also obvious from chart of NDVI areal extend of each year of selected image (Figure 6). It is observed that this area has more potential to improve the agriculture practice by increasing the cultivated land and range land for livestock.

Several studies were carried out on Wadi Auranah using the geospatial techniques for the last few years. The present study is the assessment of spatio-temporal change detection of Wadi Auranah. The results of spatial change analysis support the potential of the wadi and the fertility of the soil for the production of vegetation. Different studies using different techniques show that the Wadi is productive. M. Al-Saud in 2008, using the ASTER image, extracted and analyzed the linear features of the Wadi. Al-Saud developed lineament map and lineament frequency map that show the central part of the Wadi has many fracture zones with high density. The high density fracture zones allow the surface water to percolate downward through rocks and soil and recharge the potential zone. Drainage density map developed by Al-Saud in 2009 showed that the high density drainage was found in the middle of the wadi. The hypothesis developed by the Al-Saud and the present results of spatio-temporal difference with NDVI assessment in the part of the Wadi support each other.

Another study, also conducted by Al-Saud in 2009 about the watershed characterization of Wadi Auranah, calculated the average rainfall from Tropical Rainfall Mapping Mission (TRMM) data is 451 million m^3 per year are about 145 m^3 per km^2. This is not the optimum for the recharge of aquifer but there is a difference of precipitation from catchment and flood plain area of the Wadi. High lands received about 300 mm while plains received about 50 mm (Al-Saud, 2010). This study also reveals the relief gradient is 0.58 and mean catchment slope is 1.71 leading to the hypothesis that the run off in the catchment is fast while towards the plain in wadi it is slow. The wastewater treatment plant is located in the plains of the Wadi, near the Wadi courses, where the slope is low. Therefore, this place in the lower middle of the Wadi with lush vegetation receives enough water to recharge the groundwater area.

9. Conclusion

Spatio-temporal change assessment study was conducted on the Wadi Auranah for the spatial change of vegetation cover in the last 20 years. (Landsat satellite image of TM 1990, ETM+ 2000, 2010 and OLI 2013 were utilized for processing and analyzing. Spectral change assessment of each image revealed the increasing trend of vegetation in the central part of the Wadi. NDVI process on the images further enhanced vegetation on images and assists to calculate precisely the increasing rate in vegetation covering the area. About 73 km^2 of area has been calculated in the last 20 years in this area. Geographical location of the Wadi, utility of the water from the treatment plants and results of previous studies of geo-spatial techniques on Wadi Auarnah favor the potential of land and groundwater recharge conditions of this area. The further planning for afforestation and land use for cultivation will share the environmental and economic prosperity of the country.

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References

Abdulrahman A. (2012), Vegetation analysis of Wadi Al-Jufair, a hyper-arid region in Najd, Saudi Arabia, *Saudi Journal of Biological Sciences*, **19**, 357-368.

Ahmed Abdelwareth (2004), The Final Report of new and existing Networks of Water and Sanitation in Makkah, Advisory Board, Ministry of Water and Electricity, General Directorate of Water in Makkah.

Al Saud M. (2009), Morphometric Analysis of Wadi Aurnah Draiange System, Western Arabian Peninsula, *The open Hydrology Journal,* **3**, 1-10.

Al Saud M. (2009), Watershed Characterization of Wadi Urnah, Western Arabian Peninsula, *Journal of Water Resource and Protection*, **1**, 316-324.

Al Saud M. (2010), Mapping Potential Areas for Groundwater Storage in Wadi Aurnah Basin, Western Arabian Peninsula, Using Remote Sensing And Geographic Information System Techniques, *Hydrology Journal*, **18**, 1481-1495.

Ali H.S., Mohmmad H.Q. and Mohemad I.M. (2010), Digital Elevation Model and Multivariate Statistical Analysis of Morphometric Parameters of some Wadis, Western Saudi, *Arabian Journal of Geoscience*, **5**(1), 147-157.

Alley W.M., Healy R.W., LaBaugh J.W. and Reilly T.E. (2002), Flow and storage in groundwater systems, *Science*, **296,** 1985–1990.

Bhanderi A.K. (2012), Feature Extraction using Normalized Difference Vegetation Index (NDVI): a Case Study of Jabalpur City, 2nd International Conference on Communication, Computing & Security [ICCCS-2012], *Procedia Technology*, **6**, 612-621.

Brown J.C., Kastens J.H., Coutinho A.C., de Castro Victoria D. and Bishop C.R. (2013), Classifying multiyear agricultural land use data from Mato Grosso using time-series MODIS vegetation index data, *Remote Sensing of Environment,* **130**, 39–50.

Cui Y.P., Liu J.Y., Hu Y.F., Kuang W.H. and Xie Z.L. (2012), An Analysis of Temporal Evolution of NDVI in Various Vegetation Climate Regions in Inner Mongolia, China, *Procedia Environmental Sciences,* **13**, 1989-1996.

Ding Y., Zhao K., Zheng X. and Jiang T. (2014),Temporal dynamics of spatial heterogeneity over cropland quantified by time-series NDVI, near infrared and red reflectance of Landsat 8 OLI imagery, *International Journal of Applied Earth Observation and Geoinformation,* **30**, 139-145.

El Nahry A.H., Ali R.R. and El Baroudy A.A. (2011), An approach for precision farming under pivot irrigation system using remote sensing and GIS techniques, *Agricultural Water Management,* **98**(4), 517-531.

Erini S.P. (2011), Identification of Lineaments with possible structural Origin using ASTER Images and DEM derived Products in Western Crest, Greece, Proc. European Association for Remote Sensing Laboratories (EARsel), Edenburg, UK.

Goswami S., Gamon J.A. and Tweedie C.E. (2011), Surface hydrology of an arctic ecosystem: Multiscale analysis of a flooding and draining experiment using spectral reflectance, Journal of Geophysical Research, 116, G00107. doi:10.1029/2010JG001346

Jia K., Liang S., Zhang L., Wei X., Yao Y. and Xie X. (2014), Forest cover classification using Landsat ETM+ data and time series MODIS NDVI data, *International Journal of Applied Earth Observation and Geoinformation*, **33**, 32-38.

John A.G. (2013), Spatial and temporal in primary productivity in coastal Alakan tendra: Decreased vegetation growth following earlier snow melt, *Remote Sensing of Environment,* **129**,144-153.

Ortega M.F. (2014), Gas monitoring methodology and application to CCS projects as defined by atmospheric and remote sensing survey in the natural analogue of campo de Calatrava, *Global Nest Journal,* **16**(2), 270-280.

Papadavid G., Kountios G. and Michailidis A. (2013), Monitoring and Determination of Irrigation Demand in Cyprus, *Global Nest Journal*, **15**(1), 93-101.

Papadopoulos A., Papadopoulos F., Tziachris P., Metaxa I. and Iatrou M. (2014), Site specific Agriculture Soil Management With the use of the new Technologies, *Global Nest Journal*, **15**(1), 59-67.

Pérez González M.E., del Pilar Garcia Rodríguez, González-Quiñones V. and Jiménez Ballesta R. (2006), Spatial Variability of the Soil Quality in the surroundings soil lake environment, *Environmental Geology*, **51**, 143-149, DOI 10.1007/s00254-006-0317-y.

Raynolds M.K., Comiso J.C., Walker D.A.N and Verbyla D. (2008), Relationship between satellite-derived land surface temperatures, arctic vegetation types, and NDVI, *Remote Sensing of Environment*, **112**, 1884-1894.

Rudolf L., Christian S., Christoph S. and Rudolf, R., (2012), International Water Research Alliance Saxony (IWAS). TU Desden, UFZ, TU Darmstadt,GIZ. Web site: http://www.ufz.de/iwassachsen/index.php?en=18029

Seeboonruang U. (2014), An empirical Decomposition of Deep Groundwater Time Series and Possible link to Climatic Variability, *Global Nest Journal*, **16**(1), 87-103.

Xiao X.M., Boles S., Liu J., Zhuang D. and Liu M. (2002), Characterization of forest types in Northeastern China, using multi-temporal SPOT-4 vegetation sensor data, *Remote Sensing of Environment*, **82**, 335–348.

Yang Y., Zhua J., Zhao C., Liua S. and Tong X. (2011), Spatial continuity study of NDVI was based on kriging and BPNN algorithm, *Mathematical and Computer modeling*, **54**, 1138-114.