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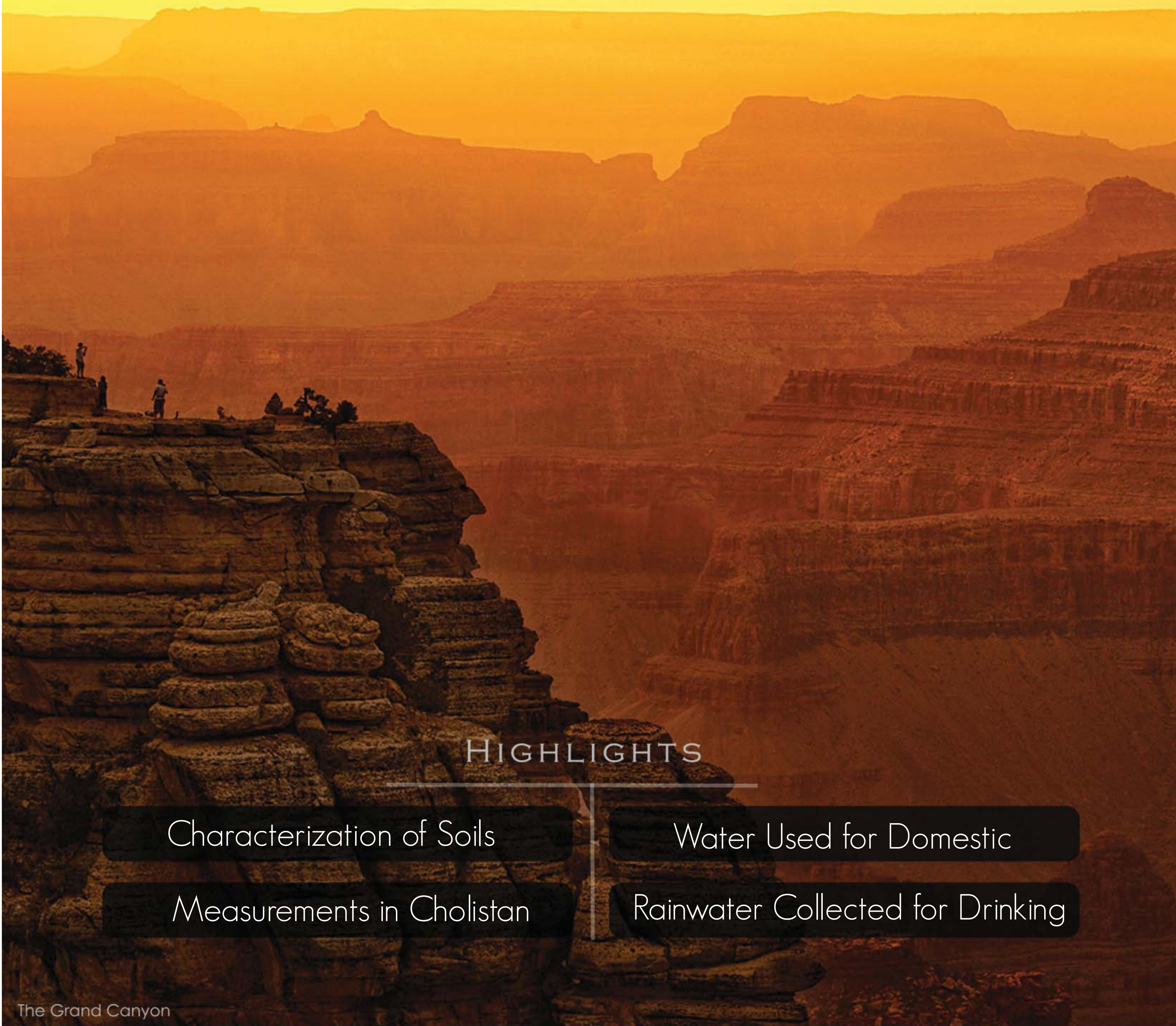

HIGHLIGHTS

- Characterization of Soils
- Measurements in Cholistan
- Water Used for Domestic
- Rainwater Collected for Drinking

The Grand Canyon

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Landsat ETM+ and MODIS EVI/NDVI Data Products for Climatic Variation and Agricultural Measurements in Cholistan Desert

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Abstract - The Landsat ETM+ has shown great potential in agricultural mapping and monitoring due to its advantages over traditional receive procedures in terms of cost effectiveness and timeliness in availability of information over larger areas and ingredient the temporal dependence of multitemporal image data to identify the changing pattern of vegetation cover and consequently enhance the interpretation capabilities. Integration of multi-sensor and multi-temporal satellite data effectively improves the temporal attribute and accuracy of the results. Since 2000, NASA's MODIS sensors (onboard Terra satellite) has provided composite data at 16-days interval to produce estimates of gross primary production (GPP) that compare well with direct measurements. The MODIS Enhanced Vegetation Index (EVI) and Normalized Difference Vegetation Index (NDVI) which are independent of climatic drivers, also appears as valuable surrogate for estimation of seasonal patterns in GPP.

Keywords : Cholistan desert, EVI, Landsat ETM+, MODIS, NDVI, vegetation phenology.

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LANDSAT ETM+ AND MODIS EVINDVI DATA PRODUCTS FOR CLIMATIC VARIATION AND AGRICULTURAL MEASUREMENTS IN CHOLISTAN DESERT

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Landsat ETM+ and MODIS EVI/NDVI Data Products for Climatic Variation and Agricultural Measurements in Cholistan Desert

Farooq Ahmad [α], Qurat-ul-ain Fatima [σ] & Hira Jannat Butt [ρ]

Abstract - The Landsat ETM+ has shown great potential in agricultural mapping and monitoring due to its advantages over traditional receive procedures in terms of cost effectiveness and timeliness in availability of information over larger areas and ingredient the temporal dependence of multi-temporal image data to identify the changing pattern of vegetation cover and consequently enhance the interpretation capabilities. Integration of multi-sensor and multi-temporal satellite data effectively improves the temporal attribute and accuracy of the results. Since 2000, NASA's MODIS sensors (onboard Terra satellite) has provided composite data at 16-days interval to produce estimates of gross primary production (GPP) that compare well with direct measurements. The MODIS Enhanced Vegetation Index (EVI) and Normalized Difference Vegetation Index (NDVI) which are independent of climatic drivers, also appears as valuable surrogate for estimation of seasonal patterns in GPP. The required data preparation for the integration of MODIS data into GIS is described with focus on the projection from the MODIS/Sinusoidal projection to the national coordinate systems. However, its low spatial resolution has been an impediment to researchers pursuing more accurate classification results. This paper summarizes a set of remote sensing applications of MODIS EVI/NDVI data products in estimation and monitoring of seasonal and inter annual ecosystem dynamics which were designed for studying climatic variation and agricultural measurements and can also be implemented in the drylands (Cholistan Desert) of Pakistan.

Keywords : Cholistan desert, EVI, Landsat ETM+, MODIS, NDVI, vegetation phenology.

I. Introduction

The Moderate Resolution Imaging Spectroradiometer (MODIS) is a key instrument onboard the Terra and Aqua satellite platforms (Huete et al., 2006; Carrão et al., 2008). Terra's orbit around the Earth is timed so that it passes from north to south across the equator in the morning, while Aqua passes south to north over the equator in the afternoon (Salomonson and Toll, 1991; GSFC/NASA, 2003; Huete, 2005). The MODIS Terra and MODIS Aqua are viewing the entire Earth's surface every 1 to 2 days, acquiring data in 36 spectral bands (Huete, 2005). These data are being used to improve our understanding of land surface global dynamics and processes. The MODIS is playing an important role in the development of validated, global data products useful to interactive Earth system models, able to predict climatic variation or environmental change accurately enough to assist policy makers in making sound decisions concerning the protection of the planet (Riggs et al., 1998; Huete, 2005). There are now over 12 years of MODIS Terra data (first image, February 24, 2000) and 10 years of MODIS Aqua data (first image, June 26, 2002), available producing high quality scientific products with calibration specifications of 2% reflectance and 5% radiance and geolocation of 50 m (Huete, 2005).

II. Study Area

Cholistan Desert (Figure 1) is an extension of the Great Indian Desert, covering an area of 26,330 km^2, lies within the southeast quadrant of Punjab province, placed between 27° 42' and 29° 45' North latitude and 69° 52' and 73° 05' East longitude (Ahmad, 2005; 2008; 2012).

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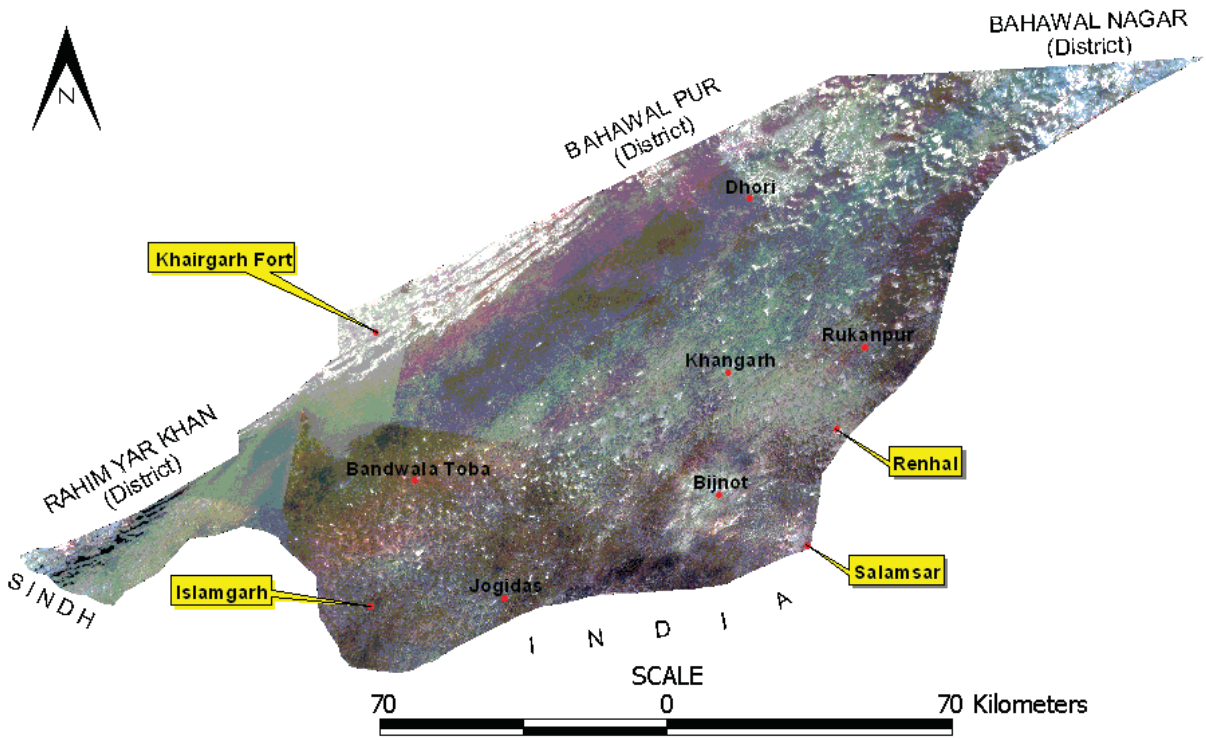

Figure 1: Cholistan Desert - Landsat ETM+ 2003 mosaic image. Source: http://glovis.usgs.gov/

III. Research Design and Methods

The MODIS EVI/NDVI data products for Cholistan Desert were acquired, in this case MOD13Q1 (MODIS Terra_250 m), MOD13A1 (MODIS Terra_500 m), MYD13Q1 (MODIS AQUA_ 250 m), MYD13A1 (MODIS AQUA_500 m) data were downloaded from the Land Processes Distributed Active Archive Center (LPDAAC). Tile number covering this area is h24v06, reprojected from the Integerized Sinusoidal projection to a Geographic Lat/Lon projection (Figure 2), and Datum WGS84 (GSFC/NASA, 2003; Ahmad, 2012a; 2012c).

The MODIS is an optical scanner that measures Earth radiance in 36 bands, ranging from 0.46 μm to 14.39 μm. The MODIS is a key instrument onboard the Terra satellite. The MODIS provides images over a given pixel of land just as often as the Advanced Very High Resolution Radiometer (AVHRR) but in much finer detail and with measurements in a greater number of wavelengths using detectors that were specifically designed for measurements of land surface dynamics (Huete, 2005).

Spectral indices of vegetation, based on satellite observations in the near-infrared (NIR) and visible (usually red) wavebands are widely employed as measures of green vegetation density. The index most commonly used is the Enhanced Vegetation Index (EVI), although a number of alternative indices based on the same two spectral bands have been developed, used mostly with the aim of reducing the sensitivity of the index to extraneous factors such as soil background or the atmosphere (Justice et al., 2002).

Vegetation indices among other methods have been reliable in monitoring vegetation change (Glenn et al., 2008). One of the other most widely used indices for vegetation monitoring is the Normalized Difference Vegetation Index (NDVI), because the vegetation differential absorbs visible incident solar radiation and reflects much of the Near Infra-Red (NIR). Data on vegetation biophysical characteristics can be derived from visible and NIR and mid-infrared portions of the electromagnetic spectrum (EMS). The NDVI approach is based on the fact that healthy vegetation has low reflectance in the visible portion of the EMS (Huete et al., 2002; Huete, 2005) due to chlorophyll and other pigment absorption and has high reflectance in the NIR because of the internal reflectance by the mesophyll spongy tissue of green leaf. The NDVI can be calculated as a ratio of red and the NIR bands of a sensor system (Huete, 2005).

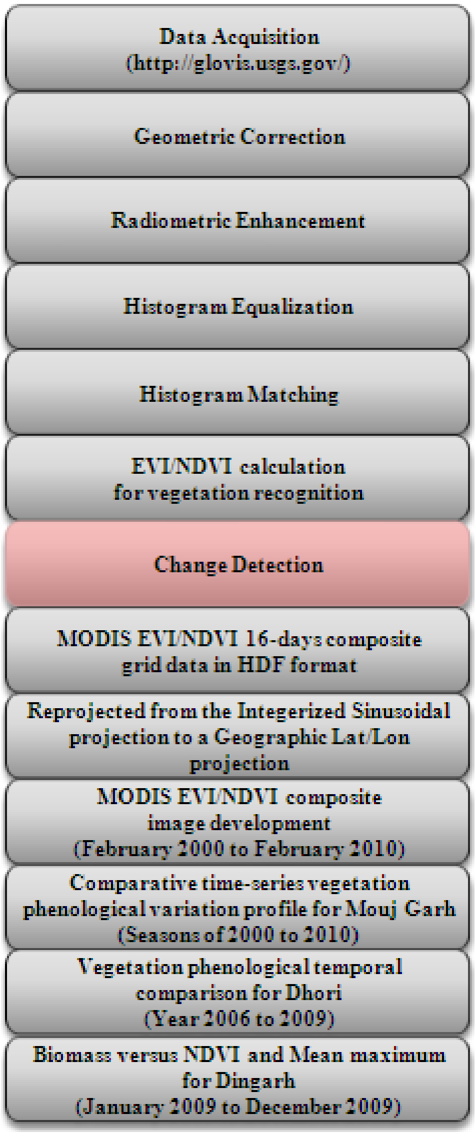

Figure 2 : Scheme for research design and methods.

The NDVI values range from -1 to +1; because of high reflectance in the NIR portion of the EMS, healthy vegetation is represented by high NDVI values between 0.1 and 1 (Liu and Huete, 1995; USGS, 2008; 2010). Conversely, non-vegetated surfaces such as water bodies yield negative values of NDVI because of the electromagnetic absorption property of water. Bare soil areas represent NDVI values which are closest to 0 due to high reflectance in both the visible and NIR portions of the EMS (Townshend, 1992). The NDVI is related to the absorption of photosynthetically active radiation and basically measures the photosynthetic capability of leaves, related to vegetative canopy resistance and water vapour transfer (Wan, 2003; Rahman et al., 2004).

Present research aims to reveal vegetation change using multi-temporal satellite data (Singh, 1989). ERDAS Imagine software has been used to generate the false colour composite, by combining the near infrared, red and green bands (4, 3, 2 respectively) for Landsat ETM+ images of 1999 and 2003 (path 149, row 40; path 150, row 40 and 41; path 151, row 40 and 41). This was carried out for vegetation recognition, because chlorophyll in plants reflects very well for the near infrared band compared to the visible band of the electromagnetic spectrum (Hatfield et al., 1984). Ground control points obtained using Global Positioning System (GPS) from locations (Steven, 1987; Shaw and Turner, 2000; Brook and Kenkel, 2002) in relation to the classes of the research area has been plotted on Landsat image.

IV. Vegetation Indices

The Global MODIS vegetation indices, produced at 16-days and 250, 500, 1000 m and Climate Modeling Grid spatial resolutions (Huete, 2005), provide consistent spatial and temporal comparisons of terrestrial vegetation canopy greenness, a composite property of leaf area, chlorophyll and canopy structure (Gallo et al., 1985; Chen et al., 2007).

Two vegetation index products are derived from atmosphere corrected, bidirectional red, near-infrared, and blue surface reflectances that are masked for water, clouds and cloud shadow; the MODIS NDVI which provides continuity with NOAA's AVHRR (Holben, 1986; Cihlar and Huang, 1994; DeFries et al., 1995; Verhoef et al., 1996; Ramesh et al., 2003; Potter et al., 2005; 2007) time series record for historical and climate applications, and the enhanced vegetation index (EVI), which minimizes canopy-soil and aerosol variations and improves sensitivity over dense vegetation conditions (Qi et al., 1994). The two products more effectively characterize a global range of vegetation states and processes, and improve upon the extraction of canopy biophysical parameters (Jiang et al., 2008).

V. Modis Vegetation Index Algorithm

In order to generate the proper Vegetation Index quality data, the algorithm will make a last run and reanalyze the input quality information (GSFC/NASA, 2003). Because the VI quality data structure is different than that of the input, the algorithm will, both pass input QA fields untouched to the VI quality, and generate new QA fields that are specific to the Vegetation Index. The MODIS VI quality data is 16 bit long, and contains 10 different QA fields. Although MODIS quality data is hard to deal with as it is, it is in the user's benefit to realize how valuable this data could be (Huete, 2005). VI's are most useful as (GSFC/NASA, 2003):

- Radiometric measures of the amount, structure, and condition of vegetation
- Indicators of seasonal and inter-annual variations in vegetation useful in change detection studies, phenology observations, and vegetation mapping, and

- Intermediaries in the assessment of various biophysical vegetation parameters, including:

  - o Green cover fraction
  - o Biomass
  - o Leaf area index
  - o Fraction of absorbed photosynthetically active radiation.

VI. Results

The EVI and NDVI models were applied upon 1999 and 2003 ETM+ images (Figure 3a, b; Table 1) and further change detection technique was used for EVI and NDVI calculation. The findings showed that the sand dunes have undulating to steep topography, with the dunes lying parallel to each other and connected by small streamers. They are very well drained and have coarse textured, structure less soils derived from aeolian material (Khan, 1993). The near level to gently sloping areas have deep to very deep sandy soils which are very well drained, calcareous and coarse textured. Loamy soils occur on the level to near level areas with hummocks of fine sand on the surface. These soils are moderately deep, relatively well drained, calcareous and with a moderately coarse to medium texture (FAO/ADB, 1993). Clayey soils occur on level areas and are moderately deep, poorly drained, calcareous, saline-sodic, moderately fine textured to fine textured with a pH range from 8.6 to 10.0 (Baig et al., 1980; Ahmad, 2008). The soil of Cholistan Desert is productive for dryland agriculture. Groundwater is saline, it can be used for irrigation to grow salt tolerant trees, vegetables, crops and fodder grasses in non-saline, non-sodic coarse textured soils. This can occur with minimum adverse effects due to the rapid leaching of salts beyond the root zone (Ahmad, 2008).

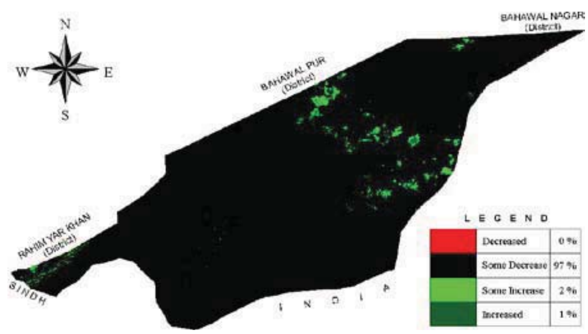

Figure 3a : Map showing change detection using EVI model. Source: After Ahmad F 2012.

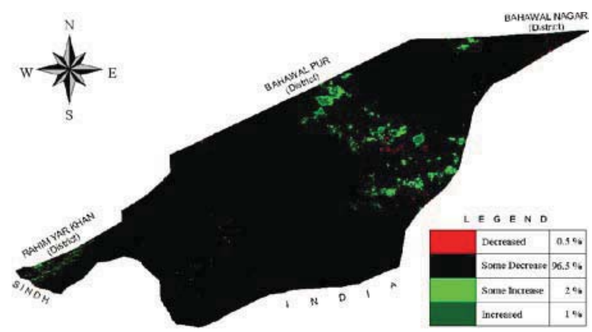

Figure 3b : Map showing change detection using NDVI model. Source: After Ahmad F 2012.

Table 1 : Vegetation matrix percentage for individual change classification.

Vegetation Indices	Decreased %	Some Decrease %	Some Increase %	Increased %
EVI	0	97	2	1
NDVI	0.5	96.5	2	1

Figure 4 shows comparative vegetation phenological variation profile for Khangarh, Cholistan Desert. MODIS EVI Terra 250 m, MODIS EVI Terra 500 m, MODIS NDVI Terra 250 m and MODIS NDVI Terra 500 m data for the year 2009 was used to evaluate green cover fraction and biomass at the same location. The result showed that EVI differs from NDVI by attempting to correct for atmospheric and background effects. EVI appears to be superior in discriminating subtle differences in areas of high vegetation density, situations in which NDVI tends to saturate. The NDVI has been used for several decades, which is advantageous for studying historical changes (Trishchenko et al., 2002). The EVI is a good indicator of the phenology of the land cover types, the research tested the contribution of EVI data to the land cover classification (Gao and Mas, 2008). Further, MODIS EVI Terra 500 m provides better result as compared to MODIS EVI Terra 250 m data. The finer the resolution of a satellite product, in time and space, results in 'higher frequency' noise. Aggregating a product to a coarser resolution generally "smooths" things out.

Figure 5 shows comparative time-series vegetation phenology metrics for Renhal, seasons of 2000 to 2010. MODIS EVI Terra 500 m and MODIS EVI Aqua 500 m data was used to evaluate green cover fraction and biomass at the same location. Differences in Terra's and Aqua's orbits result in different viewing and cloud-cover conditions for a given location. Terra satellite, the local equatorial crossing time is approximately 10:30 am in a descending node with a sun-synchronous, near-polar, circular orbit. Aqua satellite, the local equatorial crossing time is approximately 1:30 pm in an ascending node with a sun-synchronous, near-polar, circular orbit (Salomonson and Toll, 1991; GSFC/NASA, 2003; Huete, 2005).

The result showed that MODIS EVI Terra 500 m data provides better result as compared to MODIS EVI Aqua because around noon on a sunny, dry day with no clouds and no pollution is the best atmospheric conditions for remote sensing in the visible portion of the spectrum. Comparative time-series vegetation phenology metrics showed that climate was stable (start/end) and land degradation or desertification can't be seen during the seasons of 2000 to 2010. Variation in biomass and soil productivity can be seen due to summer monsoon especially in the years 2000, 2001, 2003 and 2007; indicates that the soil at Renhal is productive and small scale dryland agriculture can be practiced using rainwater or ground saline water for irrigation.

Figure 6 shows comparative time-series vegetation phenological variation profile for Mouj Garh, seasons of February 2000 to February 2010 at 16-days interval. MODIS EVI Terra 500 m and MODIS NDVI Terra 500 m data was examined for evaluation of climatic variation in the desert environment. The finding showed that climate at Mouj Garh was stable (start/end) and land degradation can't be seen thoughout the decade 2000 to 2010. The soil at Mouj Garh is productive and irrigated through perennial canal system.

Figure 7 shows biomass versus NDVI and mean maximum from January 2009 to December 2009 at Dingarh, Cholistan Desert. The biomass and NDVI demonstrated clear inter-seasonal consistency indicated by the larger amount of biomass and the corresponding higher NDVI values in January, February, March, April, August, September, October, November and December 2009 and the smaller amount of biomass in May, June and July 2009. The variation in biomass are fairly well represented by the changes of NDVI. The inter-seasonal (Gazdar, 1987) consistency of NDVI and biomass support the common use of NDVI to study vegetation response to climate variation (Anyamba and Eastman, 1996; Kogan, 1997; Li and Guo, 2012).

Figure 8 shows comparative time-series vegetation phenological profile for Bandwala Toba, Cholistan Desert, year 2002 to 2009. The profile showed that climate was stable (start/end) and land degradation can't be seen. The year 2003 showed the maximum NDVI values during June to September. The profile also indicates that green cover fraction, biomass productively and soil moisure increased due to summer monsoon at Bandwala Toba. The year 2009 showed minimum NDVI values during June and July due to extreme temperature. The NDVI is successful as a vegetation measure (Choudhury, 1987; Jakubauskas et al., 2002; Chen et al., 2006; Zoran and Stefan, 2006). The strength of the NDVI is in its ratioing concept (Moran et al., 1992), which reduces many forms of multiplicative noise (illumination differences, cloud shadows, atmospheric attenuation, and certain topographic variations) present in multiple bands (Liu and Huete, 1995; Chen et al., 2002). The NDVI is referred to as the 'continuity index' to the existing 20+ year NOAA-AVHRR derived NDVI (Rouse et al., 1973) time series (Moran et al., 1992; Verhoef et al., 1996; Jakubauskas et al., 2001; Huete et al., 2002; Zoran and Stefan, 2006; USGS, 2010; Ahmad 2012b), which could be extended by MODIS data to provide a longer term data record for use in operational monitoring studies (Chen et al., 2003).

Figure 9 shows vegetation phenological temporal comparison for Dhori, period 2006 to 2009. The temporal curves indicate that the other vegetation phenology metrics, climate was stable, green cover fraction, and biomass productively increased due to summer monsoon. The profile showed maximum biomass in 2008 and minimum in 2009. Dhori is located at the northern part of the desert and small scale agriculture is practiced in summer season. Year-to-year fluctuations of rainfall in the desert provide an opportunity to characterize and assess the temporal dynamics of desertification or land degradation processes and phenology. Such information was retrieved and analyzed by combined use of satellite imageries in the reflectivity and thermal spectral bands (Karnieli and Dall'Olmo, 2003).

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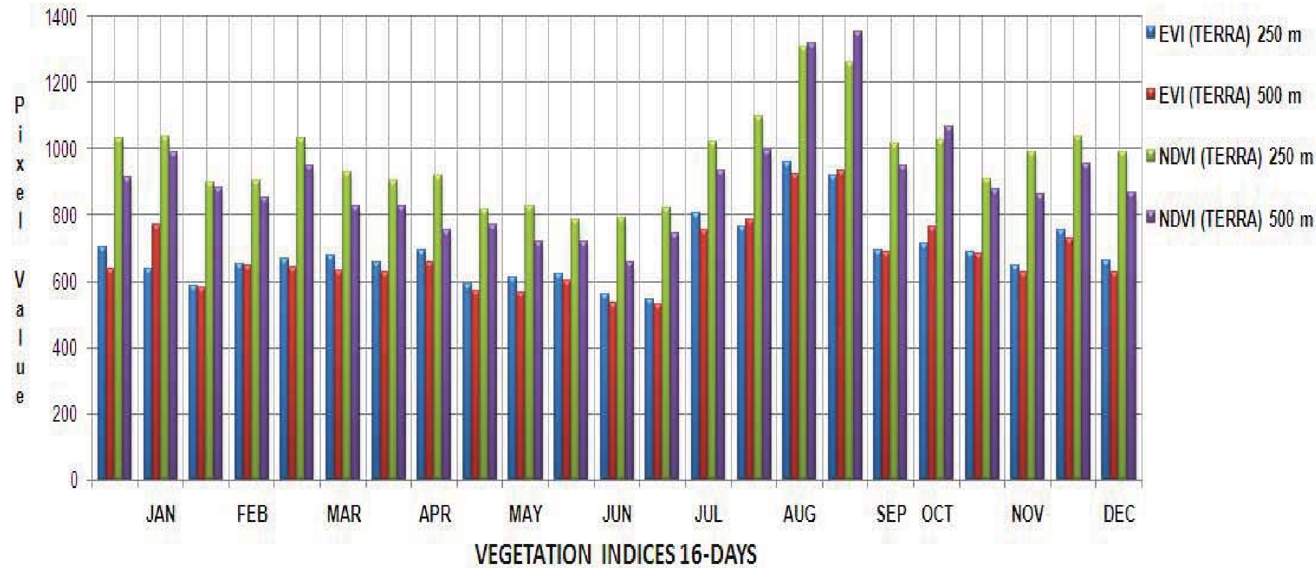

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Figure 4 : Comparative vegetation phenological variation profile for Khangarh, Cholistan Desert, Year 2009.

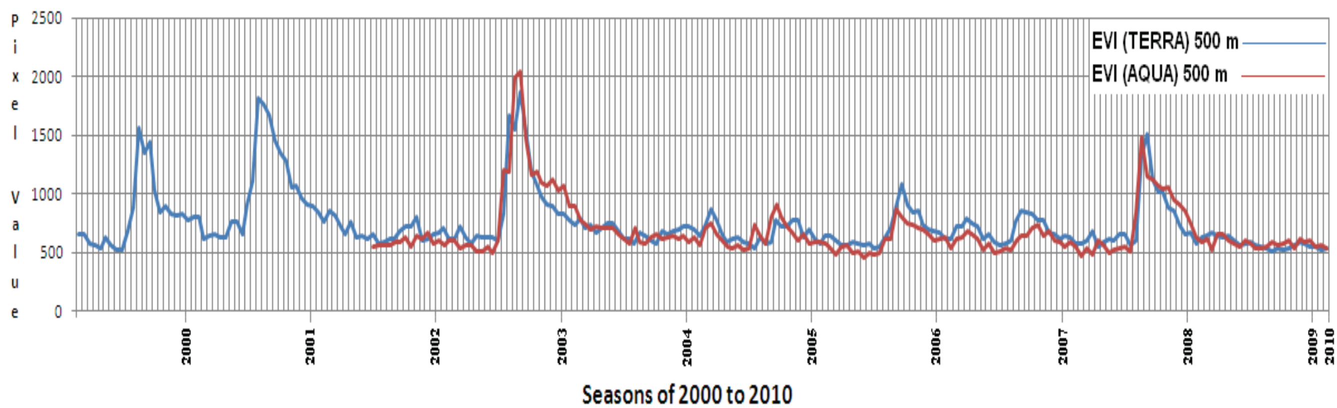

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Figure 5 : Comparative time-series vegetation phenology metrics for Renhal, Cholistan Desert.

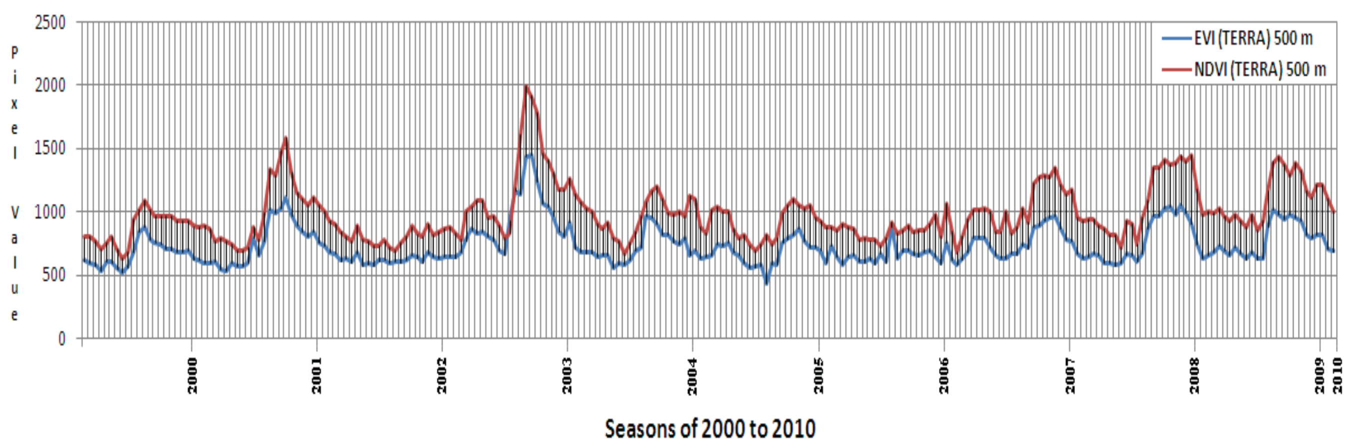

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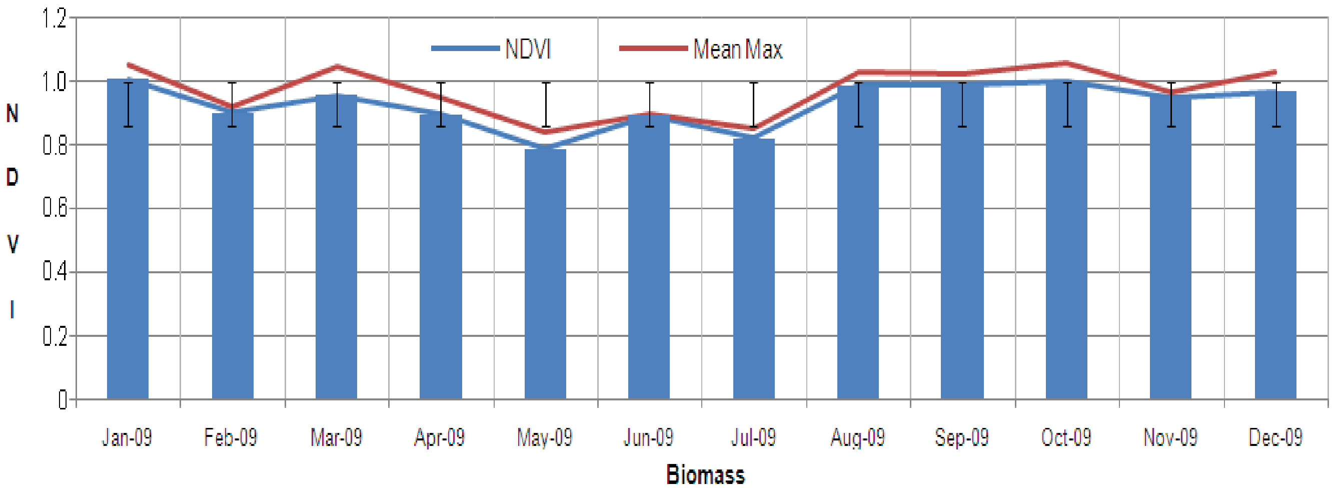
Figure 6 : Comparative time-series vegetation phenological variation profile for Mouj Garh, Cholistan Desert.



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Biomass versus NDVI and mean maximum from January 2009 to December 2009 at Dingarh, Cholistan Desert.
(The error bars of biomass are shown with 1 standard deviation).

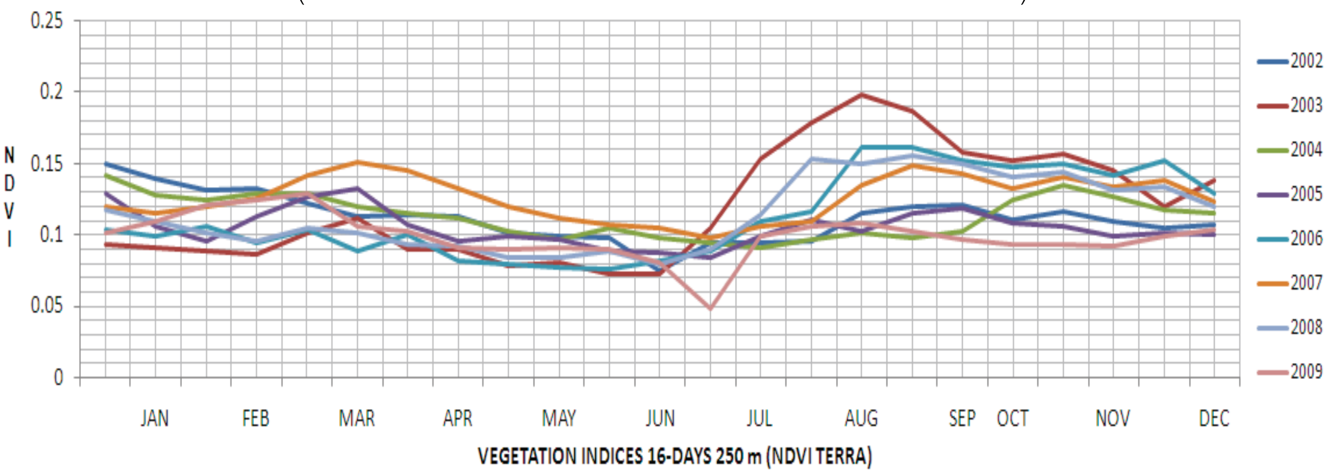

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Figure 8 : Comparative time-series vegetation phenological profile for Bandwala Toba, Cholistan Desert, Year 2002 to 2009.

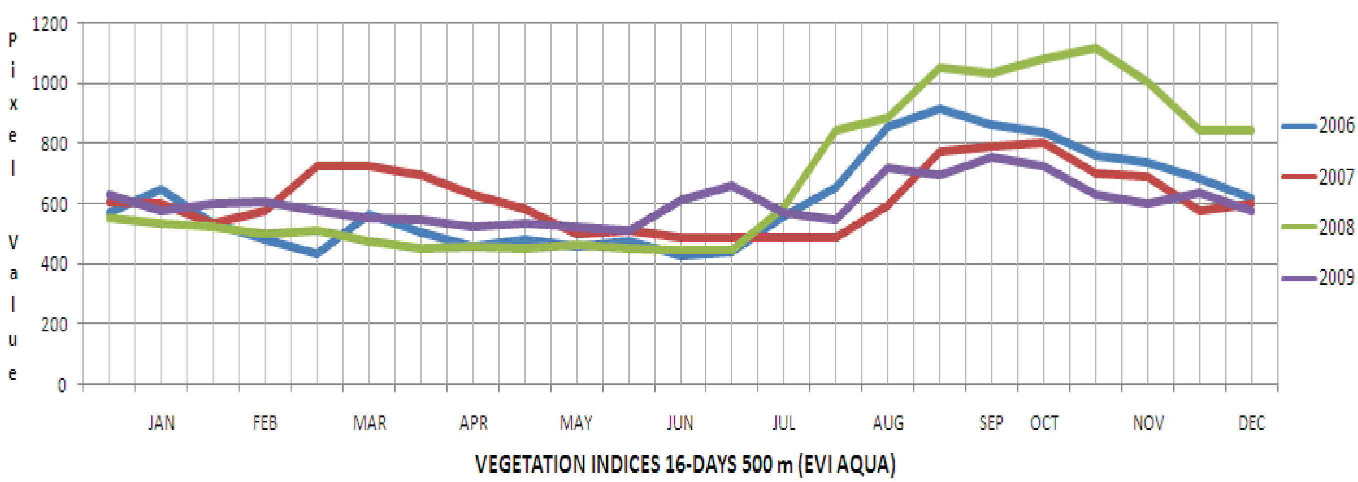

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Figure 9 : Vegetation phenological temporal comparison for Dhori, Cholistan Desert, Year 2006 to 2009.

VII. Discussion and Conclusions

This communication presents a new methodology for studying vegetation phenology using remote sensing (Charbonneau and Kondolf, 1993). The methodology provides a flexible means to monitor vegetation dynamics over large area using remote sensing. Initial results using MODIS data for the Cholistan Desert demonstrate that the method provides realistic results that are geographically and ecologically consistent with the known behaviour of vegetation in the desert. In particular, the MODIS-based estimates of green up onset, maturity onset, and dormancy onset show strong spatio-temporal patterns that also depend on land cover type (Baret and Guyot, 1991; Charbonneau and Kondolf, 1993; Justice et al., 1998).

The methodology presented in this research paper has several desirable properties. Since it treats each pixel individually without setting thresholds or empirical constants, the method is globally applicable (Vermote and Vermeulen, 1999; Vermote et al., 2002). Further, it is capable of identifying phenologic behaviour characterized by multiple growth and senescence periods within a single year, which is common in semiarid regions. Finally, because the method is tied to a specific calendar period, it provides the potential to monitor vegetation phenology in near real time (Campbell, 1987; Lillesand and Kiefer, 1994; Lillesand et al., 2004).

Phenology is the study of the times of recurring natural phenomena. One of the most successful of the approach is based on tracking the temporal change of a vegetation index such as EVI or NDVI. The evolution of vegetation index exhibits a strong correlation with the typical green vegetation growth stages (Zhao et al., 2005). The results (temporal curves) can be analyzed to obtain useful information such as the start/end of vegetation growing season. However, remote sensing based phenological analysis results are only an approximation of the true biological growth stages. This is mainly due to the limitation of current space based remote sensing, especially the spatial resolution, and the nature of vegetation index. A pixel in an image does not contain a pure target but a mixture of whatever intersected the sensor's field of view (Gao and Mas, 2008).

Validation is a key issue in remote sensing-based studies of phenology over large areas (Huete, 1999; Schwartz and Reed, 1999; Zhang et al., 2003; 2004). While a variety of field programs for monitoring phenology have been initiated (Schwartz, 1999; Zhang et al., 2003; 2003a; 2004), these programs provide data that are typically specie-specific and which are collected at scales that are not compatible with coarse resolution remote sensing observations.

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References Références Referencias

1. Ahmad, F. (2005). Historical and archaeological perspectives of soil degradation in Cholistan. Journal Geographic, Vol. 10, pp.31-35.
2. Ahmad, F. (2008). Runoff farming in reducing rural poverty in Cholistan desert. Revista Sociedade & Natureza, Vol. 20(1), pp.177-188.
3. Ahmad, F. (2012). Spectral vegetation indices performance evaluated for Cholistan Desert. Journal of Geography and Regional Planning, Vol. 5(6), pp.165-172.
4. Ahmad, F. (2012a). A review of remote sensing data change detection: Comparison of Faisalabad and Multan Districts, Punjab Province, Pakistan. Journal of Geography and Regional Planning, Vol. 5(9), pp.236-251.
5. Ahmad, F. (2012b). NOAA AVHRR satellite data for evaluation of climatic variation and vegetation change in the Punjab Province, Pakistan. Journal of Food, Agriculture & Environment, Vol. 10(2), pp.1298-1307.
6. Ahmad, F. (2012c). Detection of change in vegetation cover using multi-spectral and multi-temporal information for District Sargodha. Revista Sociedade & Natureza, Vol. 24(3), pp.557-571.
7. Anyamba, A. and Eastman, J. (1996). Interannual variability of NDVI over Africa and its relationship to El Ninõ/Southern Oscillation. International Journal of Remote Sensing, Vol. 17(13), pp.2533-2548.
8. Baig, M., Akram, M. and Hassan, M. (1980). Possibilities for range development in Cholistan desert as reflected by its physiography and soils. The Pakistan Journal of Forestry, pp.61-71.
9. Baret, F. and Guyot, G. (1991). Potentials and limits of vegetation indices for LAI and APAR assessment. Remote Sensing of Environment, Vol. 35, pp.161-173.
10. Brook, R.K. and Kenkel, N.C. (2002). A multivariate approach to vegetation mapping of Manitoba's Hudson Bay Lowlands. International Journal of Remote Sensing, Vol. 23(21), pp.4761-4776.
11. Campbell, J.B. (1987). Introduction to Remote Sensing. The Guilford Press, New York, p.281.
12. Carrão, H., Gonçalves, P. and Caetano, M. (2008). Contribution of multispectral and multitemporal information from MODIS images to land cover classification. Remote Sensing of Environment, Vol. 112(3), pp.986-997.

13. Charbonneau, R. and Kondolf, G.M. (1993). Land use change in California, USA: Nonpoint source water quality impacts. Environmental Management, Vol. 17, pp.453-460.
14. Chen, P.Y., Fedosejevs, G., Tiscareño-LóPez, M. and Arnold, J.G. (2006). Assessment of MODIS-EVI, MODIS-NDVI and VEGETATION-NDVI composite data using agricultural measurements: An example at corn fields in western Mexico. Environmental Monitoring and Assessment, Vol. 119, pp.69-82.
15. Chen, P.Y., Srinivasan, R., Fedosejevs, G., Báez-González, A.D. and Gong, P. (2002). Assessment of NDVI composite using merged NOAA-14 and NOAA-15 AVHRR sata. Geographic Information Sciences, Vol. 8(1), pp.31-38.
16. Chen, P.Y., Srinivasan, R., Fedosejevs, G. and Kiniry, J.R. (2003). Evaluating different NDVI composite techniques using NOAA-14 AVHRR data. International Journal of Remote Sensing, Vol. 24, pp.3403-3412.
17. Chen, Z., Hu, C. and Muller-Karger, F. (2007). Monitoring turbidity in Tampa Bay using MODIS/Aqua 250-m imagery. Remote Sensing of Environment, Vol. 109(2), pp.207-220.
18. Choudhury, B.J. (1987). Relationship between vegetation indices, radiation absorption, and net photosynthesis evaluated by sensitivity analysis. Remote Sensing of Environment, Vol. 22, pp.209-233.
19. Cihlar, J. and Huang, F. (1994). Effect of atmospheric correction and viewing angle restriction on AVHRR data composites. Canadian Journal of Remote Sensing, Vol. 20(2), pp.132-137.
20. DeFries, R., Hansen, M. and Townshend, J.R.G. (1995). Global discrimination of land cover from metrics derived from AVHRR Pathfinder-data sets. Remote Sensing of Environment, Vol. 54, pp.209-222.
21. FAO/ADB (1993). Cholistan area development project, Report No. 59/53 ADB-PAK 58 (Final version). Food and Agriculture Organization (FAO), Rome, Italy, pp.14-59.
22. Gallo, K.P., Daughtry, C.S. and Bauer, M.E. (1985). Spectral estimation of absorbed photosynthetically active radiation in corn canopies. Remote Sensing of Environment, Vol. 17, pp.221-232.
23. Gao, Y. and Mas, J.F. (2008). MODIS EVI as an ancillary data for an object-based image analysis with multi-spectral MODIS data. URL:http://www.isprs.org/proceedings/XXXVIII/4-C1/Sessions/Session5/6590_YGao_Proc_ poster.pdf. (Accessed on September 07, 2011).
24. Gazdar, M.N. (1987). Environmental crisis in Pakistan. The Open Press, Kuala Lumpur, pp.7-15.
25. Glenn, E.P., Huete, A.R., Nagler, P.L. and Nelson, S.G. (2008). Relationship between remotely-sensed vegetation indices, canopy attributes and plant physiological processes: What vegetation indices can and cannot tell us about the landscape. Sensors, Vol. 8, pp.2136-2160.
26. GSFC/NASA (2003). MODIS technical specifications. URL: http://modis.gsfc.nasa.gov/about/specs.html. (Accessed on September 05, 2011).
27. Hatfield, J.L., Asrar, G. and Kanemasu, E.T. (1984). Intercepted photosynthetically active radiation estimated by spectral reflectance. Remote Sensing of Environment, Vol. 14, pp.65-75.
28. Holben, B.N. (1986). Characteristics of maximum values composite images from temporal AVHRR data. International Journal of Remote Sensing, Vol. 7, pp.1417-1434.
29. Huete, A.R. (2005). Global variability of terrestrial surface properties derived from MODIS visible to thermal-infrared measurements. Proceedings of IGARSS 05 Geoscience and Remote Sensing Symposium, 25-29 July 2005. URL: http://ieeexplore.ieee.org/iel5/10226/32601/01526782.pdf. (Accessed on September 05, 2011).
30. Huete, A.R., Didan, K., Miura, T., Rodriguez, E.P., Gao, X. and Ferreira, L.G. (2002). Overview of the radiometric and biophysical performance of the MODIS vegetation indices. Remote Sensing of Environment, Vol. 83(1-2), pp.195-213.
31. Huete, A.R., Didan, K., Shimabukuro, Y.E., Ratana, P., Saleska, S.R., Hutyra, L.R., Yang, W., Nemani, R.R. and Myneni, R. (2006). Amazon rainforests green-up with sunlight in dry season. Geophysical Research Letters, 33(L06405), 4 p.
32. Huete, A.R., Justice, C. and Leeuwen, van W. (1999). MODIS vegetation index (MOD 13), Algorithm theoretical basis document ATBD13. URL: http://modis.gsfc.nasa.gov/data/atbd/atbd_mod13.pdf. (Accessed on September 05, 2011).
33. Jakubauskas, M.E., David, R. and Kastens, J.H. (2002). Crop identification using harmonic analysis of time-series AVHRR NDVI data. Computers and Electronics in Agriculture, Vol. 37(1-3), pp.127-139.
34. Jakubauskas, M.E., Legates, D.R. and Kastens, J.H. (2001). Harmonic analysis of time-series AVHRR NDVI data. Photogrammetric Engineering & Remote Sensing, Vol. 67(4), pp461-470.
35. Jiang, Z., Huete, A.R., Didan, K. and Miura, T. (2008). Development of a two-band Enhanced Vegetation Index without a blue band. Remote Sensing of Environment, Vol. 112(10), pp. 3833-3845.
36. Justice, C., Vermote, E., Townshend, J.R.G., DeFries, R., Roy, D.P., Hall, D.K., Salomonson, V.V., Privette, J., Riggs, G., Strahler, A., Lucht, W., Myneni, R., Knjazihhin, Y., Running, S., Nemani, R., Wan, Z., Huete, A.R., Leeuwen, van W., Wolfe, R., Giglio, L., Muller, J.P., Lewis, P. and Barnsley, M. (1998). The Moderate Resolution Imaging

Spectroradiometer (MODIS): Land remote sensing for global change research. IEEE Transactions on Geoscience and Remote Sensing, Vol. 36, pp.1228-1249.
37. Justice, C.O., Townshend, J.R.G., Vermote, E.F., Masuoka, E., Wolfe, R.E., Saleous, N., Roy, D.P. and Morisette, J.T. (2002). An overview of MODIS land data processing and product status. Remote Sensing of Environment, Vol. 83, pp.3-15.
38. Karnieli, A. and Dall'Olmo, G. (2003). Remote-sensing monitoring of desertification, phenology, and droughts. Management of Environmental Quality: An International Journal, Vol. 14(1), pp.22-38.
39. Khan, J.A. (1993). The Climate of Pakistan. Rehbar Publishers, Karachi, Pakistan, pp.9-13.
40. Kogan, F.N. (1997). Global drought watch from space. Bulletin of the American Meteorological Society, Vol. 78(4), pp.621-636.
41. Li, Z. and Guo, X. (2012). Detecting climate effects on vegetation in northern mixed prairie using NOAA AVHRR 1-km time-series NDVI data. Remote Sensing, Vol. 4, pp.120-134.
42. Lillesand, T.M. and Kiefer, R.W. (1994). Remote Sensing and Image Interpretation. 3rd Edition, John Wiley & Sons, Inc., New York, pp.203-210.
43. Lillesand, T.M., Kiefer, R.W. and Chipman, J.W. (2004). Remote Sensing and Image Interpretation. 5th Edition, John Wiley & Sons, Inc., New York, pp.178-198.
44. Liu, H.Q. and Huete, A.R. (1995). A feedback based modification of the NDV I to minimize canopy background and atmospheric noise. IEEE Transactions on Geoscience and Remote Sensing, Vol. 33, pp.457-465.
45. Moran, M.S., Jackson, R.D., Slater, P.N. and Teillet, P.M. (1992). Evaluation of simplified procedures for retrieval of land surface reflectance factors from satellite sensor output. Remote Sensing of Environment, Vol. 41, pp.169-184.
46. Potter, C., Klooster, S., Huete, A.R. and Genovese, V. (2007). Terrestrial carbon sinks for the United States predicted from MODIS satellite data and ecosystem modeling. Earth Interactions, Vol. 11, pp.1-21.
47. Potter, C., Tan, P-N., Kumar, V., Kucharik, C., Klooster, S., Genovese, V., Cohen, W. and Healey, S. (2005). Recent history of large-scale ecosystem disturbances in North America derived from the AVHRR satellite record. Ecosystems, Vol. 8, pp.808-824.
48. Qi, J., Chehbouni, A., Huete, A.R., Kerr, Y.H. and Sorooshian, S. (1994). A modified soil adjusted vegetation index. Remote Sensing of Environment, Vol. 48, pp.119-126.
49. Rahman, Md.R., Islam, A.H.M.H. and Rahman, Md.A. (2004). NDVI derived sugarcane area identification and crop condition assessment. Planplus, Vol. 1(2), pp.1-12.
50. Ramesh, P.S., Sudipa, R. and Kogan, F. (2003). Vegetation and temperature condition indices from NOAA AVHRR data for drought monitoring over India. International Journal of Remote Sensing, Vol. 24, pp.4393-4402.
51. Riggs, G., Strahler, A., Lucht, W., Myneni, R., Knjazihhin, Y., Running, S., Nemani, R., Vermote, E., Townshend, J.R.G., DeFries, R., Roy, D., Wan, Z., Huete, A.R., Leeuwen, van W., Wolfe, R., Giglio, L., Muller, J-P., Lewis, P. and Barnsley, M. (1998). The Moderate Resolution Imaging Spectroradiometer (MODIS): Land remote sensing for global change research. IEEE Transactions on Geoscience and Remote Sensing, Vol. 36, pp.1228-1249.
52. Rouse, J.W., Haas, R.H., Schell, J.A. and Deering, D.W. (1973). Monitoring vegetation systems in the Great Plains with ERTS. Third ERTS Symposium, NASA SP-351 I, pp.309-317.
53. Salomonson, V.V. and Toll, D.L. (1991). Execution phase (C/D) spectral band characteristics of the EOS moderate resolution imaging spectrometer-Nadir (MODIS-N) facility instrument. Advances in Space Research, Vol. 11, pp.231-236.
54. Schwartz, M.D. (1999). Advancing to full bloom: Planning phenological research for the 21st century. International Journal of Biometeorology, Vol. 42(3), pp.113-118.
55. Schwartz, M.D. and Reed, B.C. (1999). Surface phenology and satellite sensor-derived onset of greenness: An initial comparison. International Journal of Remote Sensing, Vol. 20(17), pp.3451-3457.
56. Shaw, M.K.S. and Turner, T. (2000). Modernization of the Global Positioning System. GPS World, Vol. 11(9), pp.36-40.
57. Singh, A. (1989). Review Article: Digital change detection techniques using remotely sensed data. International Journal of Remote Sensing, Vol. 10, pp.989-1003.
58. Steven, M.D. (1987). Ground Truth: An under view. International Journal of Remote Sensing, Vol. 8, pp.1033-1038.
59. Townshend, J.R.G. (1992). Improved Global Data for Land Applications: A proposal for a new high resolution data Set, Report No. 20. International Geosphere–Biosphere Program, Stockholm, Sweden. URL: http://library.wur.nl/WebQuery/clc/916308. (Accessed on June 04, 2012).
60. Trishchenko, A.P., Cihlar, J. and Li, Z. (2002). Effects of spectral response function on surface reflectance and NDVI measured with moderate resolution satellite sensors. Remote Sensing of Environment, Vol. 81, pp.1-18.

61. USGS (2008). Earth Resources Observation and Science Center. URL: http://glovis.usgs.gov/ (Accessed on December 04, 2008).
62. USGS (2010). What is NDVI? United States Geological Survey: Science for Changing World. URL: http://ivm.cr.usgs.gov/ (Accessed on September 10, 2011).
63. Verhoef, W., Meneti, M. and Azzali, S. (1996). A colour composite of NOAA-AVHRR NDVI based on time series analysis (1981–1992). International Journal of Remote Sensing, Vol. 17(2), pp.231-235.
64. Vermote, E.F., El-Saleous, N.Z. and Justice, C.O. (2002). Atmospheric correction of MODIS data in the visible to middle infrared: First results. Remote Sensing of Environment, Vol. 83, pp.97-111.
65. Vermote, E.F. and Vermeulen, A. (1999). Atmospheric correction algorithm: Spectral reflectances (MOD09) algorithm technical background document. URL: http://modis.gsfc.nasa.gov/data/atbd/atbd_mod08.pdf. (Accessed on September 07, 2011).
66. Wan, Z. (2003). MODIS Land-Surface Temperature products users' guide. URL: http://www.icess.ucsb.edu/modis/LstUsrGuide/usrguide.html. (Accessed on September 07, 2011).
67. Zhang, X.Y., Friedl, M.A. and Schaaf, C. (2003a). Monitoring vegetation phenology using MODIS. Remote Sensing of Environment, Vol. 84(3), pp.471-475.
68. Zhang, X.Y., Friedl, M.A., Schaaf, C. and Strahler, A.H. (2004). Climate controls on vegetation phenological patterns in northern mid- and high latitudes inferred from MODIS data. Global Change Biology, Vol. 10, pp.1133-1145.
69. Zhang, X.Y., Friedl, M.A., Schaaf, C., Strahler, A.H., Hodges, J.C.F., Gao, F., Reed, B.C. and Huete, A.R. (2003). Short communication: Monitoring vegetation phenology using MODIS. Remote Sensing of Environment, Vol. 84, pp.471-475.
70. Zhao, M., Heinsch, F.A., Nemani, R.R. and Running, S. (2005). Improvements of the MODIS terrestrial gross and net primary production global data set. Remote Sensing of Environment, Vol. 95, pp.164-176.
71. Zoran, M. and Stefan, S. (2006). Climatic changes effects on spectral vegetation indices for forested areas analysis from satellite data. Proceedings of the 2nd Environmental Physics Conference, 18-22 February 2006, Alexandria, Egypt, pp.73-83.

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The Role of Forest Trees in Indigenous Farming Systems as a Catalyst for Forest Resources Management in the Rural Villages of Cross River State, Nigeria

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Abstract - The concern of humanity is the need to tackle the increasing challenges of severe degradation of the forest ecosystem and its resources. The study examined the critical role of forest tree species in indigenous farming systems on the management of forest resources in the rainforest villages of Cross River State, Nigeria. The participatory Rural Appraisal (PRA) method, household questionnaire survey, field inventory and measurement were used to generate the required data. The data were analyzed using statistics such as simple percentage, mean, standard deviation, tables, graphs, charts and one-way analysis of variance (ANOVA). The study result indicated that the practice of tree felling during land preparation for farming is a minority attribute of the study population. 69.91 percent of the people allow trees on farmlands during land clearance, while 31.09% are found in tree-felling.

Keywords : forest management, farming systems, inventory, resources, tree retention, sustainability.

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Keywords : forest management, farming systems, inventory, resources, tree retention, sustainability.

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I. Introduction

Trees are the essential component of the indigenous agricultural systems. When people clear land for farming, they leave a wide selection of species on farmlands. Most of these species are preserved or managed to meet the immediate needs of the population such as food, medicines, income, agricultural materials and ecological needs.

According to Raintree (1998), the changes in forestry practice that emphasized forestry for local community especially in developing countries together with parallel development such as farming systems approach in agriculture are part of the response to a broad-based societal demand for greater participation of local people in their own development. Various scholars (Hough, 1990; Warner, 1991; Bisong, 1993) have identified trees in farming system as a strategy for restoring degraded areas, increasing people's access to valued forest products and conserving existing forest ecosystem. The role of trees and forestry in maintaining stability in ecosystem has come to the forefront in the search for solution to environmental degradation.

Although farmers have always incorporated trees in their farming systems; but since the onset of technological advancement trees became a neglected factor in agriculture (Park, 1992). Mono-cropping, combined with widespread use of artificial fertilizers and pesticides seem to have been the only means of increasing productivity, thus, undermining natural fertilizers from trees (Clunies-Ross and Hildyard, 1992). To some extent, Brills, Ende, Leede, Paap and Wallace (1996) reported that many tropical areas who adopted these innovations in agricultural landscapes ended with disastrous results such as wild spread soil erosion and degradation, chemical pollution of water, soil and air. Recent studies on traditional farming systems in many areas of the world suggest that complex poly-cultures with trees have many advantages for the local economy over modern systems of extensive annual and monoculture (Ajake 2008, Akorn, 1990). Mixed tree system however, shows that local farmers can and do manage agro-ecosystem on sustainable basis. The integration of trees into farming system remains relevant in the on-farm biodiversity conservation strategy and the expansion of the production of many fruits, vegetables, medicinal plant and bush meat. Biodiversity support programme (1993) reported that forest farming has been practiced for at least 1,000 years, and the distinction between "natural" forest and those altered by human activities is often difficult to discern. Indeed, many agricultural technologies evolved from the practices of forest dwellers that depended on trees and other forest plants for their needs. Brills et al, (1996) revealed that trees are important for their ecological and economic functions in a farming system. When trees and crops are grown together on the same piece of land, they would be interactions between the two components, which may have positive or negative effects. But Gregersen, Synder and Dieter (1989) earlier in their study indicated that tree allowed during forest clearance or introduced into farming systems can help improve the productivity of farmlands by fixing nitrogen, providing green manure and reducing wind erosion and soil moisture loss especially when they are used in shelter belts or windbreaks.

The importance of leaving tree species of good phenotypic quality during forest clearance for timber and farming, particularly during regeneration sampling has revealed low levels of established seedlings and advanced growth of desirable species is a further instance of close coincidence of interest between the objectives of production and those of genetic resource conservation (Kemp, Namkoong and Wadsworth, 1993). However, this practice has been commonly overlooked by the pressure for maximum harvest yield and profit. Although, success in silvicultural practices has been defined in terms of bringing timber to maturity and producing natural regeneration on farmlands where the soils show no signs of deterioration (Dawkins, 1988), the impacts on the genetic resources, especially on the total range of biological diversity on plant and animals in the forest, particularly the use or arboricides, can have far more persistent and disseminating influences than crop manipulation or logging. The success of the sulvicultural treatments has sometime been due to their accidental encouragement of the regeneration of species which were not at the time considered desirable, but which are now in substantial demand. The essential question regarding the conservation of genetic resources is the extent to which harvesting practices and sulvicultural system allow for the retention of a wide spectrum of potentially valuable genetic diversity which provide resources for the rural population. This is most likely to be achieved if different farming systems and different systems within the same production forestry are subjected to assessment and analysis based on the ecological principles to favour the regeneration and bringing to maturity the different elements of the main "guilds" including the climax species.

Several studies have identified the utility of trees in increasing the overall farm productivity (Raintree, 1998), fuel wood and construction materials (Brills et al, 1996) erosion control and soil conservation (Iboanugo, 1993); socio-economic improvement of rural communities (Ajake, 2008) among others. However, tree species are recognized for their various functions. In some parts of the world, farmers have planted trees as hedgerows at intervals along the contour to transform a permanent cropping with increased yields. In Sikko District, Flores, Indonesia, Prussner (1981) reported that the planting of "*Leucaena*" tree has been successfully implemented on more than 20,000 hectares of highly erodible, steep soils since 1973. "*Leucaena*" was planted as hedgerows on the contour to control erosion and provide feed, fixed nitrogen, fertilizer and fuel wood. Nair (1993) recommended the establishment of multipurpose trees for land reclamation of several eroded and degraded grazing areas. Although, encouraging reports of their application are however scanty, success has been accomplished by tree planting and subsequent soil amelioration in the salt-affected soils of north western India where species such as *Acacia nilotica*;*A tortilis; prosopis juliflora; Butea Monosperma* and *encalyptus spp* were adopted (Ahmed, 1991). Similar studies in Yurimagua, Peru (Szott, et al, 1991), parts of Amazonian (Unruh, 1990), Kalimantan, Indonesia (Inoue and Iahjie 1990); and Togo (Dreshsel, et al, 1991), have investigated fallow improvement strategies in shifting cultivation areas. In Bangladeshi, Gregesen, Synder and Dieter (1989) report that farmers were using mangrove trees to stabilize tidal mudbank; Indian farmers used *Terminalia spp* to reclaim salinized areas, whereas Indonesia farmers used *Gliricida* species to suppress pericious weed growth. In Enugu, Nigeria, Ojukwu (1998) identified anti-erosion species for multipurpose such as *Irvingia gabonensis, Dacrayodes edulis, Canarium Schewenfuthic, Crythrophleum suuaeons, Treculia africana etc* and farm tree species as *Parkia biglobosa*, *pietum guineensis, Afzelia Africana* etc. These species were planted to prevent shallow landslides in hilly areas and erosion along slopes. All these studies as presented have not focused on the use of indigenous tree species to reduce pressure from the forest.

Even though trees are having inevitable role in the farming systems such as environmental management and socio-economic livelihood of most people across the world, conflicts do exist between cultivating trees and raising agriculture which emphasized the use of machines and fertilizers have dominated crop production. These practices have adverse effect especially on forest ecosystem and the environment in general. The retention of trees on farming systems has been recognized in the rainforest communities of Cross River State, South Eastern Nigeria as an inevitable priority among the rural farmers. Bisong (1993) and Ajake (2008) have recognized the function of forest trees in the study area in term of income generation, good medicare, employment generation, raw materials, provision of food among others. Dunn, et al (1994) note that farmers in Cross River State are aware of some tree species, which if left on the farm will improve crop yield. But Bisong (1994) estimated the proportion of cash income from agriculture, forest products and other sources and notes that income from farming is greater than that from forest products. However, Balogun (1994) observes that the above analysis is not complete because it ignores value of food and non-timber forest products (NTFPS) consumed within the household. Trees in farming systems therefore have significant role in the socio-economic activities of the people and constitute the basis of forest resources management in the study area.

Although, forest resources are rapidly decreasing, their value and utility of the forest is increasing daily. Agricultural systems that meet human requirements for livelihood sustenance but exert minimal damage to biotic or forest resources are at the core of the search for sustainable land-use system. This study explored trees in indigenous farming systems and their role in forest resource management in the rainforest communities of Cross River State, South Eastern Nigeria. Emphasis is basically on indices such as size of farm holdings, cropping pattern and practices, number of trees integrated into rural farming systems, types and number of farm plots per household and their impact on forest resources management in the study area.

II. Study Area

The study was conducted in the rainforest villages of Cross River State, South Eastern Nigeria. The area is located between longitudes' $7^0 40''$ and $9^0 50''$ east and $4^0 40''$ and $7^0 00''$ North and cover a landmass of approximately 23,074.43km^2 (fig. 1). The study area lies within the tropical rainforest ecological zone of Nigeria, which is climatically disposed to the growth of forest plants. The forest is characterized by dense primary and secondary forests, made up of the disturbed, open forests and presumably forest fallows, rich in flora and fauna species and occupying the largest area in Nigeria of about 7610.00km^2 representing 35.2 percent of the total land area of the state (CRSFC, 2011). The forests are stocked with timber and non-timber forest products, which are increasingly being exploited or harvested for the daily sustenance of the people. These products determine the rural economy of the state.

The population in 2006 was 2,888,966 people spread over eighteen local government areas of Abi, Akamkpa, Akpabuyo, Bakassi, Bekwerra, Biase, Boki Calabar municipality, Calabar south, Etung, Ikom, Obanliku, Obubra, Obudu, Odukpani, Ogoja, Yala and Yakurr (Figure 1). The high forest areas are found in Akamkpa, Biase, Obubra, Yakurr, Etun, Ikom, Boki, Obudu and Obanliku (CRSFC, 2011).

III. Method of Study

Data collection was largely through the household questionnaire survey, forest inventory of tree species, field measurement and participatory Rural Appraisal (PRA) method. The PRA method was adopted to provide background information of the people concerning the harvesting of timber and non-timber forest products, farming processes, cropping pattern and practices and the type of forest tree species retained and planted in rural farming systems. The open-ended questionnaire allowed the household heads used for the study to express themselves and indicate their feelings and perception about the effects of forest trees retention and planting in the rural farming systems on the management of forest resources in the study area. Forest field inventory and measurement were carried out to determine plant frequencies and density on farmlands, farm types and sizes. Other materials such as, a metric tape, a string and pegs for measurement of farm sizes were equally used to complement the field survey.

The study sampled eighteen rural forest communities across the Local Government Areas having forest ecosystem. A purposive sampling was adopted for the choice of the rural communities, while the household heads were systematically selected for the questionnaire administration. The number of household heads selected was based on the household population sizes of each village. Fifty percent sampling proportion was used in the selection of the household heads from each village. A total number of 1,457 household heads were sampled from overall household number of 2,906 with the population size of 42,826 for the whole area under study. The administration of the questionnaire was carried out on the 1,457 household heads systematically selected for the study. The communities under study include Agbokim, Ajassor, Okuni, Akparabong, Abo, Orumenkpang, Odonget, Iyametet, Ibogo, Agoi Ekpo, Ibami, Idoma, Iko Ekperem, Iwuru central, Bayatong, Okorshie, Bendi & Busi.

The data from the field studies and questionnaire administration were analyzed using appropriate quantitative and qualitative statistics such as graphs, maps, charts, parentages, means, standard deviation and One-way Analysis of Variance (ANOVA). The One-way Analysis of Variance was basically used to test the hypothesis which was meant to determine which farm size that can encourage tree integration in the area.

IV. Result and Discussions

The results and discussion of findings was based on the objective and focus of study and was presented under sub-sections.

a) *Farming Processes and Forest Management*

Evidence in the study area, shows that bush fallow system is a solution to the agricultural limitation and sustainable forest resources management. There is *in-situ* conservation of forest trees which is a characteristic feature of clearing and cropping practices. In all the study areas, it is apparent that forest trees are retained on farmlands during forest clearing. There is a strong tendency among the rural people to selectively keep trees alive and integrate them into farming systems. Trees are not only left on farmlands during land preparation stages, they are consciously cultivated by farmers as an integral part of the farming system (Figure 2).

The result of the household survey shows that the practice of tree felling during forest clearing is a minority attribute of the study population. Many people retain tree species on farmlands for diverse reasons during clearing of forest ecosystems for farming. The result shows that 69.91 percent retain trees on farmlands during clearing of forest, while 31.09% are involved in tree felling due to their cropping pattern. Variations exist in the household responses to tree retention and clearance during land preparation for farming across the sampled villages (Figure 3).

The result shows that trees retention practices after land clearance is greater in Ajassor, Akparabong, Abo, Orumenkpang, Ibogo and Idoma. This sampled villages account for more than 70 percent of the population responses. For those farmers who claimed to clear all trees the overwhelming reason given was that there is danger of shading the crops. Clear-felling of trees during land preparation for fanning is more in Odonget, Bendi, Iwuru Central, Agoi Ekpo and Ibami study settlements. This attracts 40% to 55% of the study population in the area. The PRA study identified over a hundred forest plant species in the rural farming system. These species may be retained during forest clearance or cultivated in order to increase output of forest resources and farm produce. Inventory of forest trees on farmlands conducted during this study identified nineteen forest species frequently retained or planted by the people. These species were also indicated during the household questionnaire survey. Because of the utility of the forest species on farmlands, the study population response varies accordingly (Figure 4).

It is apparent that numerous species of forest plants are left in the farmlands of indigenous people. The forest species most favoured by majority of the households are Mahogany *(Entandrophragma spp),* Bush mango *(Irvingia gaboneensis),* Mimosup *(Baillonellia toxisperma),* Iroko *(Melicia excelsa),* Native pear *(Dacryodes edullis).* These species are retained or planted by 64%, 90%, 56%, 76% and 58% respectively of the study population. Other significant species of over 22% population response are Camwood (*Pterocarpus osun),* Cotton tree *(Ceiba pantadra),* Opepe *(Nauclea diderrichii),* small leaf *(Piptadenistrum africanum),* Black afara *(Terminalia ivorensis),* Achi *(Brachystegia Spp),* Oil palm *(Elaeis guineensis),* Afang *(Gnetum africanum),* Native kola *(Cola accummata).* Cedar *(Lovoa trichiloides),* Bitter kola *(Garcina cola).* Native mango *(Magnifera indica),* and Ebony *(Diospyros spp).*

There are numerous tree species which did not significantly show up on aggregate on farmlands, but do occur in the farming systems of the people. These species are indicative of numerous forest resources integrated into the farming systems of the study rainforest villages of Cross River State. The study observes that the nineteen common plant species are indigenous to the people and are valued for numerous reasons.

b) *Cropping pattern and practices in the study area*

The study observed that intercropping is carried out under a careful spatial and temporal sequence of crop arrangements on farm plots. Several crops were identified in the study area. The most common and widely cultivated crops are cassava *(Manihot esculenta),* Yam *(Dioscerea Spp),* cocoyam *(Xanthosama sagittifolia, Culocasia esculenta),* flutted pumpkin *(Teifairia occidentalis),* Cucumber *(Cucumis Sativis),* pepper *(Capsicum Spp),*okro *(Abelmoschus esclentus),* Maize *(Zeamays),* Garden eggs *(Solanum melongena),* mellon (*Cucumis melo),* Pineapple *(Ananas sativus),* plantain (*Musa paradisiaca),* oil palm *(Elaeis guineensis),* cocoa (*Theeobroma Cacao*), banana, sugar cane, vegetables and rice (*Oriza Sativa*). The intercropping depended on the vegetation conditions (high forest, secondary forest and fallows), soil and climatic conditions.

The household survey and PRA interviews identified five main cropping patterns (crop combinations). The result is presented in Table 1. The mean scores of population responses to mono food tend to be the highest with 48.42, while the mean score for mixed food crop is 45.6. The high mean scores for the two farming systems indicate that mono food crop and mixed food crop are widely adopted by the people as their farming practices. The crops adopted for mono food crop production are cassava, rice, yam, cocoyam, sugar cane, maize, melon, pineapple etc, while mixed food crop production across the villages, are yam, cassava, cocoyam, melon, pepper, cucumber, garden eggs, maize, okro and sugar cane. These are all intercropped together in a farming system, and sometime two or more of the crops are cultivated together. The practice of mono-food crop production was attributed to the soil conditions, cheap cost of labour, ease of maintenance, increase in output and economic value. Apart from pineapple that is intensively grown in Orumenkpang, other mono crops are widely cultivated across villages. These crops were grown mostly in red soils, clay soil, as well as sandy loamy soil or white soils.

The study discovers that most rural households are involved in mixed crop farming. This was attributed to scarcity of land, ease of production, availability of household labour, soil condition and vegetation status. For instance, the above crops are considered suitable for virgin forest lands or old fallow re-growth. Early maize, pepper and garden eggs are planted together in well burnt farm plots. They are particularly around the stumps of well burnt trees. Maize, fluted pumpkin, cocoyam, yam and green vegetable can also be grown together at the same time. If cassava is desirable to be included in this arrangement, it is introduced three months or four months later. Most of these crops are suitable for soils referred to as red soil and white soil by the indigenous people. But because of the texture and colour of the soil, such as light brown with loose grains, they may also be referred to as sandy loamy soils. While the red soils are mostly clay derived from the basement complex basalt.

The next higher mean of 34.83 is for mixed trees and food crops production. This combination involves growing the crops such as cocoa, plantain, kolanut, cashew, with food crops such as cocoyam, pepper, cassava and vegetables. The PRA study investigation shows that, food crops are integrated especially when the tree crops are still growing. For instance, planting of cocoa is considered in the same farmland with cocoyam, cassava and vegetables. But when the tree crops are grown to mature stage, food crops are introduced mostly in the gaps within the farmlands or are eliminated. The tree crops were considered as products with high economic value but their cultivation is capital intensive and requires enough labour. Other farm types of significance are mono tree crops and mixed tree crops, which attract the mean of 19.82 and 27 respectively. The monotree crops involve the cultivation of oil palm, cocoa, orange, banana, plantain and cashew, while mixed tree crops requires the combination of cocoa, plantain, banana, etc. Although the latter is capital and labour intensive but attracts more income to the people than other systems of production.

In addition, the high standard deviation of 42.50 for mixed tree production and 43.07 for mixed tree and food crop indicate that the level of disparity of the distribution of the respondents to these farm types, across the various communities is very high. This means that, while some farm types may record very low distribution (2 or 3), others have extremely high distribution (182 or 174) (Table 1). The study concluded that mixed food crop, mixed tree and food crops are the main farming practices or crop combinations across the villages. These farm types encourage the integration of forest tree species into the rural farming system. The integration of forest trees into rural farmlands was confirmed by the study population as a new technology that has improved the productivity of farm crops and forest product vis-a-vis reducing pressure on the remaining forest ecosystem in Cross River State - South eastern Nigeria.

c) *Farm sizes and forest management*

The size of farm holding determines the extent to which the land is utilized and to which trees are interspersed with farm crops. The participant observation and field measurement conducted show that farm sizes vary significantly according to the household. The farm sizes of the study population are categorized into three groups. The findings in Table 2 show that the farm sizes of most households were less than (<) one hectare, representing a population mean score of 42.78 and standard deviation of 24.88, while those between 1-5 hectares attract population mean score of 32.72 and standard deviation of 28.0. A few people have farm sizes greater than five hectares representing a mean score of 5.56. It was observed that the more forest trees are on farmlands, the higher the quantity of forest resources harvested, and the increase in income generation and food supply. This reduces the frequency of the people visit to the high forest for harvesting of forest products. The high standard deviations indicated for farm sizes less than one hectare and 1-5 hectares shows high level of disparity of distribution of population responses to these farm sizes across the constituents' part of the state. The study observed that farm sizes determine the number of forest tree species on farmlands. Further investigation through tree survey inventory on farmlands and household questionnaire survey was carried out in the eighteen sampled villages. The result is presented in table 3. The sizes of farm holdings determine the population of forest trees. The result shows that the mean number of trees in farm sizes greater than five hectare is higher than other farm sizes. For instance, the mean number of trees in farm sizes greater than five hectares is 250.56 with standard deviation of 33.74. This is closely followed by farm sizes of one to five hectares with 141.72 mean numbers of trees, and 24.65 as standard deviation. The least mean value of trees is 48.17 for less than one hectare farms. This analysis implies that smaller farm sizes have fewer number of trees retained or planted. It was observed that farm sizes of less than one hectare are mainly associated with mono food crops and mixed crop farm types, with crop combination of cassava, yams, rice, sugar cane, cocoyam, vegetable, pepper etc. Apart from rice farms, forest trees are found dispersed or scattered on mono food and mixed food crop farms in the study area. Most common forest tree species on rural farming systems are Bush mango *(Irvingia gaboneensis),* Mahogany *(Etandrophragra spp)* Mimosup *(Baillonelia toxisperma),* Iroko *(Melicia excelsa),* small leaf *(Piptadenistrum africanum),* Achi (*Brachystegia spp),* Native mango *(Mangifena indica),* silk cotton tree *(Ciba pentandra),* Umbrella tree *(Musanga cecropoides),* locust bean *(Parkia spp),* Sheanut *(Poga oleosa),* Wild palms (*Elacis guineensis).* These farms are common in Iyametet, Idonget, Agoi Ekpo, Ibami, Ibogo, Orumenkpang, Okuni, Idoma and Iwuru Central.

The mono tree crop and mixed tree farm types are developed in large plantation of six hectares and above. These plantations are mainly cocoa, plantain, banana, oil palm cashew etc. Because of their sizes, high population of forest plants or tree species are retained or planted than other farms. Although oil palm plantation may not require many trees for their growth, cocoa, plantain and banana plantations are dominated by several forest tree species which were considered very critical by most of the farmers. Forest trees and plants associated with these farm types are Bush mango *(Irvingia gabonensis),* Native Kola (*Cola acuminata*), Bitter Kola (*Cola nitida*), Native pear (*Dacryodes edullis*), Afang (*Gnetum afriamum*), Editan *(Lasianthera africanum),* Star apple or Udara *(Chrysophyllum albidum)* Hot leaf/seed (*Piper guineensis),* Pawpaw *(Carica papaya).* Groundnut tree *(Ricinodendron leudetii),* White afara *(Teminalia superba*), Mahogany *(Etandrophragma spp),* Mimosup *(Baillonellia toxisperma),* Iroko (*Melicia excelsa)* Achi *(Brachystegia spp).* Bread fruit *(Triculia africanum),* Atama (*Heinsia crinata),* Ceda *(Lovoa trichiloides),* Cane wood *(Pterocarpus osun),* Small leaf *(Piptadenistrum africanum)* etc. In addition to the ecological functions of these forest trees species on plantation farms, the study discovered that most of these species were of high economic, medicinal, and social value to the people. The mixed trees and food crop farming systems are within the farm sizes of two to five hectares. These farm types are dominated by the production of food and tree crops such as cocoa, cocoyam, pepper, plantain, banana, cassava, vegetables, garden eggs, pineapples etc. The participant observation in the study villages reveals that bitter kola, native kola and bush mango are now developed into agricultural plantations having the forest tree species earlier mentioned. To determine the degree of variation of forest trees across the various farm sizes across the villages, a null hypothesis was formulated and tested.

d) Test of hypothesis

Ho: There is no significant difference in the population of forest trees integrated per farm size in rural farming system.

The tree survey inventory and household questionnaire survey were adopted to generate the required data (Table 3) for testing the hypothesis. Forest trees population across the sampled villages were summed up and categorized into three main farm sizes identified in the study area. The one way analysis of variance was applied to determine which farm size that can encourage tree integration in the area. The results are presented in Table 4.

The analysis produced a calculated F-ratio of 287.88 which was higher than the tabulated F-ratio of 3.15. This was statistically significant at 0.05 level, thus rejecting the hypothesis. This result reveals that there is statistically significant difference between the three sets of data with respect to the number of forest trees on farm sizes in the study area. The result further implies that, the population of tree species is higher in farm sizes greater than five hectares. Therefore, the study conclude that as farm size increases there is a corresponding increase of forest tree species integrated into farmlands. If this trend of tree integration into farmlands continues, it may reduce pressure from the primary forest and ensure sustainable management of forest resources in the study area. The household survey and forest trees inventory further investigated the population responses to forest trees based on the farming systems. The result is presented in Table 5. The result shows that there is no considerable variation in planting and retention of forest tree species in traditional farming systems. This may be a function of the relative importance of forest trees on farmlands. The result further shows that forest tree retention is common with mono food crop and mixed food crop farm types. This accounts for 55.1% and 60% respectively. Trees cultivation is more common in mono tree crops, mixed tree crops, and mixed tree and food farm types. This attracts a higher population of 55.5%, 54% and 56.28% respectively. This was attributed to the increasing forest trees on farmlands. The study also discovered the propagation of non-timber forest products within farmlands. For instance hot alligator pepper, afang, editan, hot leaf/seeds etc are grown in Iwuru central, Ibogo, Iko Ekperem, Ibami and Agoi Ekpo. Therefore, the conversion of forest to agricultural lands by the indigenous people does not lead to the loss of many important forest species. These are normally conserved during forest clearance or planted to improve productivity of farmlands.

Furthermore, the study observes that most households have several plots of farmland for the purpose of land acquisition, forest and farm productivity in the study area. The Participatory Rural Appraisal study reveals that one household can have different farms of cassava, yam, cocoa, plantain etc. With this, it was difficult to determine the sizes of farmland for a particular household. To determine the number of farm plots, a survey of the study population was carried out in the eighteen sampled villages. The findings in the Table 6 indicated that a significant number of the households own about five plots. This accounts for a mean score of 42.56 and standard deviation of 28.02. The high population of people having one to five plots was attributed to the difficulty involved presently in most communities to acquire new plots from the virgin forest. While 24.06 of the study population confirmed that they have six to ten plots, whereas an insignificant number of people representing a population mean score of 2.18 and standard deviation of 1.67 indicated for about sixteen plots of farmlands. The result implies that household with several number of farm plots are significantly involved in planting of forest trees than those with a few number of farm plots. Therefore, it was observed that even though several number of farm plots can promote forest tree species integration in farming systems; it *was* an indirect way of increasing deforestation. This is because the quest for more farm plots requires the clearing of the virgin forest. The high standard deviation for people having one to five plots indicates a high level of disparity of the population distribution across the sampled communities. This means that while some communities may record very low distribution, others have high population distribution of household heads.

In conclusion, the study suggest that indigenous people should be encouraged to utilize few number of farm plots through the integration of valuable forest trees species into the farming systems, instead of acquiring more farm lands from the virgin forest which increase deforestation in the study area.

V. Conclusion/Recommendations

Trees left on farmlands during land preparation process, and consciously cultivated by indigenous farmers as integral part of the rural farming systems have great impacts on forest management. Evidence in the study area are glaring that the utilization of forest tree species at the indigenous farmlands has drastically reduced the number of trips and pressure which human population is mounting on the primary forest especially in the remaining natural forest ecosystem of Cross River State, Nigeria" The tendency among the rural people to selectively keep trees of significance alive and integrate them into farming systems should be promoted as the only alternative in managing forest resources. These practices tend to increase output of forest resources and farm produce which constitute the rural economy. In addition, since the acquisition of several farmlands increases deforestation, indigenous people should encourage to utilize few number of farm plots through integration of valuable tree species which can improve output and income.

Although, the indigenous people are knowledgeable about tree crop interaction, but it is necessary that adequate forestry and agricultural education through extension services be encouraged and intensified in order to sustain the consciousness of managing the remaining forest for ecological and other benefits to rural people and the state at large. The increment of forest area through tree planting for the purpose of carbon sequestration (carbon credit) and climate change moderation has been the recent interest of Cross River State and Nigeria as a whole, this can only be achieved when the indigenous farmers are integrated into the programmes and the intensification of tree retention and cultivation in rural farming systems is encouraged among the indigenous people. Finally, trees and indigenous farming systems and practices is basis of sustainable forest management in the rainforest of Cross River State, Nigeria.

References Références Referencias

1. Ahmed, P. (1991): "Agroforestry; A viable land use of Akali soils" *Agroforestry systems*, vol. 14, PP.23-37.
2. Ajake, A. O. (2008): *Exploitation and management of forest Resources in Cross River State, Nigeria.* Unpublished Ph.D Thesis, Department of Geography, University of Nigeria, Nsukka.
3. Akorn, J. B. (1990): ''Indigenous Agroforestry systems in the latin America tropics", In Alteri, M. A. and Hetch S. B(eds), *Agroforestry and small farm Development*, CRC press, Boca Raton, Fla, pp. 58-70.
4. Balogun, P. (1994): "Social and Economic issues of forestry in Cross River State" *Working Paper*, No. 16 PP.1-49.
5. Biodiversity Support Programme (1993): African Biodiversity foundation for the future, WWF, London.
6. Bisong, F. E. (1993): Farming systems, Human Ecology and Natural Resources conservation in the Cross River State, FDD/CRSFP, caliber, Pp.15-85.

7. Brills, C., ENDE, P.V; Leade, B.; Paap, P. and Wallace (1996): *Agroforestry: Agrodok series* Agromisa. The Netherlands. Cross River state forestry commission (2011): Draft Cross River State Forest Policy, Cross River State Forestry Commission, Calabar.
8. Dawkins, H. C. (1988): "The first Century of Tropical Silviculture Successes Forgotten and Failure Misunderstood", In Medermott ,M.J (ed.), *The Future of tropical Rainforest,* Oxford press Land on, pp.8-36.
9. Drechsel, P., Glaser, B., and Zech, W. (1991):''Effect of four multipurpose Tree species on soil amelioration during Tree fallow in Central Togo''. *Agroforestry systems* , No.16,193-202.
10. Dunn, R. M., Otu, D. D., and Wong, J. G (1994): ''Reconnaissance Inventory of High forest and Swamp forest areas in Cross River state" *Working paper for Cross River State forestry project*.
11. Gregersen, H., Sydney, D., and Dieter, E. (1989): ''People and Trees: The Role of social forestry in sustainable Development" *Economic Development. Institute of the world Bank Seminar Series*, World Bank, Washington D.C, PP.1-162.
12. Hough, J. (1990): ''Michiru Mountain conservation Area: Integrating conservation with human needs". In west, P.C and Steven, R.B (eds), *Resident people and Natural parks: Social Delimmas and strategies in international conservation,* University of Amazons press, PP-130-137.
13. Inoue, M. and Lahjie A. M.(1990): ''Dynamics of Swidden Agriculture in East Kaliamantan'' *Agroforesty systems*, No.4, PP. n-23.
14. Igbuanugo, A. B. I. (1993): ''Agroforestry as a measure for water erosion control'', In Oduwaiye (ed), *Forestry for urban and Rural Development,* forestry Association of Nigeria, Ibadan PP.187-191.
15. Kemp, R. H.; Namkoong, G. and Wadsworth, F. (1993): Conservation of Genetic Resources in Tropical Forest management; principles and concepts. FAO, Rome.
16. Nair, P. K. R. (1993): "The prospects forAgroforestry in the Tropics'' *World Bank Technical paper*, NO.131, World Bank, Washington D,C.
17. Ojukwu, N. B. (1998): *Promoting Agroforestry in Ihenwuzhi –An Approach towards achieving sustainable land and Resource management.* Unpublished M.Sc. Thesis, Enugu State University of Science and Technology, Enugu.
18. Park, C. C.(1992): Tropical Rainforest Routledge, London.
19. Prussner (1981): *Leucaena Leucocephalla farming system for agroforesty and control of Swidden agriculture*, USAID, Jarkata.
20. Raintree, J. B.(1987): "Agroforesty , Tropical land use and Tenure" *Proceedings of an international workshop on Tenure issues in Agroforesty* LCRAF, Nairobi, PP.35-77.
21. Szott, L. Sinclair, F. L. and Walker, D. H.(1991): "Agroforestry in Acid soils of the Humid Tropics'' *Advance in Agroforestry* No. 45,PP-275-301.
22. Unruh, J. D. (1990): ''Iterative Increase of Economic tree species in managed Swidden follows of the Amazons'' Agroforesty systems, No.11.PP.n5-197.
23. Warner, K. (1991); Shifting cultivation: Local Technical Knowledge and Natural Resource management in the Tropics. FAO, Rome. PP. 1-22.

Table 1 : Cropping pattern and practices in the study area.

Farm types	Total responses	Min.	Max	Mean	Standard Deviation
Mixed food crop	811	12	126	45.06	31.35
Mixed trees crop	486	2	182	27.00	1 42.50
Mono food crop	872	10	96	48.42	25.67
Mono tree crops	357	2	82	19.82	24.87
Mixed tree/food crop	627	3	174	34.83	43.07
Total	3181	2	182	35.34	36.32

Source : Field work, 2010/ 2011

From Table 1, the mean scores of population responses to mono food tend to be the highest with 48.42, while the mean score for mixed food crop is 45.6. The high mean scores for the two farming systems indicate that mono food crop and mixed food crop are widely adopted by the people as their farming practices.

Source :

Table 2 : Farm sizes per household

Farm size in hectares	Total response	Min.	Max.	Mean	Standard deviation
Less than 1 hectare	770	16	109	42.78	24.89
1-5 hectares	589	3	130	32.72	28.03
Greater than 5 hectares and above(>5ha)	100	00	18	5.56	4.78
Total	1459	00	130	27.04	26.64

Source : Fieldwork, 2010/2011

The findings in Table 2 show that the farm sizes of most households were less than (<) one hectare, representing a population mean score of 42.78 and standard deviation of 24.88, while those between 1-5 hectares attract population mean score of 32.72 and standard deviation of 28.0. A few people have farm sizes greater than five hectares representing a mean score of 5.56.

Table 3 : Number of forest tree species per farm size.

Sampled village	<1hectare	1-5	➢ 5 hectares	Total
Agbokim	62	142	281	485
Ajassor	68	136	278	482
Akparabong	70	185	298	553
Okuni	48	134	232	414
Abo	56	129	269	454
Orumenkpang	42	131	249	422
Odonget	38	128	236	402
Iyametet	36	143	291	470
Agoi Ekpo	69	182	280	531
Ibanni	58	146	261	465
Ibogo	37	128	234	399
Idoma	48	142	201	391
Iko Ekperem	52	171	285	508
Iwuru central	34	121	206	361
Bayatong	26	84	192	302
Okorshie	49	49	161	271
Bendi	36	168	241	445
Busi	38	140	205	383
Total	867	2551	4510	7928
Mean	48.17	141.72	250.56	146.81
Std Deviation	13.14	24.65	33.74	87.10
Minimum	26	84	192	26
Maximum	70	185	298	298

Source : Fieldwork 2010/2011

The sizes of farm holdings determine the population of forest trees. The result shows that the mean number of trees in farm sizes greater than five hectare is higher than other farm sizes. For instance, the mean number of trees in farm sizes greater than five hectares is 250.56 with standard deviation of 33.74. This is closely followed by farm sizes of one to five hectares with 141.72 mean numbers of trees, and 24.65 as standard deviation. The least mean value of trees is 48.17 for less than one hectare farms.

Table 4

Source of variance	Sum of square	Df	Mean square	Cal. F-ratio	Tab. F-ratio
Between Group	369351.60	2	184675,80	287.88	3.15
Within Groups	32716.56	51	641.501		
Total	402,068.10	53			

Source : Fieldwork 2010/2011

From Table 4, the analysis produced a calculated F-ratio of 287.88 which was higher than the tabulated F-ratio of 3.15. This was statistically significant at 0.05 level, thus rejecting the hypothesis.

Table 5 : Number of trees planted or retained on farmlands.

Farm types	Trees planted	Tree retained	Total
Mono food crop	70(44.9%)	86(55.1%)	156 (100%)
Mono tree crop	122(55.5%)	98(44.5%)	200 (100%)
Mixed food crop	64(40%)	96(60%)	160 (100%)
Mixed tree crop	142(54%)	121(46%)	263 (100%)
Mixed tree/food crop	139(56.28%)	108(43.72%)	247(100%)
Total	537(52.34%)	509(47.66%)	102 (100%)

Source : Fieldwork, 2005/2006.

In Table 5, the result shows that there is no considerable variation in planting and retention of forest tree species in traditional farming systems. This may be a function of the relative importance of forest trees on farmlands. The result further shows that forest tree retention is common with mono food crop and mixed food crop farm types.

This accounts for 55.1% and 60% respectively. Trees cultivation is more common in mono tree crops, mixed tree crops, and mixed tree and food farm types. This attracts a higher population of 55.5%, 54% and 56.28% respectively.

Table 6 : Average number of farm plots per household.

Sampled villages	1-5 Plots	6-10 Plots	11-15 Plots	15 Plots and above
Agbokim	12	14	21	6
Ajassor	16	32	25	4
Akparabong	41	10S	62	5
Okuni	78	58	41	4
Aboibam	28	12	2	1
Orumenkpang	10	29	4	2
Odonget	51	11	5	2
lyametet	116	20	4	9
Agoi Ekpo	82	21	6	2
Ibami	65	6	8	4
Ibogo	42	14	7	2
Idoma	24	16	4	4
Iko Ekperem	51	14	7	1
Iwuru central	43	20	14	2
Bayatong	14	18	2	1
Okorshie	43	12	7	0
Bendi	31	0	*4*	0
Busi	28	12	4	1
Total	766	433	221	39
Mean	42.56	24.06	12.26	2.18
Std Deviation	28.02	23.93	15.50	1.67
Minimum	10	6	2	0
Maximum	116	108	62	5

Source : Field work 2010/2011

The findings in the Table 6 indicated that a significant number of the households own about five plots. This accounts for a mean score of 42.56 and standard deviation of 28.02. The high population of people having one to five plots was attributed to the difficulty involved presently in most communities to acquire new plots from the virgin forest. While 24.06 of the study population confirmed that they have six to ten plots, whereas an insignificant number of people representing a population mean score of 2.18 and standard deviation of 1.67 indicated for about sixteen plots of farmlands.

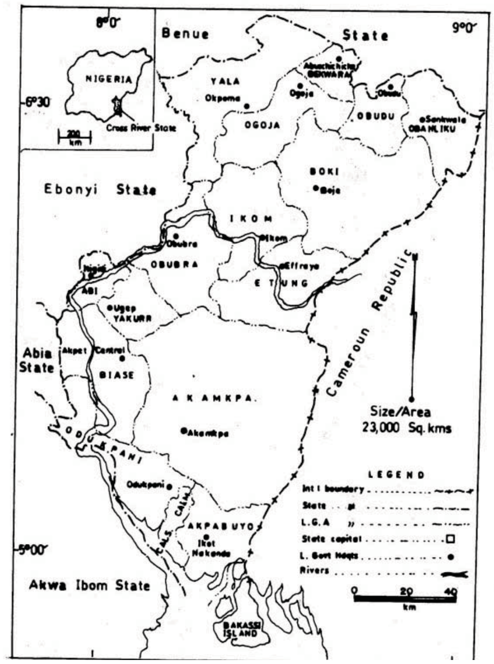

Figure 1 : Location of Cross River State, Nigeria.

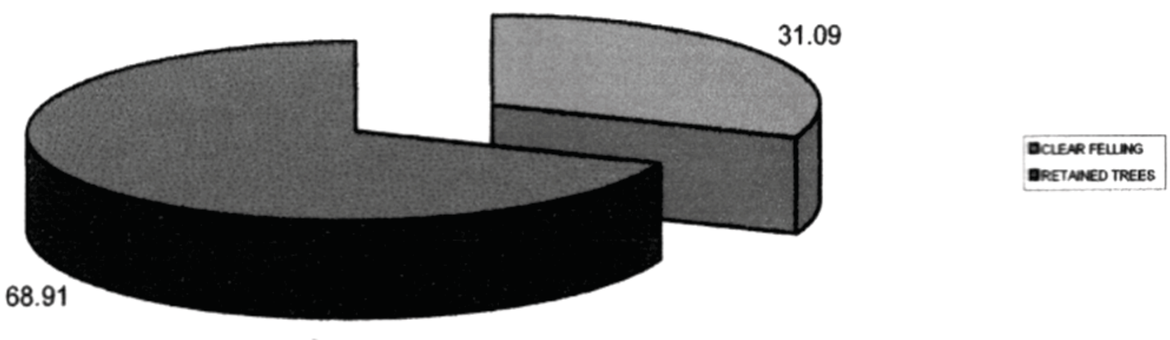

Figure 2 : Trees and land clearance in the study area.

Fig. 2 shows that 69.91 percent of the population retained trees on farmlands during forest clearance while 31.09% are involved in tree felling due to their cropping pattern.

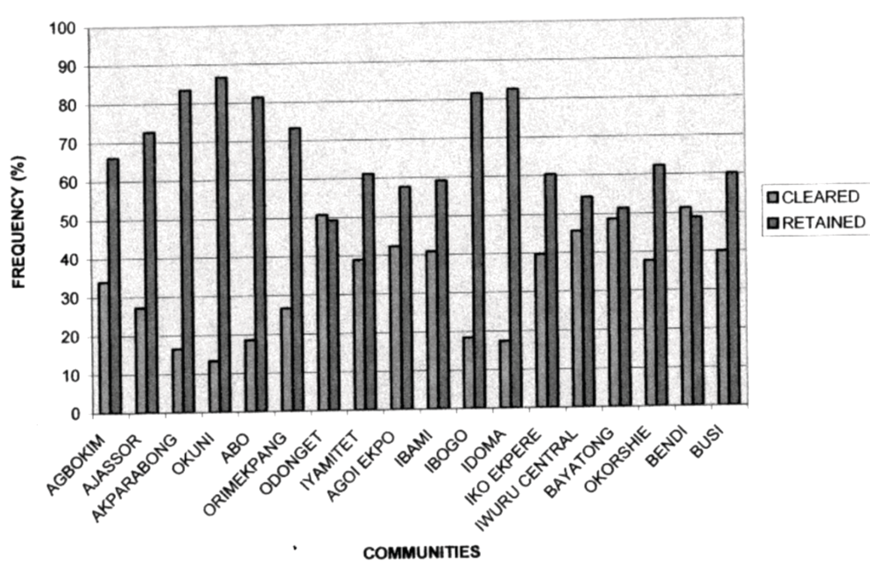

Figure 3 : Spatial distribution of trees and land clearance.

Fig. 3 show that there exist significant variations in the household responses to tree retention and clearance during land preparation for farming across the sampled villages. The findings revealed that over 70 percent of the respondents across the villages indicated tree retention during forest clearance for farming while clear felling of trees attracted between 40- 55 percent of the study population especially in Odonget, Bendi, Iwuru central, Agoi Ekpo and Ibami.

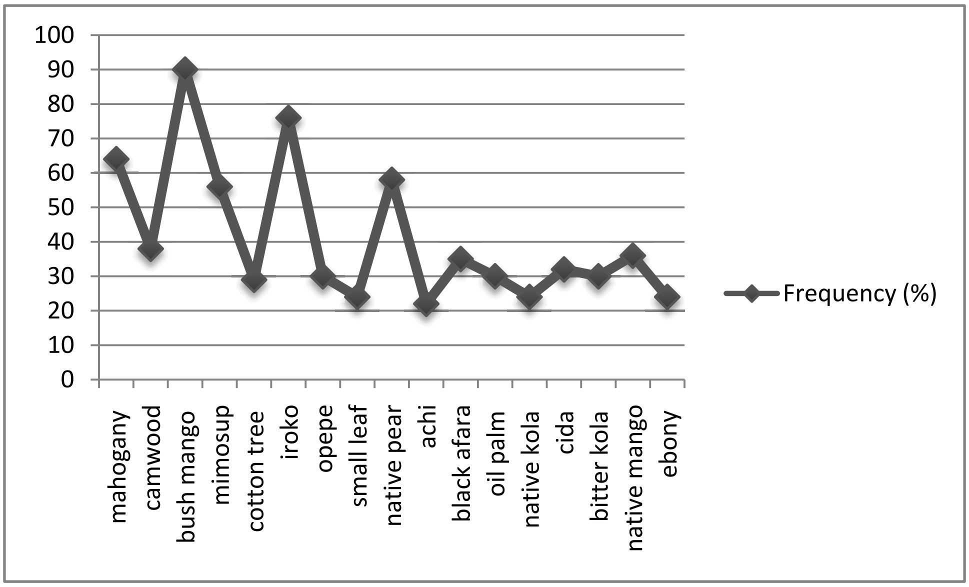

Figure 4 : Population response to management of selected tree species in rural farming systems.

It is apparent that numerous species of forest plants are left in the farmlands of indigenous people. The forest species most favoured by majority of the households are Mahogany *(Entandrophragma spp),* Bush mango *(Irvingia gaboneensis),* Mimosup *(Baillonellia toxisperma),* Iroko *(Melicia excelsa),* Native pear *(Dacryodes edullis).* These species are retained or planted by 64%, 90%, 56%, 76% and 58% respectively of the study population.

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Effects of Gas Flaring and Oil Spillage on Rainwater Collected for Drinking in Okpai and Beneku, Delta State, Nigeria

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Abstract - This paper evaluates the effects of gas flaring and oil spillage on rainwater quality for domestic use in Okpai and Beneku areas of Delta State, Nigeria. Both field and laboratory techniques were employed in the analyses of rainwater quality. Rain water samples were collected in the dry (December, January and February) and wet (June, July and August) seasons from Okpai (experimental site) and Benekuku (controlled site). The water samples were analyzed for chemical, physical and biological parameters using the methods of Radojevic and Bashkin, 1976; USEPA ,2007; and Kolo, 2007.The results showed that gas flaring and oil spillage have significantly changed some physic-chemical and biological properties of drinking water in the study area. For instance, there were changes in the taste, color, temperature, conductivity, alkalinity and total dissolved salts. These could have serious health implications on the ihabitants of the area. Apart from these, other parameters analyzed corresponded to the approved maximum permissible limits for drinking water set by NAFDAC, USEPA and WHO.

Keywords : gas flaring, oil spillage, pollution, rain water quality.

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EFFECTS OF GAS FLARING AND OIL SPILLAGE ON RAINWATER COLLECTED FOR DRINKING IN OKPAI AND BENEKU, DELTA STATE, NIGERIA

Strictly as per the compliance and regulations of:

Effects of Gas Flaring and Oil Spillage on Rainwater Collected for Drinking in Okpai and Beneku, Delta State, Nigeria

A. Dami [α], H. K. Ayuba [σ] & O. Amukali [ρ]

Abstract - This paper evaluates the effects of gas flaring and oil spillage on rainwater quality for domestic use in Okpai and Beneku areas of Delta State, Nigeria. Both field and laboratory techniques were employed in the analyses of rainwater quality. Rain water samples were collected in the dry (December, January and February) and wet (June, July and August) seasons from Okpai (experimental site) and Benekuku (controlled site). The water samples were analyzed for chemical, physical and biological parameters using the methods of Radojevic and Bashkin, 1976; USEPA ,2007; and Kolo, 2007.The results showed that gas flaring and oil spillage have significantly changed some physic-chemical and biological properties of drinking water in the study area. For instance, there were changes in the taste, color, temperature, conductivity, alkalinity and total dissolved salts. These could have serious health implications on the inhabitants of the area. Apart from these, other parameters analyzed corresponded to the approved maximum permissible limits for drinking water set by NAFDAC, USEPA and WHO. On the basis of the principles of sustainable development, it is recommended that the Gas Flaring Emissions Reduction Policy should be effectively implemented in order to reduce the direct and negative effects of these pollutants on the human population living in the study area.

Keywords : gas flaring, oil spillage, pollution, rain water quality.

I. Introduction

The coastal areas of the Niger Delta in Nigeria have experienced tremendous oil exploration and exploitations over the years (Nwilo and Badejo, 2005). This is largely due to the huge deposits of crude oil and natural gas deposits within the region. The World Bank report of 2002 succinctly stated that Rivers and Delta states alone produced about 75% of Nigeria's petroleum, which represents over 50% of national government's revenues. In the same year (2002), Nigeria was rated the fifth largest supplier of crude oil to the United States. Nigeria's proven oil reserves fuel the economy because it is almost exclusively dependent on earnings from the oil sector and this generates about 20% of GDP, 95% of foreign exchange and about 65% of budgeting revenues (CIA World fact Book, 2008).

However, human activities have impacted negatively on the delicate balance of nature and the fragile ecosystems of atmospheric, surface and ground water bodies (Nwankwo and Ogagarue, 2011). Domestic, agricultural and industrial wastes have over time been discharged into the environment (air, water and soil) and these end up accumulating within such entities and causing health and environmental problems. When pollutants are received by water, generally they are dispersed over water molecules immediately to nullify their attendant effects. But, if this continues over time uncontrollably, the carrying capacities of such water bodies could be exceeded and their resultant health and environmental impacts would be felt.

Generally, gaseous pollutants move into the atmosphere, displace and affect the quality of air. These could condense in the cloud and later fall back as rain. When they fall back as rain, they settle either directly on surface waters or on soils before been conveyed to surface water bodies where they accumulate. These pollutants could later sink into the underground aquifers to cause underground water pollution too. All these generally upset the water food web and affects health and environment of living organisms that depend on them.

The overall effect of water pollution is much easily noticeable in surface than atmospheric and underground water bodies. For instance, agricultural pollutants like pesticides, herbicides and fertilizers (Kolo, 2007) and industrial pollutants (Akan, 2006) have reportedly caused serious environmental problems to living organisms. The severity of the negative impact has been found to be more on stagnant waters than the moving ones (Bhutia, 2009). This is because, when pollutants are received, they accumulate and sediment beneath untransformed, and resultantly, they reach high concentrations that could induce health and environmental effects on dependent living organisms. This is unlike moving waters that carry pollutants and disperse them out, immediately. This study assesses the effects of gas flaring and oil spillage on atmospheric (rain) water collected for domestic use in the area.

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II. Study Area

The Niger Delta is located within the southern part of Nigeria. It is home to numerous creeks, rivers and possesses the world's largest wetland with significant biological diversity (Twumasi and Merm, 2006). Okpai/Aboh region are within Ndokwa East Local Government Area and are situated within the Sombriero Warri deltaic plain deposit invaded by mangroves. The area is located within latitudes 5°40′N and 5°50′N and longitudes 6°15′E and 6°30′E (Figure 1) (Oseji and Ofomola, 2010).

The geographical Niger Delta has been said to cover an estimated area of between 19,100 km^2 to 30,000 km^2 based on hydrological, ecological as well as political boundaries (SPDC, 2006 and UNDP, 2006). Okpai/Aboh region is within a low-lying height of not more there 3.0 meters above sea level and generally covered by fresh water, swamps, mangrove swamp, lagoonal marshes, tidal channels, beach ridges and sand bars along its aquatic fronts (Dublin-Green *et al*, 1997).

The area has a characteristic tropical monsoon climate at the coast with rainfall peaks in June and September/October with prevailing tropical maritime air mass almost all year round with little seasonal changes in wind directions (Olaniran, 1986). Annual mean total rainfall has been put at between 1,500mm and 3,000 mm with a mean monthly temperature range of 24-25 °C during the rainy season in August and 27-29°C during tail end of dry season in March/April. Leroux (2001) reported that maximum temperatures are recorded between January and March (33°c) while minimum temperature are recorded in July and December (21°c), respectively. Temperatures are seriously moderated by cloud cover and damp air. It experiences a tropical climate consisting of rainy season (April to November) and dry season (December to march). The average annual rainfall is about 2,500mm while the wind speed ranges between 2-5m/s in the dry season to up to 10m/s in the rainy season especially during heavy rainfall and thunderstorms.

The region is criss-crossed with distributories and creeks. This area has been classified geomorphologically to consist of tidal flat and large flood plains lying between mean, low and high tides. Three different highs exist within the Kwale block, namely; a central high where most of the wells have been drilled an eastern high housing one well and a north western high whose extent has not been clearly defined. The area lies within the freshwater forested region of the Niger Delta.

III. Methodology

Rain water samples were collected from two distinct locations. The first was within the Agip Gas Plant in Okpai area (experimental site) while the second was about 5km away at Benekuku (control site), both within Ndokwa-East Local Government area of Delta State, Nigeria. Samples were collected during the dry season (December 2010, January 2011 and February 2011) and wet season (June, July and August 2011). Three samples of rainwater each were collected from both Okpai and Benekuku in the study areas, making a total of six samples at different points. The samples were collected around 5.00 – 6.00pm of the day.

The rain water samples collected were analyzed. At every point, two sets of samples were collected: one for AAS analysis and the other for anions like phosphate, sulphate and nitrate. No further treatment was needed for the anions, thus the samples were analyzed right away to minimize chemical changes in the sample and prevent losses to the environment (Radojevic and Bashkin, 1976). Pretreatment of the water samples was necessary because of the likelihood of such samples containing suspended particles along with metals. Pretreatment involved addition of an acid to preserve the sample, destroying organic matter and bringing all metals into solution (Radojevic and Bashkin, 1976), A few drops of concentrated HNO_3 acid was added to water samples after collection to preserve the samples, destroy organic matter and minimize absorption on the walls of the container.

Preparation of standard stock solutions and working standards were done following the methods by USEPA (2007) for calcium, magnesium, sodium, potassium, iron, copper, zinc, cadmium, lead, chromium and aluminium. McConkey broth single and double strengths were also prepared. Full details on preparation of stock solutions and working standards are contained in Amukali (2012). 100cm^3 of water samples were measured and put into a beaker. A 5cm^3 aqua regia (HNO_3 : HCl in ratio 3:1) was then added and the beaker containing the mixture was placed on a hot plate and evaporated on a fume chamber. As the beaker was allowed to cool, and the 5cm^3 aqua regia were added again but this time the beaker was covered with a watch glass and returned to the hot plate. The heating continued with continuous addition of aqua regia to complete the digestion and after which it was brought down and another 5cm^3 aqua regia added, with the beaker warmed slightly so as to dissolve the residue (Radojevic and Bashkin, 1976).

The brilliant green lactose bile broth medium was prepared by dissolving 40g of the BGLB powder in 1 litre of distilled water. The solution was then thoroughly mixed and put into test tubes fitted with Durham tubes and sterilized by autoclaving at 121°C for 15 minutes. Parameters analyzed include pH, temperature, taste, colour, conductivity, alkalinity, turbidity, DO, BOD, COD, TDS, TSS, SO_4^{2-}, PO_4^{3-}, NO_3^-, Chlorides and fluorides. The Atomic Absorption Spectrometer (AAS) was used for the determination of all metals studied in this work. Examples of metals studied included calcium, magnesium, sodium, potassium, iron, copper, zinc, cadmium, lead, chromium, and aluminium. Coliform counts were then studied following the method adopted by Kolo (2007) Five tubes each of 50ml, 10ml and 1ml of single strength McConkey Broth Medium were inoculated with volumes of the water samples and incubated for 24 hours at 24ºC. Data collected from the experimental analyses were all subjected to analysis of variance using simple statistical models. One-way analysis of variance and t-test ($p<0.005$) were used to establish whether the parameters varied significantly among water samples and between sampling points at Okpai and Benekuku.

IV. Results and Discussion

Table 1 shows the summary of the twenty nine (29) parameters analyzed both Okpai and Beneku.

Table 1 : Summary of Atmospheric (Rain) Water Quality and their Effects.

S/No.	Parameters	Okpai Rainwater (dry season) DRY.OK. RW	Beneku rainwater (dry season) DRY. BN. RW	Okpai Rainwater (wet season) WET. OK. RW	Beneku rainwater (wet season) BN. RW/ WET.	Max. Permissible Value	Polluted	Unpolluted	Health/ Environment Effects
1.	pH	5.083	6.527	5.973	6.483	6.0 – 8.5	DRY.OK.RW/WET.OK.RW	DRY.BN.RW/WET.BN.RW	Indicates acidification of rain/ corrosion of pipes
2.	Temperature	30.4	28.603	28.303	27.2	25 - 30ºC	DRY.OK.RW	DRY.BN.RW/WET.OK.RW/WET.BN.RW	Drives organisms away / Aesthetics
3.	Taste	1	1	1	0	0	DRY.OK.RW/DRY.BN.RW/WET.OK.RW	WET.BN.RW	Aesthetics
4.	Colour	48	32	48.333	29	15 TCU	All	None	Aesthetic
5.	Conductivity	25.723	17.927	26.08	17.643	1,000μ/cm	None	All	None
6.	Alkalinity	8.877	7.187	8.887	6.693	30 – 500mg/l	All	None	Lowers immunity
7.	Turbidity	2.423	1.723	1.747	1.19	5 NTU	None	All	None
8.	Dissolved Oxygen	6.277	5.803	6.483	6.157	>4	None	All	None
9.	B O D	2.443	2.14	2.71	2.58	0.1 – 1.9mg/l	All	None	Smelly waters
10.	C O D	0.08	0.127	0.15	0.18	200mg/l	None	All	None
11.	T D S	15.933	10.02	15.163	8.933	1,000mg/l	None	All	None
12.	T S S	10.473	8.67	6.84	5.473	20mg/l	None	All	None
13.	Sulphates	0.004	0.003	0.012	0.01	100mg/l	None	All	None
14.	Phosphates	0.0177	0.001	0.04	0.004	10 – 50mg/l	All	None	Hypophosphotaemia
15.	Nitrates	<0.001	<0.001	<0.001	<0.001	50mg/l	None	All	None
16.	Chlorides	0.146	0.102	0.2	0.111	250mg/l	None	All	None
17.	Flourides	<0.001	<0.001	<0.001	<0.001	0.8 – 1.5mg/l	All	None	Easy bacterial contamination
18.	Calcium	1.933	1.327	1.84	1.217	50mg/l	None	All	None
19.	Magnessium	0.647	0.667	1.077	0.933	37 - 150mg/l	All	None	Hypermagnesaemia/Hard water
20.	Sodium	0.093	0.11	0.13	0.137	200mg/l	None	All	None
21.	Potassium	0.01	0.013	0.077	0.037	1 – 2mg/l	All	None	Hypopotasaemia
22.	Iron	0.006	0.004	0.003	0.001	0.3mg/l	None	All	None

23.	Copper	<0.001	<0.001	<0.001	<0.001	0.5mg/l	None	All	None
24.	Zinc	0.029	0.005	0.001	<0.001	3mg/l	None	All	None
25.	Cadmium	<0.001	<0.001	<0.001	<0.001	0.003mg/l	None	All	None
26.	Lead	<0.001	<0.001	<0.001	<0.001	0.01mg/l	None	All	None
27.	Chromium	0.011	<0.001	0.0147	<0.001	0.05mg/l	None	All	None
28.	Aluminium	0.008	<0.001	0.018	0.001	0.2mg/l	None	All	None
29.	Coliform	0	0	0	0	0	None	All	None

Sources : (Amukali, 2012)

Temperature was found to be highest with an average value of 30.4ºC at Okpai during the dry season. The maximum permissible limit for temperature of between 25-30ºC for drinking water (WHO, 1996) was only exceeded at Okpai during dry season. Bhatia (2010) stated that areas prone to discharge of industrial wastes usually have temperature ranges above those of their surrounding environments. Unarguably, the gas flare site at Okpai must have influenced an increase in air temperature, thus correspondingly increasing the temperature of rain water. This is indicative of rain water pollution since organisms that initially depended on such rain waters could find the temperature ranges no longer suitable for their continued stay and could migrate to areas with favourable temperature ranges. Increased temperature of rain water could cause corresponding increase in temperature of surface waters. High temperatures outside the optimum range for a prolonged period of time could cause organisms that depend on it to undergo stress and probably die (USEPA 1991).

Pure water is tasteless (Akan, 2006). Taste in rain water samples within Okpai in dry and wet seasons and that of Beneku in the dry season is indicative of possible contamination. This could be because of dissolved salts and other contaminants finding their ways into rain water sources through gas flaring for Okpai. Kolo (2007) suggested that taste could be an indication of the presence of iron, manganese and hydrogen sulphide in water; thus it could be deduced that objectionable taste in rain water waters for the present study except at Beneku during wet season could be due to the impact of gas flaring.

In terms of color, the maximum permissible value of 15 TCU (NIS, 2007) was exceeded by rain water samples from all studied sites during both seasons. Akan (2006) stated that pure water is colourless. Thus, any water with a characteristic colour insinuates contamination. At $p<0.005$ level of significance, there were significant differences in colour between Okpai and Beneku and even between wet and dry seasons respectively. The more than 300% value recorded at Okpai with respect to the maximum permissible value could be attributable to gas flaring activities within the region while about 200% observed at Beneku could be due to translocation movements of precipitations through agents of weather. This shows a level of contamination in rain waters of both Okpai and Beneku respectively. Like taste, colour could be an indication of dissolved salts and suspended solids. It has no health or environmental effects though, but a major determinant of a consumer's choice of drinking water.

From table 1 the conductivity was highest at Okpai during wet season with an average value of 26.08µs/cm and closely followed by same Okpai during dry season with a value of 25.723µs/cm. At Beneku, dry and wet season average values were 17.927 and 17.643 respectively. The maximum permissible limit of 1,000µs/cm was not met by all values under study. Significant differences at $p<0.005$ existed between Okpai and Beneku but none were noticed between dry and wet seasons in both study areas. Higher conductivity values at Okpai rain waters as compared to Beneku during both seasons could be due to high amounts of dissolved salts and higher evapotranspiration of water. The low values of conductivities in rain waters could be due to effects of excessive cloud cover, release of antagonistic substances and massive evapotranspiration within the region.

Alkalinity was highest at Okpai with an average value of 8.887mg/l and closely followed by same Okpai during dry season with an average value of 8.877mg/l as shown in table 1 at Beneku, the highest value of 7.187mg/l was observed during dry season but 6.693mg/l during the wet seasons respectively. All values were below the maximum permissible value range of between 30-500mg/l (NIS, 2007). At $p<0.005$ level of significance, no significant differences existed between seasons but there were significant differences between study areas. Generally, alkalinity tended to be comparatively higher in Okpai than in Beneku rain water. The higher rate could be attributed to continuous release of acidic substances into Okpai's adjoining environment. Low levels below the recommended maximum range is an indication that rain waters have high chances of acidifying lakes and other surface waters as well as ground water sources within the studied area. Consuming such waters could acidify the human bodies and predispose them to chances of reduction in immunity.

The TDS in the table 1 shows that the highest value at Okpai during dry season with an average value of 15.933mg/l. This was followed by same Okpai during wet season with an average value of 15.163mg/l. before 10.02mg/l and 8.933mg/l were then observed for Beneku dry and wet seasons respectively.). However, WHO (1996) recommended 1,000mg/l for the protection of fisheries and aquatic lives as well as for domestic water supply while less than 500mg/l (NIS, 2007) is the maximum permissible value for TDS in drinking water. All values were below the acceptable limit. There were significant differences at $p<0.05$ level of significance between Okpai and Beneku as well as between dry and wet seasons. Higher TDS values at Okpai during both seasons as compared to Beneku could be due to the release of hydrocarbons into the atmosphere through gas flaring. Based on TDS as a criterion, rain waters of both studied sites and during both seasons are safe for consumption.

V. Conclusion

The results revealed that parameters such as temperature, taste, color, conductivity, total dissolved salts and alkalinity were significantly affected as their values were either less than or exceeded the maximum permissible limits. The chemical parameters however, did not show significant changes when compared with the permissible standards

References Références Referencias

1. *Akan, J.C. (2006); Determination of pollutant levels in some surface and water wastes samples from Kano metropolis, Nigeria*. An M.Sc. Dissertation. University of Maiduguri, Maiduguri. 88p.
2. *Amukali, O (2012):* Assessment of water pollution in Ndokwa-East Local Government area, Delta State, Nigeria. An M. Sc. Dissertation, University of Maiduguri
3. *Bhatia, (2009)* Water Pollution in Chemical Industries. John Welsh Publications, India. 658p.
4. *CIA (2008):* CIA-World fact Book: United Kingdom available online at http://www.cia.gov/library/publications/the-world-factbook/print/uk.litml
5. *Dublin-Green, C.O., Awobamise, A. and Ajao, E.A. (1997): Large marine ecosystem project for the Gulf of Guinea.:Coastal profile of Nigeria.* Nigerian Institute of Oceanography. 36p.
6. *Kolo, B. (2007) Study on the chemical, Physical and biological pollutants in water and aqueous sediments of Lake Chad area, Borno State, Nigeria*. A Ph.D Thesis Submitted to The University of Maiduguri, Maiduguri, Borno State,Nigeria. 12p.
7. *Leroux, M. (2001) The Meteorology and climate of tropical Africa*. Praxis publishing limited,
8. *NIS (2007) Nigeria Standard for drinking Water Quality.* Nigerian Industrial Standard under Standards Organisation of Nigeria. Lagos, Nigeria. Pp15-19.
9. *Nwankwo, C. N. and Ogagarue, D. O. (2011):* Effects of gas flaring on surface and ground waters in Delta State, Nigeria. *In: Journal of Geology and Mining Research. 3(5):*131-136.
10. *Nwilo, P.C. and Badejo, O.T. (2005):* Management of Oil spill dispersal along the Nigerian Coastal Areas. *J. Envtal Mgt. 4*;42-51.
11. *Olaniran, O.J. (1986):* On the classification of tropical climates for this study of regional climatology: Nigeria as a case study. *Geography Annaler. Series A. Physical geography. 68* (4): 233-244.
12. *Oseji, J.O. and Ofomola, M.O. (2010):* Determination of groundwater Flow direction in Utagba Ogbe Kingdom, Ndokwa Land area of delta State, Nigeria. Archives of applied Science Research. 2(4):324-328.
13. *Radojevic, M. and Bashkin, V. N. (1976): Practical Environmental Analysis*. The Royal Society of Chemistry, Cambridge. 466p.
14. *SPDC (2006):* People *and Environment Report*. Shell Nigeria Annual report, 2006. Shell visual media services, London. 18p.
15. *Twumasi, Y.A. and Meren, E.C. (2006):* GIS and remote sensing application in the assessment of change within a coastal environment in the Niger Delta region of Nigeria*. Int. Journal Environ. Res. Public Health. 3* (1) 98-106.
16. *United Nations Development Programme, UNDP (2006) Niger Delta Human Development Report*. UNDP, Abuja, Nigeria 48p.
17. *USEPA (1991): Methods of chemical Analysis of water and waste water*. Office of water Washington DC. Pp 8-21.
18. *USEPA (2007)* Method 7000B: Flame Atomic Absorption Spectrophotometry. Downloaded on 08/11/2011 from *http://www.epa.gov/osw/hazard/testmethods/sw846/pdfs/7000b.pdf*
19. *Waziri, M. (2006):* Physicochemical and bacteriological investigation of surface and ground water of the Kumadugu-Yobe Basin of Nigeria. A Ph.D Thesis submitted to the University of Maiduguri Postgraduate School, Maiduguri, Nigeria. 24-186pp.
20. *WHO (1991) GEMS/WATER (1999-2000): The challenge ahead*. Geneva. Pp.58-61.
21. *WHO (1996):* World Health Organisation's guidelines for drinking water. 3rd edition. Geners, Switzerland. Pp 41-62.

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Physico-Chemical and Bacterialogical Analysis of the Surface Water Used for Domestic Purposes in Okpai and Beneku, Delta State, Nigeria

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Keywords : *gas flaring, oil spillage, surface water, pollution, okpai, beneku.*

GJHSS-C Classification : *FOR Code : 900401*

PHYSICO-CHEMICAL AND BACTERIALOGICAL ANALYSIS OF THE SURFACE WATER USED FOR DOMESTIC PURPOSES IN OKPAI AND BENEKU, DELTA STATE, NIGERIA

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Keywords : gas flaring, oil spillage, surface water, pollution, okpai, beneku.

I. Introduction

Water is the most unique molecular compound ever known in life. It exists in the solid, liquid and gaseous states. Water in its liquid state is what makes life possible on earth because all living organisms are composed of cells that contain at least sixty percent water (Enger and Smith, 2010). All metabolic activities in the bodies of living organisms take place in a water medium. The usefulness of water depends on whether such waters are timely, quantitatively and qualitatively available. According to Bhatia (2009), of over 70% of the earth's surface covered by water, about 97.57% is salt water from oceans while the remaining less than 3% are contained in soils, rivers, lakes, ground water as well as ice and glaciers. Since salt water cannot be readily consumed by humans or freely used for various industrial and domestic purposes, humans and other living organisms depend and compete for the limited fresh water sources available to them. Ball (1999) put it that 'water can shape history and can make or break a king'. Civilizations have flourished and collapsed as a result of changing water supplies (Waziri, 2006). The availability of quantitative and qualitative fresh water for humans have over the years influenced settlement patterns of people in certain geographical regions in preference for others. For water to be adequately utilized, it has to be reasonably free from contaminants. Otherwise, such waters could pose serious health and environmental risks to living organisms that depend on them. Portable water is a fresh water body that is unpolluted, suitable for drinking, odourless and tasteless. Such water boils at 100^0C, freezes at 0°C, is neutral to litmus and has an atmospheric pressure of 760mmHg (Kolo, 2007). Water is a universal solvent for virtually all solutes hence creates a medium upon which every other chemical reaction takes place; be it living or non-living. It cools and heats more slowly than most substances known to science. It's thus used as either a cooling or heating agent. Water could be cultivated in various forms. It could be tapped from underground aquifers via wells or boreholes; could be harvested as rain (precipitation) from the atmosphere and as is the practice in most communities be fetched from surface water sources like rivers, streams, lakes, ponds, oases, seas or even oceans. Surface water has the basic advantage of being comparatively cheaper and very easy to cultivate. Ball (1999) defined surface water as one that fails to penetrate into the soil, subsoil or flows along surface of the ground and eventually enters the lakes, rivers or oceans. The main focus of this study is to assess the

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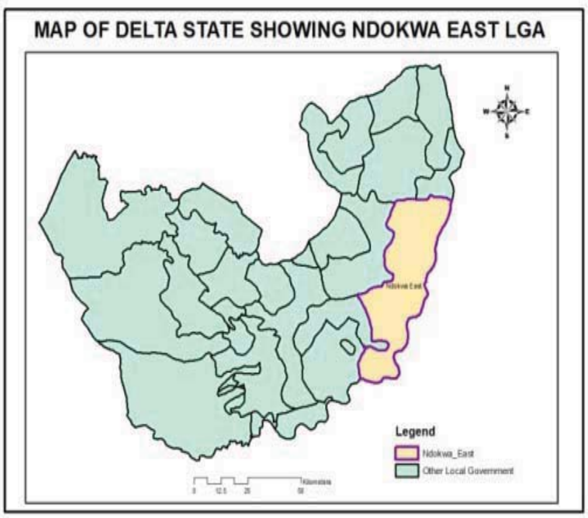
effects of gas flaring and oil spillage on surface water for domestic use in the area.

II. Study Area

The Niger Delta is located within the southern part of Nigeria. It is home to numerous creeks, rivers and possesses the world's largest wetland with significant biological diversity (Twumasi and Merm, 2006). Okpai/Aboh region are within Ndokwa East Local Government Area and are situated within the Sombriero Warri deltaic plain deposit invaded by mangroves. The area is located within latitudes 5°40′N and 5°50′N and longitudes 6°15′E and 6°30′E (Figure 1) (Oseji and Ofomola, 2010).



Source : Delta State Ministry of Lands and Survey, 2009

Geographically, Niger Delta has covered an estimated area of between 19,100 km^2 to 30,000 km^2 based on hydrological, ecological as well as political boundaries (SPDC, 2006 and UNDP, 2006). Okpai/Aboh region is within a low-lying height of not more there 3.0 meters above sea level and generally covered by fresh water, swamps, mangrove swamp, lagoonal marshes, tidal channels, beach ridges and sand bars along its aquatic fronts (Dublin-Green *et al*, 1997). The area has a characteristic tropical monsoon climate at the coast with rainfall peaks in June and September/October with prevailing tropical maritime air mass almost all year round with little seasonal changes in wind directions (Olaniran, 1986). Annual mean total rainfall has been put at between 1,500mm and 3,000 mm with a mean monthly temperature range of 24-25°C during the rainy season in August and 27-29°C during tail end of dry season in March/April. Leroux (2001) reported that maximum temperatures are recorded between January and March (33°C) while minimum temperature are recorded in July and December (21°C), respectively. Temperatures are seriously moderated by cloud cover and damp air. It experiences a tropical climate consisting of rainy season (April to November) and dry season (December to march). The average annual rainfall is about 2,500mm while the wind speed ranges between 2-5m/s in the dry season to up to 10m/s in the rainy season especially during heavy rainfall and thunderstorms. The region is criss-crossed with distributories and creeks. This area has been classified geomorphologically to consist of tidal flat and large flood plains lying between mean, low and high tides. Three different highs exist within the Kwale block, namely; a central high where most of the wells have been drilled an eastern high housing one well and a north western high whose extent has not been clearly defined. The area lies within the freshwater forested region of the Niger Delta.

III. Methodology

Surface water samples were collected from two distinct locations. The first was within the Agip Gas Plant in Okpai area (experimental site) while the second was about 5km away at Beneku (control site), both within Ndokwa-East Local Government area of Delta State, Nigeria. Samples were collected during the dry (December 2010, January 2011 and February 2011) and wet (June, July and August 2011) seasons. Means of the three months were then used to represent specific parameters for either dry or wet seasons, respectively. A total of six samples were collected from each of the distinct points. Three samples of surface water were collected from both Okpai and Beneku in the study areas. The samples were collected around 5.00 – 6.00pm of the day. The surface water samples collected were analyzed. At every point, two sets of samples were collected: one for AAS analysis and the other for anions like phosphate, sulphate and nitrate. No further treatment was needed for the anions, thus the samples were analyzed right away to minimize chemical changes in the sample and prevent losses to the environment (Radojevic and Bashkin, 1976).

Pre-treatment of the water samples elemental analysis was necessary because of the likelihood of such samples containing suspended particles along with metals. Pre-treatment involved addition of an acid to preserve the sample, destroying organic matter and bringing all metals into solution (Radojevic and Bashkin, 1976). A few drops of concentrated HNO_3 were added to the water samples after collection to preserve the samples, destroy organic matter and minimize absorption on the walls of the containers. Preparation of standard stock solutions and working standards were done following the methods by USEPA (2007) for calcium, magnesium, sodium, potassium, iron, copper, zinc, cadmium, lead, chromium and aluminium. McConkey broth single and double strengths were also prepared. Full details on preparation of stock solutions and working standards are contained in Amukali (2012).

100cm³ of water samples were measured and put into a beaker. A 5cm³ aqua regia (HNO_3 : HCl in ratio 3:1) was then added and the beaker containing the mixture was placed on a hot plate and evaporated on a fume chamber. As the beaker was allowed to cool, and the 5cm³ aqua regia were added again but this time the beaker was covered with a watch glass and returned to the hot plate. The heating continued with continuous addition of aqua regia to complete the digestion and after which it was brought down and another 5cm³ aqua regia added, with the beaker warmed slightly so as to dissolve the residue (Radojevic and Bashkin, 1976).

The brilliant green lactose bile broth medium was prepared by dissolving 40g of the BGLB powder in 1 litre of distilled water. The solution was then thoroughly mixed and put into test tubes fitted with Durham tubes and sterilized by autoclaving at 121ºC for 15 minutes. The parameters analyzed include pH, temperature, taste, colour, conductivity, alkalinity, turbidity, DO, BOD, COD, TDS, TSS, SO_4^{2-}, PO_4^{3-}, NO_3^-, Chlorides and fluorides. The Atomic Absorption Spectrometer (AAS) was used for the determination of all metals studied in this work (calcium, magnesium, sodium, potassium, iron, copper, zinc, cadmium, lead, chromium, and aluminium). Coliform counts were then studied following the method adopted by Kolo (2007) five tubes each of 50ml, 10ml and 1ml of single strength McConkey Broth Medium were inoculated with volumes of the water samples and incubated for 24 hours at 24ºC.

IV. Results and Discussion

The results for the twenty nine (29) parameters analyzed in surface water samples at both Okpai and Beneku are presented in (table 1-5). The pH was found to be highest at Beneku during wet season with an average value of 6.91. A value of 6.82 was observed at same Beneku during dry season, 5.86 at Okpai during wet season while 5.34 at same Okpai during dry season. Using the maximum permissible range of 6.0-8.5 as limit for pH (NIS, 2007) as benchmark, Beneku rain waters were comfortably within safe limits while those of Okpai were within acidic ranges, thus signifying some level of pollution during both seasons. This agrees with the observations made by Nwankwo and Ogagarue (2011) that areas prone to oil spillage have pH levels that are within acidic ranges. In addition, higher acidities at Okpai during dry than wet season is an indication that large volumes of water received during wet season tend to help in neutralizing the acidic contents of Okpai surface waters while highly acidified rains received during dry season tend to further increase the pH levels of surface waters. It could be deduced that large amounts of water received by surface waters tends to be neutralized, thereby reducing the level of acidity within the study area. Direct discharge of oil and its constituents could also be responsible for the higher acidity levels of surface waters of Okpai. Aquatic plants and animals that depend on Okpai surface waters for sustenance stand dangers of ingesting toxic substances that could lead to diseases and death. Okpai surface waters fell below the stream standard for fishing and this is a clear indication that fishes and other aquatic organisms might have migrated to nearby surface water bodies where they could have minimum stress.

Table 1 : Physical Parameters of the Samples

	Parameters			
Samples	Tempt (°C)	Colour	Taste	Turbidity (WTU)
DRY.OK.SW	27.88	35.33	2	6.25
DRY.BN.SW	28.50	23.00	1	4.54
WET.OK.SW	27.40	32.00	2	4.58
WET.BN.SW	27.10	21.00	1	3.67
Max. Perm. Value	25 – 30°C	15 TCU	0	5NTU

Table 2 : Chemical/Biological parameters of the samples

Samples	Conductivity	Alkalinity	Dissolved Oxygen	B O D	T D S	T S S	pH
DRY.OK.SW	187.33	11.21	3.10	0.77	62.46	9.62	5.33
DRY.BN.SW	81.04	3.03	3.53	1.12	24.54	10.27	6.82
WET.OK.SW	191.42	11.37	3.54	0.91	48.33	11.44	5.86
WET.BN.SW	86.10	2.26	3.77	1.22	11.42	10.34	6.91
Max. Perm. Value	1,000μ/cm	30 – 500mg/l	>4	0.1 – 1.9mg/l	1,000mg/l	20mg/l	6.0 – 8.5

Table 3 : Levels of some Anions in the samples

	Anions (Mg/L)				
Samples	SO_4^{2-}	PO_4^{3-}	NO^{3-}	Cl^-	F^-
DRY.OK.SW	1.29	0.11	0.04	0.63	<0.001
DRY.BN.SW	0.06	0.01	<0.001	0.39	<0.001
WET.OK.SW	1.31	0.020	0.03	0.895	<0.001
WET.BN.SW	0.10	0.02	<0.001	0.24	<0.001
Max. Perm. Value	100mg/l	10 – 50mg/l	50mg/l	250mg/l	0.8 - 1.5mg/l

Table 4 : Levels of some Elements in the samples

	Elements (Mg/L)										
Samples	Ca	Mg	Na	K	Fe	Cu	Cd	Zn	Pb	Cr	Al
DRY.OK.SW	6.69	2.06	0.27	0.107	0.12	0.02	<0.001	0.05	<0.001	<0.001	<0.001
DRY.BN.SW	3.71	1.98	0.03	0.07	0.01	0.01	<0.001	0.01	<0.001	<0.001	<0.001
WET.OK.SW	4.26	2.44	0.46	0.17	0.08	0.01	<0.001	0.02	<0.001	<0.001	<0.001
WET.BN.SW	3.55	2.24	0.09	0.14	0.01	0.00	<0.001	0.01	<0.001	<0.001	<0.001
Max. Perm. Value	50mg /l	37 - 150mg/l	200m g/l	1 – 2mg/l	0.3m g/l	1.0m g/l	0.003m g/l	3mg/l	0.01mg /l	0.05mg /l	0.2mg/l

Table 5 : Result of the Bacteriological Analysis

Samples	Coliform
DRY.OK.SW	<2.0
DRY.BN.SW	0
WET.OK.SW	<1.667
WET.BN.SW	0
Max. Perm. Value	0

Temperature was found to be highest with an average value of 28.5^{0}C at Beneku during the dry season. Okpai during dry season had an average value of 27.90^{0}C; 27.40^{0}C was observed for Okpai during wet season while the least value of 27.1^{0}C was noticed at Beneku (table 1). The maximum permissible limit of temperature of between 25-30^{0}C for drinking water was not exceeded by all surface water sources assessed in this study. Bhutia (2005) stated that areas prone to discharge of industrial wastes usually have temperature ranges above those of their surrounding environments. Therefore, the operational presence of a ferry that conveys people to and fro Pontu river from where Beneku surface water samples were collected, must have influenced an increase in surface water temperature of Beneku during dry season where there were lesser amounts of water available to neutralize temperatures of rain water and runoff received while wet season has lots of water available to reduce the temperature of received waters. This is indicative of surface water pollution since organisms that initially depend on such surface waters could find the temperature ranges no longer suitable for their continued stay and could migrate to areas with favourable temperature condition. Small increases in temperatures of surface waters puts aquatic organisms living in them to be under environmental stress, kills certain species plants and animals and leaving oxygen-demanding wastes to decay. Oxygen has been reported to be less soluble at higher temperatures (Khan and Khamd, 1994). Higher surface water temperatures limit migration, spawning, egg incubation, growth and metabolism as well as rates of respiration.

Pure water is tasteless (Bhutia, 2005). Okpai and Beneku surface waters (table 1) during wet and dry seasons both had a value of 2 and 1 respectively, which indicates surface water contamination. The maximum permissible limit for taste has no nominal value verbally unobjectionable (NIS, 2007) and this by our adopted scale equals zero. This phenomenon could be attributed to dissolved salts and other contaminants like spilled oil and other wastes substances that could drain into the surface water. Though, tastes as recorded in this study do not have any health effects, but does affect a consumer's choice.

Bhutia (2005) stated that pure water is colourless. Thus, any water with a characteristic colour insinuates contamination. The highest value for colour was observed for Okpai during dry season with a value of 35.33 TCU while a value of 32 TCU was recorded for Okpai during wet season. Beneku during dry and wet seasons had 23 TCU and 21 TCU respectively (table 1). The maximum permissible value for colour of 15 TCU (NIS, 2007) has been exceeded by all values in this area. Colour of surface waters must have been affected more during dry season than wet season and dissolved salts, spilled oil, coloured rain water as well as other contaminants. Colour could also be due to the presence of decaying organic matter, iron compounds, leaching of organic materials into surface waters, waste water of industrial processes, eutrophication and suspended solids.

Okpai during both dry and wet seasons were respectively more than 100% greater than the recommended maximum permissible value for colour. Generally, Okpai showed higher levels of colouration than Beneku on the one hand while dry season was higher than wet season in both study sites. This shows a level of contamination in surface waters of both Okpai and Beneku during the two seasons, most especially at Okpai. There were significant differences between wet and dry seasons and between Okpai and Beneku. Colour affects a consumer's choice for drinking water.

Conductivity was highest at Okpai during wet season with a value 191.42 μs/cm and 187.33μs/cm was recorded for same Okpai during dry season. Conductivity values for Beneku during wet and dry season with values of 86.10μs/cm and 81.04μs/cm, respectively was observed (table 2). The maximum permissible limit of 1,000μs/cm (NIS, 2007) was not met by all values under study for surface water. Significant differences existed between Okpai and Beneku and between both seasons at $p<0.05$ level of significance. Conductivity was higher at Okpai surface waters than Beneku while wet season influenced higher conductivities than dry season. Higher conductivities in surface waters during wet season as against dry season could be due to such waters receiving waters that are already loaded with salts. Higher conductivities in surface waters during wet season as against dry season could be due to such waters receiving waters that are already loaded with salts. The high rate of conductivity in Okpai surface waters could be due to excessive accumulation of salts, impurities in rain water, spilled oil, through run-off from agricultural lands and possible emissions of flared gases getting into surface waters.

Alkalinity was highest at Okpai during wet season with a value of 11.373 and this was closely followed with a value of 11.21 for Okpai during dry season. Also, 3.03 and 2.26 were then observed for Beneku during dry and wet seasons respectively (table 2). Alkalinity was found to be higher at Okpai than at Beneku. Comparatively, the high rate at Okpai could be attributed to continuous release of chemicalized substances through oil spillage and gas flaring which later drains into surface water bodies. Higher alkalinity levels in surface waters as compared to rain waters could be due to the influences of rocks, soils, certain plant activities and dissolved salts. It could be deduced that Okpai surface waters have higher capacities to neutralize acidified rains than Beneku surface waters.

The approved maximum permissible range of between 30-500mg/l for drinking water (USEPA, 1991) was not met by all study sites during the two seasons. Drinking surface waters which are already below the approved ranges could lead to the acidification of the human body's alkalinity status and these could predispose human being to higher risks of infection.

Total Dissolved Solids of Ground Water (TDS) has the highest value at Okpai during dry season with an average value of 62.46mg/l and this was followed by 48.33mg/l at same Okpai but during wet season. Values for Beneku were then 24.54mg/l and 11.42mg/l during dry and wet seasons (table 2). WHO (1996) recommends 1000mg/l for the protection of fisheries and aquatic lives while NIS (2007) recommended 500mg/l as maximum permissible limit for domestic water supply. All values were below the acceptable limit.

High TDS values at Okpai as compared to Beneku could be attributed to massive contamination by chemicals and allied substances emanating from oil related activities like gas flaring and oil spillage. Surface waters contamination in this wise could be due to continuous contamination of the waters by industrial pollutants as reported by Bhatia (2005). The high TDS with respect to Dissolved Oxygen (DO) with the low DO agrees which depict high TDS (Ademoroti, 1996).

High levels of TDS in drinking water may be objectionable to consumers due to its taste and this could cause excessive scaling in water pipes, boilers and household appliances (Kolo, 2007). Surface water for the two study sites for both seasons could be described as excellent since according to Ademoroti, (1996), a water sample is rated good if TDS is between 300 – 600mg/l, fair if between 600 – 900mg/l, poor if between 900 – 1200mg/l and unacceptable when above 1200mg/l.

The mean values of TSS show that Okpai during wet season had its highest value of 11.443mg/l. During wet season at Beneku, 10.337mg/l was recorded, 10.27mg/l at Beneku during dry season and finally 9.62mg/l at Okpai during dry season (table 2). Okpai and Beneku when compared at $p<0.005$ level of significance showed that in terms of seasons, that wetness had greater impacts over dryness, and there were peculiarities between Okpai and Beneku. The maximum permissible limit for TSS for drinking water of 500mg/l (NIS, 2007) was not exceeded by all study sites during the two seasons.

Coliform colonies (table 5) that were detected in Okpai during two seasons were less than 2.0cfu/ml and 1.67cfu/ml, respectively. The maximum permissible limit of 0cfu/ml for drinking water (NIS, 2007) was exceeded at Okpai but not in Beneku during both seasons. Industrial activities within Okpai must have influenced the presence of coliform bacteria. The stagnant nature of Okpai surface waters must have also contributed to the non dispersal of coliform bacteria in Okpai while Beneku surface waters with very high water current must have easily dispersed coliform bacteria out in a very timely way. Thus, Okpai surface waters could pose a great health and environmental danger owing to evidence of possible bacterial contamination. Pathogenic organisms like E-coli and a host of other pathogenic organisms could be present within the surface waters and this could lead to serious health hazards to the consumers.

In summary, the surface water of the study area is also relatively safe for drinking but not as rain water within the period of study (Amukali, 2012)

V. Conclusion

Surface waters at Okpai showed variation in the levels of the studied parameters with season. Okpai showed slight variation with season since during dry season; only pH, taste, colour, turbidity, magnesium and coliform exceeded the maximum permissible limits for drinking water. But during wet season; only pH, taste, colour, magnesium and coliform were above the limits. On the other hand, Beneku didn't show any marked variation between seasons. It could be deduced that Beneku surface waters were less polluted than Okpai surface waters however none is suitable for drinking except after an appropriate treatment of the water is performed.

References Références Referencias

1. *Ademoroti, C.M.A. (1996): Standard methods for Water and Effluent Analysis.* 1st Ed. Foludex Press ltd, Ibadan Pp. 22-23, 111-112.
2. *Amukali, O (2012):* Assessment of water pollution in Ndokwa-East Local Government area, Delta State, Nigeria. An M. Sc. Dissertation, University of Maiduguri
3. *Ball, P. (1999):* Life's Matrix: A Biography of Water. Farrar Straus and Giroux, New York. 23-87pp.
4. *Bhatia, (2009)* Water Pollution in Chemical Industries. John Welsh Publications, India. 658p.
5. *Dublin-Green, C.O., Awobamise, A. and Ajao, E.A. (1997): Large marine ecosystem project for the Gulf of Guinea.:Coastal profile of Nigeria.* Nigerian Institute of Oceanography. 36p.
6. *Enger, E.D and Smith, B.F. (2010): Environmental Science: A Study of interrelationships*. Eleventh Edition. McGraw-Hill International Edition, Boston. 488 p.
7. Khan, A.S. (1994). Nigeria-The Political Economy of Oil: The Political Economy of Oil-Exporting Countries. Oxford University Press for the Oxford Institute of Energy Studies. Oxford. 248p.
8. *Kolo, B. (2007) Study on the chemical, Physical and biological pollutants in water and aqueous sediments of Lake Chad area, Borno State, Nigeria*. A Ph.D Thesis Submitted to The University of Maiduguri, Maiduguri, Borno State,Nigeria. 12p
9. *Leroux, M. (2001) The Meteorology and climate of tropical Africa*. Praxis publishing limited,
10. *NIS (2007) Nigeria Standard for drinking Water Quality.* Nigerian Industrial Standard under Standards Organisation of Nigeria. Lagos, Nigeria. Pp15-19.
11. *Nwankwo, C. N. and Ogagarue, D. O. (2011):* Effects of gas flaring on surface and ground waters in Delta State, Nigeria. *In: Journal of Geology and Mining Research. 3(5):*131-136.
12. *Olaniran, O.J. (1986):* On the classification of tropical climates for this study of regional climatology: Nigeria as a case study. *Geography Annaler. Series A. Physical geography. 68* (4): 233-244.
13. *Oseji, J.O. and Ofomola, M.O. (2010):* Determination of groundwater Flow direction in Utagba Ogbe Kingdom, Ndokwa Land area of delta State, Nigeria. Archives of applied science Research. 2(4):324-328.
14. *Pescod, M. B. (1977).* Surface Water Quality Criteria for Developing Countries in Water, wastes and Health in Hot Climate. Faechem. R., McGorng, M. and Maro, D. (eds). John Wiley, London. Pp. 52 – 77.
15. *Radojevic, M. and Bashkin, V. N. (1976): Practical Environmental Analysis*. The Royal Society of Chemistry, Cambridge. 466p.
16. *SPDC (2006):* People *and Environment Report*. Shell Nigeria Annual report, 2006. Shell visual media services, London. 18p.
17. *Twumasi, Y.A. and Meren, E.C. (2006):* GIS and remote sensing application in the assessment of change within a coastal environment in the Niger Delta region of Nigeria. *Int. Journal Environ. Res. Public Health. 3* (1) 98-106.
18. *United Nations Development Programme, UNDP (2006) Niger Delta Human Development Report*. UNDP, Abuja, Nigeria 48p.
19. *USEPA (1991): Methods of chemical Analysis of water and waste water*. Office of water Washington DC. Pp 8-21.
20. *USEPA (2007)* Method 7000B: Flame Atomic Absorption Spectrophotometry. Downloaded on 08/11/2011 from *http://www.epa.gov/osw/hazard/testmethods/sw846/pdfs/7000b.pdf*
21. *Waziri, M. (2006):* Physicochemical and bacteriological investigation of surface and ground water of the Kumadugu-Yobe Basin of Nigeria. A Ph.D Thesis submitted to the University of Maiduguri Postgraduate School, Maiduguri, Nigeria. 24-186pp.
22. *WHO (1993).* World Health Organisation's Guidelines for Drinking Water. (3rd edition). Geneva, Switzerland. Pp. 41-62.

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Phenologically-Tuned MODIS NDVI-Based Time Series (2000-2012) for Monitoring of Vegetation and Climate Change in North-Eastern Punjab, Pakistan

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Abstract - One of the main factors determining the daily variation of the active surface temperature is the state of the vegetation cover. It can well be characterized by the Normalized Difference Vegetation Index (NDVI). The NDVI has the potential ability to signal the vegetation features of different eco-regions and provides valuable information as a remote sensing tool in studying vegetation phenology cycles. The vegetation phenology is the expression of the seasonal cycles of plant processes and contributes vital current information on vegetation conditions and their connections to climate change. The NDVI is computed using near-infrared and red reflectances, and thus has both an accuracy and precision. A gapless time series of MODIS NDVI (MOD13A1) composite raster data from 18th February, 2000 to 16th November, 2012 with a spatial resolution of 500 m was utilized. Time-series terrestrial parameters derived from NDVI have been extensively applied to global climate change, since it analyzes each pixel individually without the setting of thresholds to detect change within a time series.

Keywords : Climate, MODIS, NDVI, remote sensing, time series, vegetation phenology.

GJHSS-C Classification : FOR Code : 630205p, 770101p

PHENOLOGICALLY-TUNED MODIS NDVI-BASED TIME SERIES 2000-2012 FOR MONITORING OF VEGETATION AND CLIMATE CHANGE IN NORTH-EASTERN PUNJAB, PAKISTAN

Strictly as per the compliance and regulations of:

Phenologically-Tuned MODIS NDVI-Based Time Series (2000-2012) for Monitoring of Vegetation and Climate Change in North-Eastern Punjab, Pakistan

Farooq Ahmad [α] & Qurat-ul-ain Fatima [σ]

Abstract - One of the main factors determining the daily variation of the active surface temperature is the state of the vegetation cover. It can well be characterized by the Normalized Difference Vegetation Index (NDVI). The NDVI has the potential ability to signal the vegetation features of different eco-regions and provides valuable information as a remote sensing tool in studying vegetation phenology cycles. The vegetation phenology is the expression of the seasonal cycles of plant processes and contributes vital current information on vegetation conditions and their connections to climate change. The NDVI is computed using near-infrared and red reflectances, and thus has both an accuracy and precision. A gapless time series of MODIS NDVI (MOD13A1) composite raster data from 18th February, 2000 to 16th November, 2012 with a spatial resolution of 500 m was utilized. Time-series terrestrial parameters derived from NDVI have been extensively applied to global climate change, since it analyzes each pixel individually without the setting of thresholds to detect change within a time series. The required data preparation for the integration of MODIS NDVI data into GIS is described with focus on the projection from the MODIS/Sinusoidal projection to the national coordinate systems. Through the application and analyses of time-series data, this research will provide valuable understanding of the impact of environmental drivers on the spatial, annual and inter-annual variation of climate and vegetation cover dynamics across north-eastern Punjab province of Pakistan. The results have important implications for parameterization of land surface process models using biophysical variables estimated from remotely sensed data.

Keywords : Climate, MODIS, NDVI, remote sensing, time series, vegetation phenology.

I. Introduction

Long-term observations of remotely sensed vegetation dynamics have held an increasingly prominent role in the study of terrestrial ecology (Budde et al., 2004; Prasad et al., 2007; Ouyang et al., 2012). A major limitation of such studies is the limited availability of sufficiently consistent data derived from long-term remote sensing (Ouyang et al., 2012). The benefit obtained from a remote sensing sensor thereby largely depends on its spectral resolution (Jensen, 2005), which determines the sensor's capability to resolve spectral features of land surfaces (Fontana, 2009). One of the key factors in assessing vegetation dynamics and its response to climate change is the ability to make frequent and consistent observations (Thomas and Leason, 2005; Ouyang et al., 2012). Ability to assess how environmental changes affect dynamics of vegetation is increasingly important for better predictions of climate change effects (Aguilar et al., 2012). Popularity of the application of the NDVI (Rouse et al., 1973; Tucker, 1979) in ecological studies has enabled quantification and mapping of green vegetation with the goal of estimating above ground net primary productivity and other landscape-level fluxes (Wang et al., 2003; Pettorelli et al., 2005; Aguilar et al., 2012). The evolution of vegetation index exhibits a strong correlation with the typical green vegetation growth stages. The results (temporal curves) can be analyzed to obtain useful information such as the start/end of vegetation growing season (Gao and Mas, 2008; Ahmad, 2012a). The NDVI is the most commonly used index (Ahmad, 2012b) and serves as a measure of photosynthetic activity within a certain area (Fontana, 2009).

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The NDVI is based on differences in reflectance in the red region and maximum reflectance in the near infrared; it is the most widely used index in remote sensing (Aguilar et al., 2012).

The NDVI can be a useful tool to couple climate and vegetation distribution and performance at large spatial and temporal scales (Pettorelli et al., 2005; Aguilar et al., 2012) because vegetation vigor and productivity are related to temperature-precipitation and evapotranspiration. The NDVI serves as a surrogate measure of these factors at the landscape scale (Wang et al., 2003; Groeneveld and Baugh, 2007; Aguilar et al., 2012). The linear response of vegetation NDVI to rainfall for regions with low vegetation cover and rainfall is well documented (Malo and Nicholson, 1990; Yang et al., 1998; Kawabata et al., 2001; Ji and Peters, 2003; Wang et al., 2003; Groeneveld and Baugh, 2007; Aguilar et al., 2012). The relationship between NDVI and climatic factors are location-dependent, more detailed analyses are needed (Wang et al., 2003; Aguilar et al., 2012).

The Moderate Resolution Imaging Spectroradiometer (MODIS) is a key instrument onboard the Terra and Aqua satellite platforms (Huete et al., 2006; Carrão et al., 2008; Ahmad, 2012c). Terra's orbit around the Earth is timed so that it passes from north to south across the equator in the morning, while Aqua passes south to north over the equator in the afternoon (Salomonson and Toll, 1991; GSFC/NASA, 2003; Huete, 2005; Ahmad, 2012c). The MODIS has been applied in diverse applications for two reasons, the advantage of daily data and the possibility for high-quality data covering large land areas (Zhao et al., 2009; Ouyang et al., 2012) and offers a good opportunity to monitor and analyze regional land surface processes. This is especially true for NDVI vegetation analysis, for which MODIS provides a standard product (Piao et al., 2006a; Zhao et al., 2009; Ouyang et al., 2012). The MODIS design team gave substantial emphasis to instrument calibration and characterization recognizing these activities as critical for generation of accurate long-term time-series products needed for global change studies (Huete et al., 1999; Justice et al., 2002).

The MODIS, high temporal resolution sensor allow detailed monitoring of the temporal change in vegetation (Weissteiner et al., 2011; Ouyang et al., 2012). Higher resolution sensors provide spatial detail while low resolution satellites offer high temporal repetition at the expense of spatial resolution (Ouyang et al., 2012). Over the last two decades, studies of vegetation dynamics have explored several approaches to improve the spatial-temporal resolution of data from remote sensing sources. Integrating medium to high spatial resolution data with high temporal resolution data can provide a means to detect most of the variation in vegetation (Jin and Steven, 2005; Ouyang et al., 2012).

The MODIS NDVI datasets provides unique opportunities for monitoring terrestrial vegetation conditions at regional and global scales (Yang et al., 1997; Piao et al., 2006), and has widely been used in research areas of net primary production (Potter et al., 1993; Paruelo et al., 1997; Piao et al., 2006), vegetation coverage (Tucker et al., 1991; Myneni et al., 1997; Los et al., 2001; Zhou et al., 2001; Piao et al., 2003; Piao et al., 2006), biomass (Myneni et al., 2001; Dong et al., 2003; Piao et al., 2006), and phenology (Reed et al., 1994; Moulin et al., 1997; Piao et al., 2006).

Multi-year time series of NDVI can reliably measure yearly changes in the timing of the availability of high-quality vegetation. The biological significance of NDVI indices should be assessed in various habitat types before they can be widely used in ecological studies (Hamel et al., 2009). The premise is that the NDVI is an indicator of vegetation health, because degradation of ecosystem vegetation, or a decrease in green, would be reflected in a decrease in NDVI value (Hamel et al., 2009; Meneses-Tovar, 2011). The NDVI has the potential ability to signal the vegetation features of different eco-regions and provides valuable information as a remote sensing tool in studying vegetation phenology cycles at a regional scale (Guo, 2003). Phenology has emerged recently as an important focus for ecological research (Menzel et al., 2001; Hashemi, 2010).

II. Study Area

The study area lies in the north-eastern Punjab province of Pakistan from 30° 11' 52" to 32° 27' 19" North latitude and 71° 53' 23" to 75° 56' 24" East longitude. The research area is consists of six districts (Figure 1); Lahore, Sheikhupura, Hafizabad, Nankana Sahib, Kasur and Okara of the province.

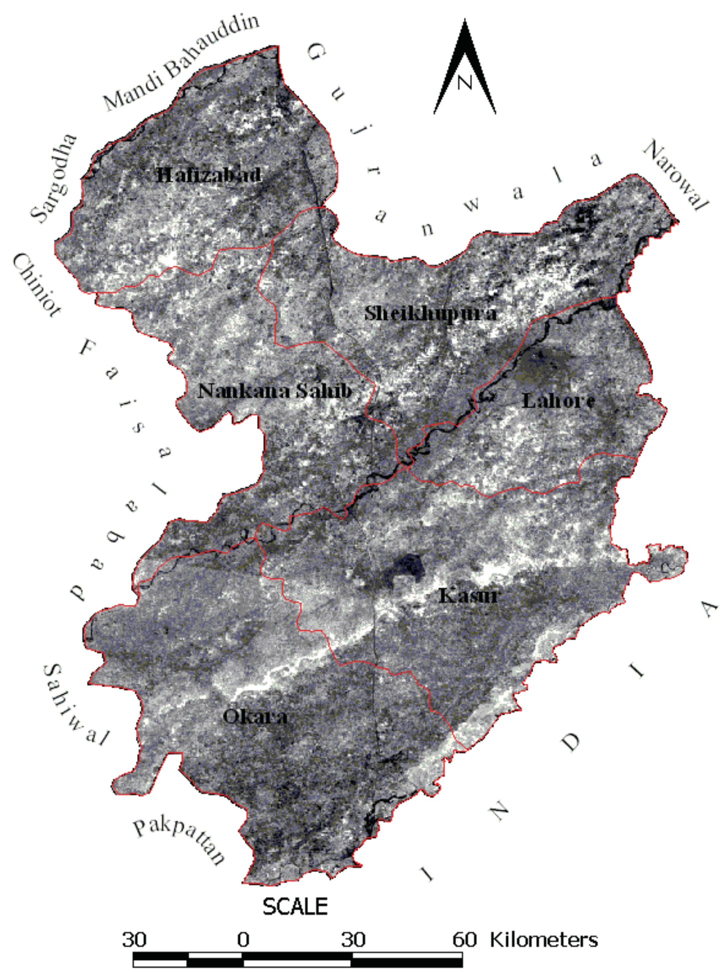

Figure 1 : Study Area - Landsat ETM+ May 31st 2003 mosaic image. *Source :* http: //glovis.usgs.gov/

III. Research Design and Methods

The MODIS is a key instrument onboard the Terra satellite and provides images over a given pixel of land specifically designed for measurements of land surface dynamics (Huete, 2005). The MODIS sensors, as a newer generation sensor specifically designed for, inter alia, terrestrial applications (Fontana, 2009) and a validation with accurately georeferenced composite data from the MODIS sensor revealed the high accuracy of the orthorectified NDVI composites and emphasized the great importance of orthorectification for data quality in rugged terrain (Barnes et al., 1998; Fontana, 2009). The MODIS provides higher radiometric sensitivity (Barnes and Salomonson, 1993; Fontana, 2009). In each of the 36 spectral bands, the 12-bit resolution results in 4096 levels of discrimination in measured response (Guenther et al., 1998; Fontana, 2009). The bands are sensitive to different portions of the electromagnetic spectrum between 0.46 μm and 14.39 μm at spatial resolutions of 250 m, 500 m, and 1 km, depending on the spectral band (Fontana, 2009). The output delivered by the MODIS level 1B algorithm includes geolocated at aperture radiances in all 36 spectral bands (Isaacman et al., 2003; Xiong et al., 2003; 2003a; Xiong et al., 2005; Fontana, 2009).

Earth location data is available at sub-pixel accuracy. This extraordinary geolocation accuracy is achieved due to several reasons (Wolfe et al., 1995; 2002; Fontana, 2009): First, the spacecrafts carrying MODIS are very stable and provide highly precise external orientation knowledge. Second, the MODIS instrument was designed to give precise interior orientation knowledge (Khlopenkov and Trishchenko, 2008; Fontana, 2009). Third, an accurate global DEM (Logan, 1999; Fontana, 2009) is used to model and remove relief-induced distortions. Fourth, a global set of GCPs based on Landsat imagery served to determine biases in the sensor orientation, which were finally used to improve geolocation processing (Ackerman et al., 1998; 2006; Fontana, 2009).

The MODIS NDVI data products for research area were acquired, in this case MOD13A1 (MODIS TERRA_500 m) data were downloaded from the Land Processes Distributed Active Archive Center (LPDAAC). Tile number covering this area is h24v05, reprojected from the Integerized Sinusoidal projection to a Geographic Lat/Lon projection, and Datum WGS84 (GSFC/NASA, 2003; Ahmad, 2012a). A gapless time series of MODIS NDVI composite raster data from 18th February, 2000 to 16th November, 2012 with a spatial resolution of 500 m was utilized (Figure 2) for phenologically-tuned MODIS NDVI-based time series development. The datasets provides frequent information at the spatial scale at which the majority of human-driven land cover changes occur (Townshend and Justice, 1988; Verbesselt et al., 2010).

The NDVI values range from -1 to +1; because of high reflectance in the NIR portion of the EMS, healthy vegetation is represented by high NDVI values between 0.1 and 1 (Liu and Huete, 1995; USGS, 2008; 2010). Conversely, non-vegetated surfaces such as water bodies yield negative values of NDVI because of the electromagnetic absorption property of water. Bare soil areas represent NDVI values which are closest to 0 due to high reflectance in both the visible and NIR portions of the EMS (Townshend, 1992). The NDVI is related to the absorption of photosynthetically active radiation and basically measures the photosynthetic capability of leaves, which is related to vegetative canopy resistance and water vapour transfer (Wan, 2003; Rahman et al., 2004; Ahmad, 2012a).

The NDVI is successful as a vegetation measure is that it is sufficiently stable to permit meaningful comparisons of seasonal and inter-annual changes in vegetation growth and activity (Choudhury, 1987; Jakubauskas et al., 2002; Chen et al., 2006; Zoran and Stefan, 2006; Nicandrou, 2010; Ahmad, 2012a; 2012b). The strength of the NDVI is in its ratioing concept (Moran et al., 1992), which reduces many forms of multiplicative noise (illumination differences, cloud shadows, atmospheric attenuation, and certain topographic variations) present in multiple bands (Chen et al., 2002; Nicandrou, 2010; Ahmad, 2012a).

ERDAS imagine 2011 software was used for extraction of NDVI layer from MODIS data product and development of gapless composite image from 18th February, 2000 to 16th November, 2012. In this study, eighteen villages out of six districts of north-eastern Punjab province were selected randomly. The data products were used to generate phenological time-series variation profile for Kot Jan Muhammad, Amarkot, Jodhwala, Sukka Chak, Adilgarh, Jagganwala, Qila Deva Singh, Ali Raza Abad, Shakranj Pur, Titranwali, Ajianwala, Makki Unchi, Bodal Khaneke, Asrur, Katlohi Kallan villages and phenological temporal comparison at 16-days interval for Thatha Khudayar and Haveli villages, year 2007 to 2011. Further, biomass versus NDVI and mean maximum; January 2011 to December 2011 was generated for Bahak Maqaiyaddin village of the research area.

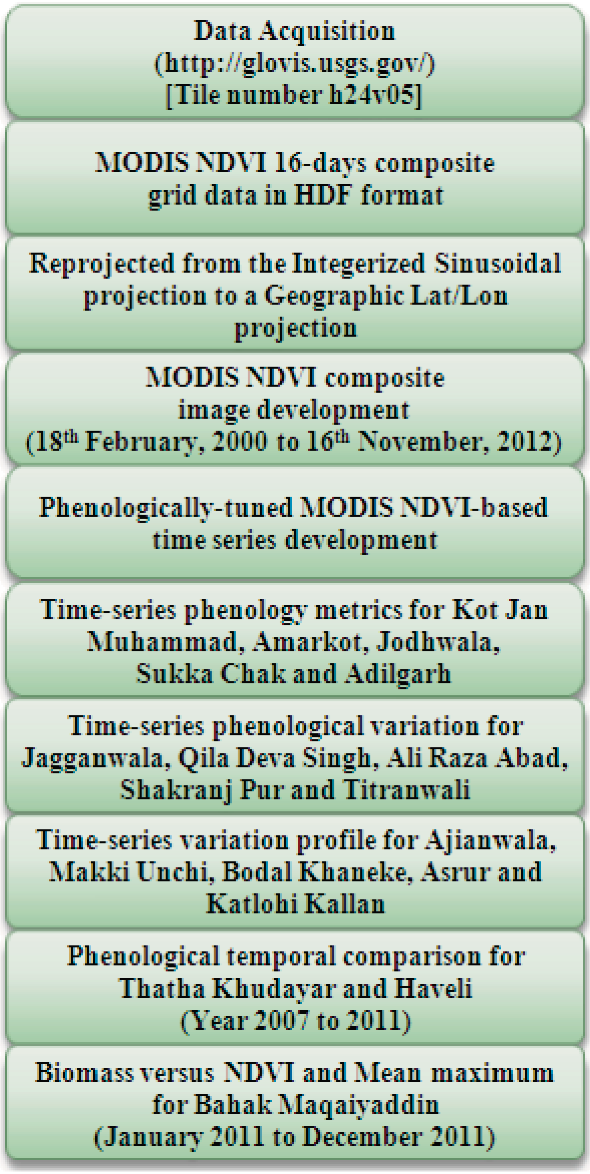

Figure 2 : Scheme for research design and methods.

Remote sensing is often used for detecting seasonal vegetation changes (Sakamoto et al., 2005). Various methods using daily NDVI data have been developed for monitoring natural vegetation (Akiyama et al., 2002; Saito et al., 2002; Xiao et al., 2002; Sakamoto et al., 2005). Vegetation Indices are seamless data products that are computed from the same mathematic formulae across all pixels in time and space, without prior assumptions of biome type, land cover condition, or soil type and thus represent actual, long-term measurements of the land surface (Huete et al., 2002). The NDVI product works optimally with cloud filtering, radiometric calibration, precise geolocation, and a snow mask. In addition, the product performs best using top-of-canopy reflectance inputs, corrected for atmospheric ozone, molecular scattering, aerosol, and water vapour (Huete et al., 2006).

IV. Results

Figure 3 shows time-series phenology metrics for Kot Jan Muhammad district Hafizabad. The profile showed that climate was more or less stable. The trend analysis showed slight positive tendency due to increase in precipitation in winter season or western disturbances especially during 2009 to 2012, but severe dryness was observed in January 2003 (NDVI value 0.85) and June 2010 (NDVI value -0.01). Fluctuations were observed at start/end pixel values. The NDVI value on 18th February, 2000 was 0.72 while the NDVI value on 16th November, 2012 was 0.28 (Figure 3).

The phenological studies can be used to evaluate the effects of climate change (Chandola et al., 2010). The vegetation phenology is important for predicting ecosystem carbon, nitrogen, and water fluxes (Baldocchi et al., 2005; Richardson et al., 2009; Chandola et al., 2010), as the seasonal and interannual variation of phenology have been linked to net primary production estimation, crop yields, and water supply (Aber et al., 1995; Jenkins et al., 2002; Chandola et al., 2010).

Figure 4 shows time-series phenology metrics for Amarkot district Lahore. The profile showed that climate was not stable and the trend analysis showed negative tendency. The fluctuations in the phenological profile were due to variation in the temperature-precipitation at Amarkot. Fluctuations were observed at start/end pixel values. The NDVI value on 18th February, 2000 was 0.60 while the NDVI value on 16th November, 2012 was 0.28 (Figure 4). The soil productivity in winter season was higher as compared to summer season. In summer season the temperature raises upto 51°C or more and in winter the temperature falls below 0°C. The monsoon occurs in summer season from June till September. Monsoon rains bring much awaited relief from scorching heat. These monsoon rains are quite heavy by nature. The western disturbances generally occur during the winter months and causes moderate rainfall (Khan, 1993; Ahmad, 2012).

Change information of the earth's surface is becoming more and more important in monitoring the local, regional and global resources and environment. The large collection of past and present remote sensing imagery makes it possible to analyze spatio-temporal pattern of environmental elements and impact of human activities in past decades (Jianya et al., 2008; Ahmad, 2012).

Figure 5 shows time-series phenology metrics for Jodhwala district Kasur. The profile showed that climate was stable and the trend analysis showed slight positive tendency. The NDVI value on 18th February, 2000 was 0.52 while the NDVI value on 16th November, 2012 was 0.49 (Figure 5). The variation in the vegetation phenological temporal metrics was due to changes in the temperature-precipitation. The green cover fraction and soil productivity in winter season was much higher as compared to summer season. The NDVI has been used for several decades, which is advantageous for studying historical changes (Trishchenko et al., 2002; Ahmad, 2012).

Figure 6 shows time-series phenology metrics for Sukka Chak district Okara. The profile showed that climate was stable and the trend analysis showed positive tendency. The NDVI value on 18th February, 2000 was 0.68 while the NDVI value on 16th November, 2012 was 0.23 (Figure 6). The fluctuations in the phenological profile were due to variation in the temperature-precipitation. The winter disturbances were stronger as compared to summer monsoon and land degradation or desertification can't be seen at Sukka Chak. The soil productivity in winter season was much higher as compared to summer season. The phenology metrics showed a clear relationship with the seasonality of rainfall, winter and summer growing seasons (Wessels et al., 2011; Ahmad, 2012).

Figure 7 shows time-series phenology metrics for Adilgarh district Nankana Sahib. The profile showed that climate was stable and the trend analysis showed gradually positive tendency. The NDVI value on 18th February, 2000 was 0.64 while the NDVI value on 16th November, 2012 was 0.36 (Figure 7). The green cover fraction and soil productivity in winter season was much higher as compared to summer season.

Remote sensing provides a key means of measuring and monitoring phenology at continental to global scales and vegetation indices derived from satellite data are now commonly used for this purpose (Nightingale et al., 2008; Tan et al., 2008; Ahmad, 2012).

Figure 8 shows time-series phenological variation for Jagganwala district Hafizabad. The profile showed that climate was stable and the trend analysis showed no change during the entire period, but severe dryness was observed in December 2002 and January 2003. Fluctuations were observed at start/end pixel values. The NDVI value on 18th February, 2000 was 0.69 while the NDVI value on 16th November, 2012 was 0.35 (Figure 8). The fluctuations in the phenological profile were due to variation in the temperature-precipitation. The winter disturbances were much stronger as compared to summer monsoon and land degradation or desertification can't be seen at Jagganwala. The green cover fraction and soil productivity in winter season was much higher as compared to summer season.

Variations in vegetation activity have been linked with changes in climates (Los et al., 2001; Tucker et al., 2001; Zhou et al., 2001; 2003; Lucht et al., 2002; Piao et al., 2003). Besides climate alterations leading to changes in the productivity and phenology of natural vegetation (Villalba et al., 1998; Villalba et al., 2003; Baldi et al., 2008), direct human drivers such as land use and land cover changes (Grau et al., 2005; Fearnside, 2005; Huang et al., 2007; Baldi and Paruelo, 2008; Baldi et al., 2008), infrastructure enterprises (Canziani et al., 2006; Baldi et al., 2008), and urban expansion (Romero and Ordenes, 2004; Pauchard et al., 2006; Baldi et al., 2008; Ahmad, 2012) took place.

Figure 9 shows time-series phenological variation for Qila Deva Singh district Nankana Sahib. The profile showed that climate was stable and the trend analysis showed gradual positive tendency during the entire period, but little dryness was observed in January 2003 (NDVI value 0.13) and July, 2010 (NDVI value 0.09). Fluctuations were observed at start/end pixel values. The NDVI value on 18th February, 2000 was 0.73 while the NDVI value on 16th November, 2012 was 0.25 (Figure 9). The NDVI exhibits a strong correlation with the typical green vegetation growth stages (Zhao et al., 2005; Gao and Mas, 2008; Ahmad, 2012; 2012a).

Figure 10 shows time-series phenological variation for Ali Raza Abad district Lahore. The profile showed that climate was more or less stable during the entire period. The fluctuations in the phenological profile were due to variation in the temperature-precipitation at Ali Raza Abad. The NDVI value on 18th February, 2000 was 0.61 while the NDVI value on 16th November, 2012 was 0.32 (Figure 10).

To enhance the vegetation signal in remotely sensed data and provide an approximate measure of live green vegetation, a number of spectral vegetation indices have been developed by combining data from multiple spectral bands into single values because they correlate the biophysical characteristics of the vegetation of the land-cover (Campbell, 1987) from the satellite spectral signals (Yang et al., 2008).

Figure 11 shows time-series phenological variation for Shakranj Pur district Okara. The profile showed that climate was not stable, severe interannual variation in temperature-precipitation was observed at Shakranj Pur and the trend analysis showed gradual positive tendency during the entire period. Severe dryness was observed in August 2008 (NDVI value 0.004). Fluctuations were observed at start/end pixel values. The NDVI value on 18th February, 2000 was 0.51 while the NDVI value on 16th November, 2012 was 0.25 (Figure 11).

Figure 12 shows time-series phenological variation for Titranwali district Nankana Sahib. The profile showed that climate was stable and the trend analysis showed no change. The fluctuations in the phenological profile were due to variation in the temperature-precipitation during the entire period. The winter disturbances were much stronger as compared to summer monsoon and land degradation or desertification can't be seen at Titranwali. The green cover fraction and soil productivity in winter season was much higher as compared to summer season. Fluctuations were observed at start/end pixel values. The NDVI value on 18th February, 2000 was 0.67 while the NDVI value on 16th November, 2012 was 0.27 (Figure 12).

Figure 13 shows time-series variation profile for Ajianwala district Sheikhupura. The profile showed that climate was stable and the trend analysis showed slight positive change, but little dryness was observed in January 2003 (NDVI value 0.05). The fluctuations in the phenological profile were due to variation in the temperature-precipitation during the entire period. The winter disturbances were much stronger as compared to summer monsoon at Ajianwala. Fluctuations were observed at start/end pixel values. The NDVI value on 18th February, 2000 was 0.72 while the NDVI value on 16th November, 2012 was 0.35 (Figure 13).

Time series of acquired multi-spectral image represent characteristics of a landscape and each element represented has a particular spectral response. The time series of such vegetation indices observed over a period can help in further classification of the vegetation as crop and other type of vegetation (Musande et al., 2012).

Figure 14 shows time-series variation profile for Makki Unchi district Sheikhupura. The profile showed that climate was stable and the trend analysis showed no change. The green cover fraction and soil productivity in winter season was much higher as compared to summer season. The NDVI value on 18th February, 2000 was 0.78 while the NDVI value on 16th November, 2012 was 0.26 (Figure 14). The NDVI provides useful information for detecting and interpreting vegetation land cover it has been widely used in remote sensing studies (Dorman and Sellers, 1989; Myneni and Asrar, 1994; Gao, 1996; Sesnie et al., 2008; Karaburun, 2010; Ahmad, 2012).

Figure 15 shows time-series variation profile for Bodal Khaneke district Kasur. The profile showed that climate was not stable; the trend analysis showed negative tendency and severe dryness was observed in August-September 2011 (NDVI value -0.02). The fluctuations in the phenological profile were due to variation in the temperature-precipitation at Bodal Khaneke. Fluctuations were observed at start/end pixel values. The NDVI value on 18th February, 2000 was 0.23 while the NDVI value on 16th November, 2012 was 0.17 (Figure 15).

The ecology of the north-eastern Punjab province is mainly arid to semi arid. Abundant evidence verifies that the natural resources were unwisely over-exploited to achieve higher growth rates in agriculture. The country is now suffering from problems like water scarcity for crop cultivation with salinity and sodicity problems, more erratic and low rainfalls for rain-fed agriculture and low carrying capacity of rangelands representing more three-fifth of total geographic area. Agriculture is the only sector which is entirely dependent on the quality of natural resources for sustaining higher productivity (Farooq et al., 2007; Ahmad, 2012).

Figure 16 shows time-series variation profile for Asrur district Sheikhupura. The profile showed that climate was not stable and the trend analysis showed gradual positive tendency during the entire period, but little dryness was observed in January 2003 (NDVI value 0.05). The profile also showed gradual increase in precipitation from December 2004 to November 2012. The winter disturbances were much stronger, and the duration also increased from December 2009 to present at Asrur. The NDVI value on 18th February, 2000 was 0.43 while the NDVI value on 16th November, 2012 was 0.23 (Figure 16). The healthy and dense vegetation show a large NDVI (Fuller, 1998; Ahmad, 2012).

Figure 17 shows time-series variation profile for Katlohi Kallan district Kasur. The profile showed that climate was more or less stable. The trend analysis showed no change, but little dryness was observed in January 2003 (NDVI value 0.12). The NDVI value on 18th February, 2000 was 0.68 while the NDVI value on 16th November, 2012 was 0.32 (Figure 17).

The NDVI can be used not only for accurate description of vegetation classification and vegetation phenology (Tucker et al., 1982; Tarpley et al., 1984; Justice et al., 1985; Lloyd, 1990; Singh et al., 2003; Los et al., 2005; Ahmad, 2012) but also effective for monitoring rainfall and drought, estimating net primary production of vegetation, crop growth conditions and crop yields, detecting weather impacts and other events important for agriculture and ecology (Kogan, 1987; Dabrowska-Zielinska et al., 2002; Singh et al., 2003; Chris and Molly, 2006; Baldi et al., 2008; Glenn et al., 2008; Ahmad, 2012).

Figure 18 shows phenological temporal comparison for Thatha Khudayar district Sheikhupura. In this profile MODIS NDVI 500 m data products for the period 2007 to 2011 at 16-days interval was evaluated. The findings showed that the impact of summer monsoon was stronger as compared to winter disturbances. The precipitation was received in both the summer and winter season. The climate was stable during the entire period at Thatha Khudayar.

Figure 19 shows phenological temporal comparison for Haveli district Okara using MODIS NDVI 500 m data products at 16-days interval for the period 2007 to 2011. The temporal curves indicate that climate was stable, green cover fraction, and biomass productively increased due to precipitation in summer and winter season. The profile showed maximum soil and biomass productivity in 2009 and minimum in 2010 and land degradation can't be seen at Haveli.

Figure 20 shows biomass versus NDVI and mean maximum from January 2011 to December 2011 for Bahak Maqaiyaddin district Hafizabad. The biomass and NDVI demonstrated clear inter-seasonal consistency indicated by the larger amount of biomass and the corresponding higher NDVI values in January, February, March, July, August, September and October

2011 and the smaller amount of biomass in April, May, June, November and December 2011 at Bahak Maqaiyaddin. The variations in biomass are fairly well represented by the changes of NDVI. The inter-seasonal consistency of NDVI and biomass support the common use of NDVI to study vegetation response to climate variation (Anyamba and Eastman, 1996; Kogan, 1997; Li and Guo, 2012).

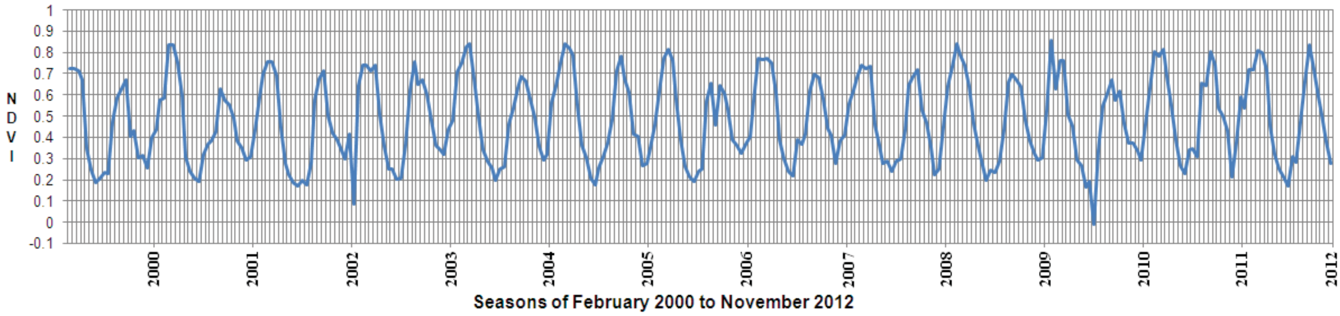

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Figure 3 : Time-series phenology metrics for Kot Jan Muhammad, District Hafizabad.

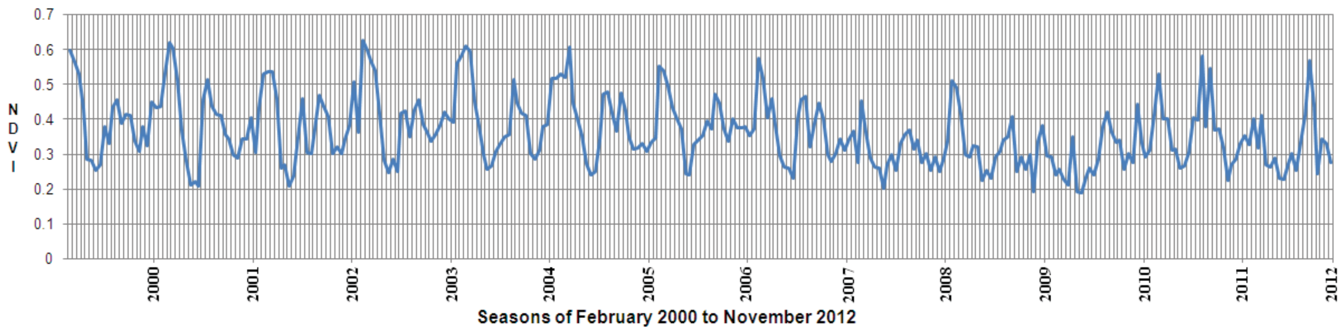

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Figure 4 : Time-series phenology metrics for Amarkot, District Lahore.

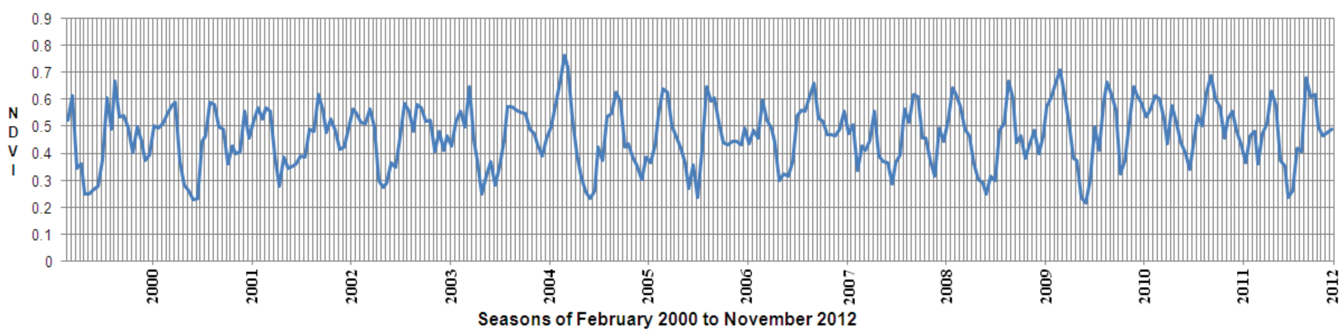

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Figure 5 : Time-series phenology metrics for Jodhwala, District Kasur.

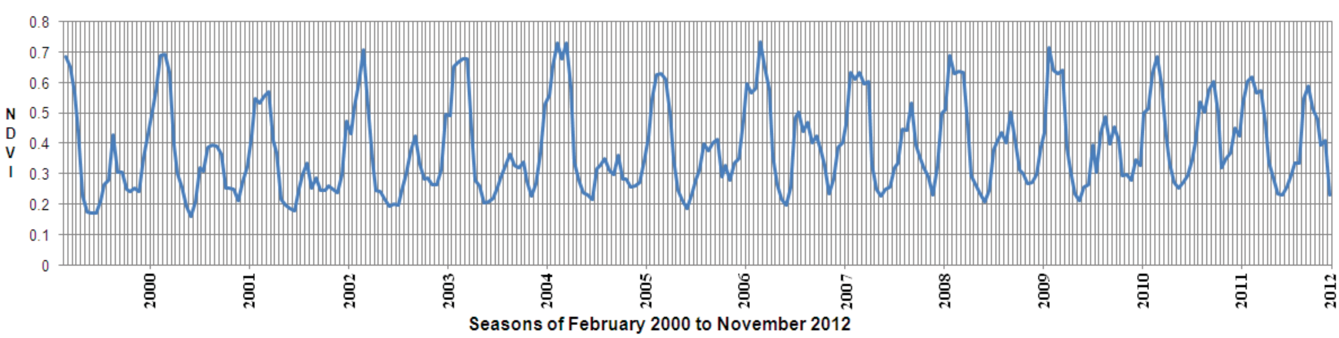

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Figure 6 : Time-series phenology metrics for Sukka Chak, District Okara.

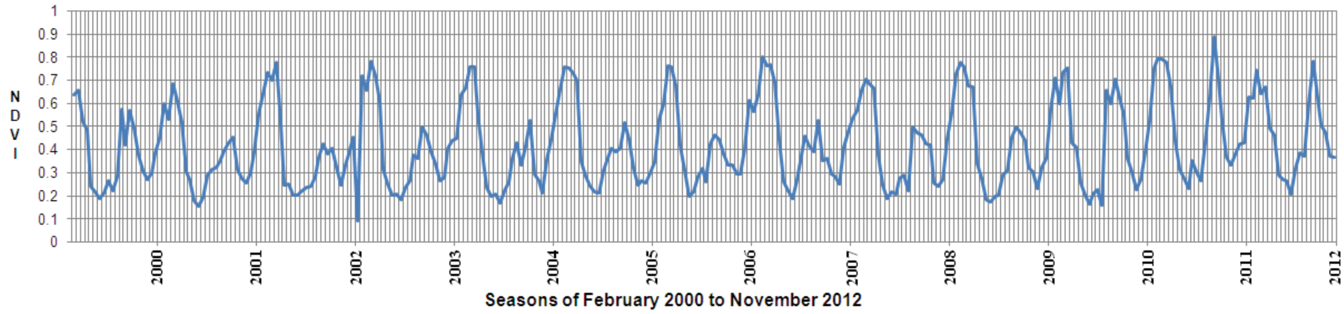

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Figure 7 : Time-series phenology metrics for Adilgarh, District Nankana Sahib.

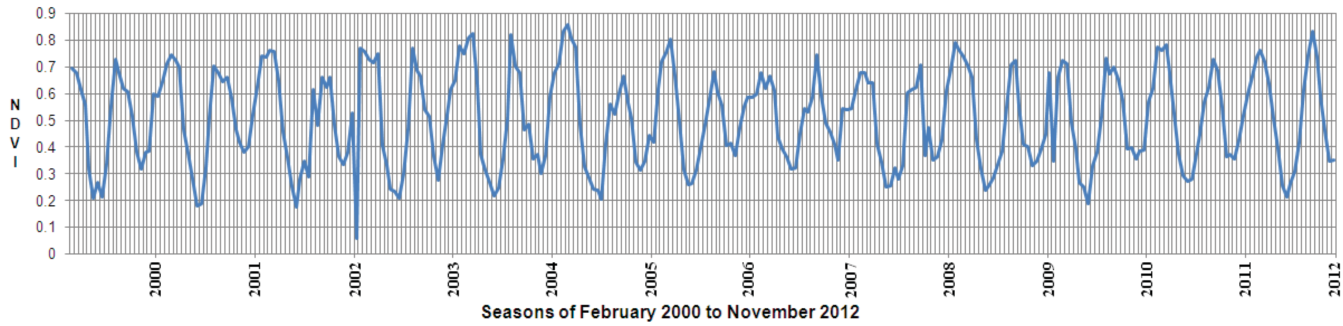

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Figure 8 : Time-series phenological variation for Jagganwala, District Hafizabad.

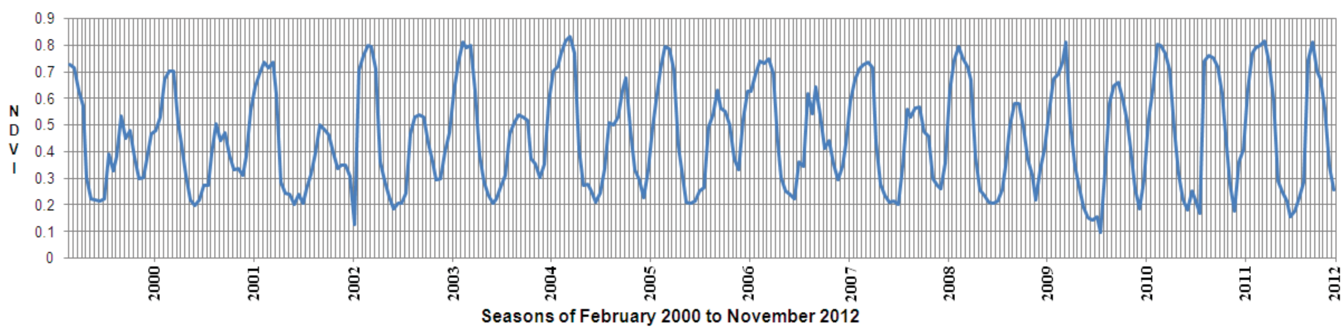

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Figure 9 : Time-series phenological variation for Qila Deva Singh, District Nankana Sahib.

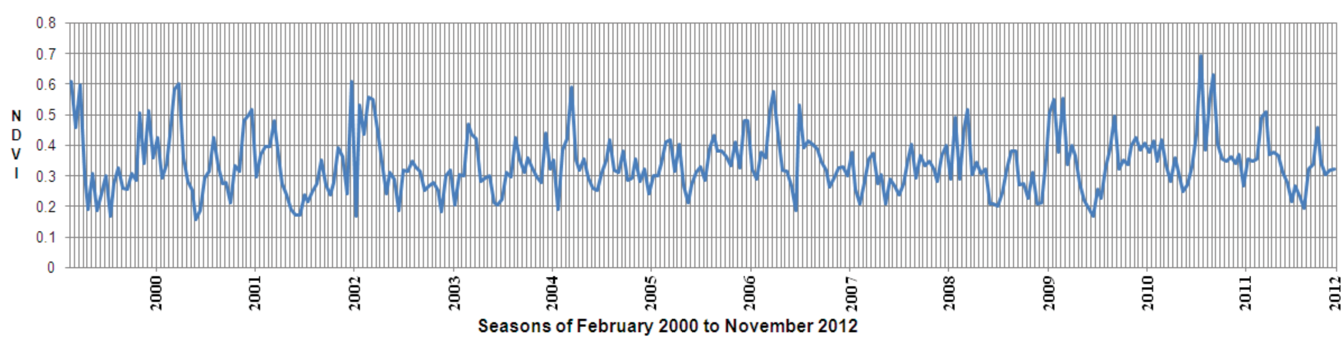

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Figure 10 : Time-series phenological variation for Ali Raza Abad, District Lahore.

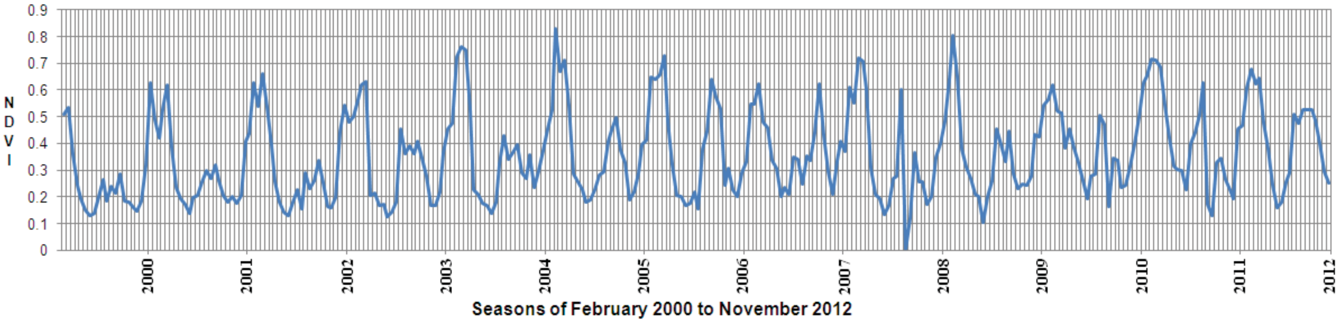

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Figure 11 : Time-series phenological variation for Shakranj Pur, District Okara.

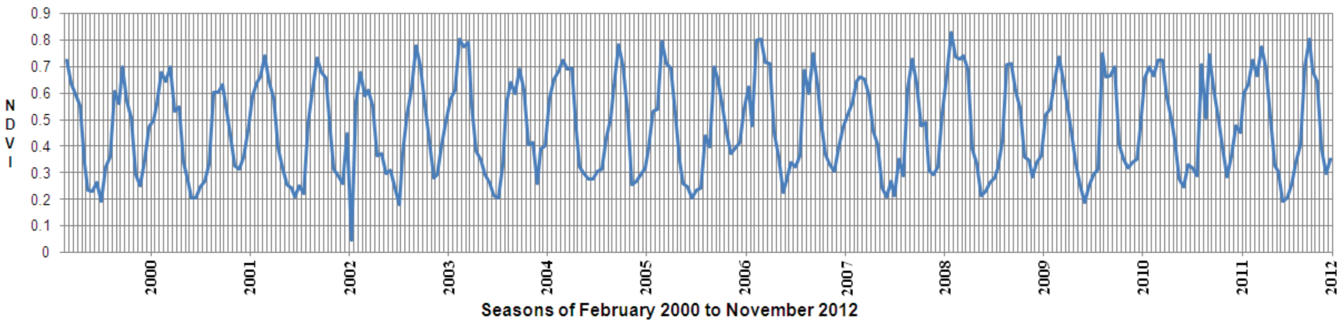

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Figure 12 : Time-series phenological variation for Titranwali, District Nankana Sahib.

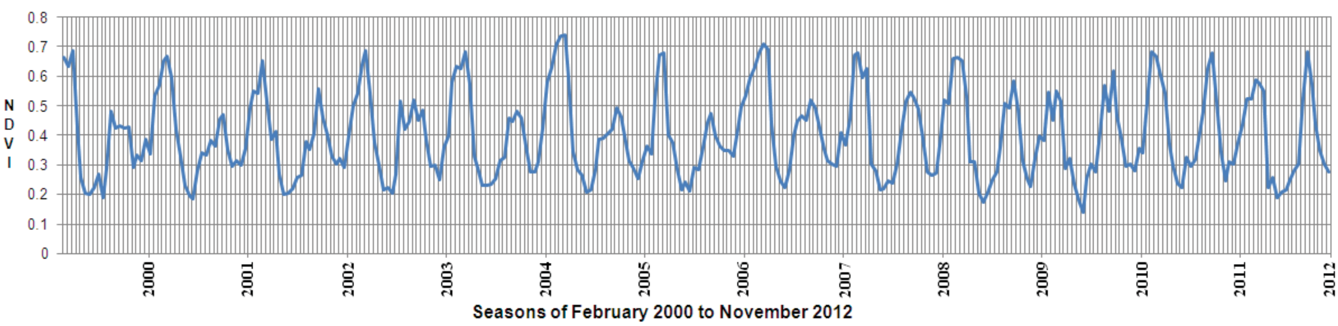

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Figure 13 : Time-series variation profile for Ajianwala, District Sheikhupura.

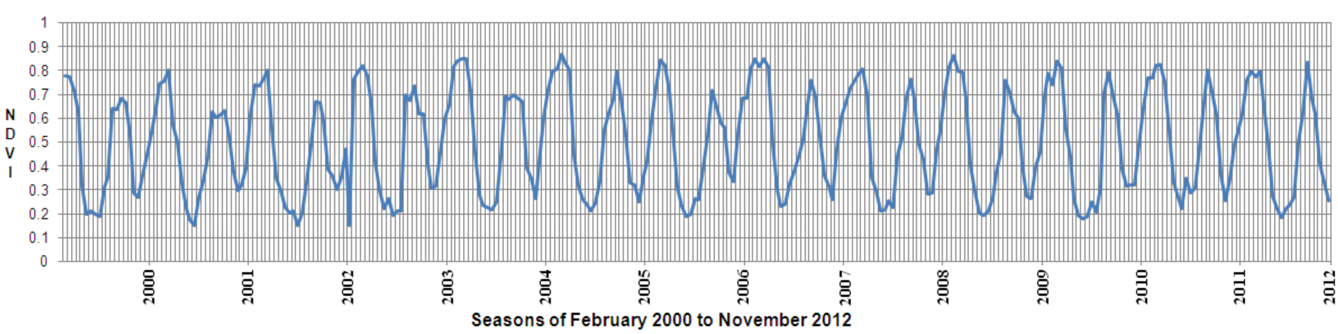

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Figure 14 : Time-series variation profile for Makki Unchi, District Sheikhupura.

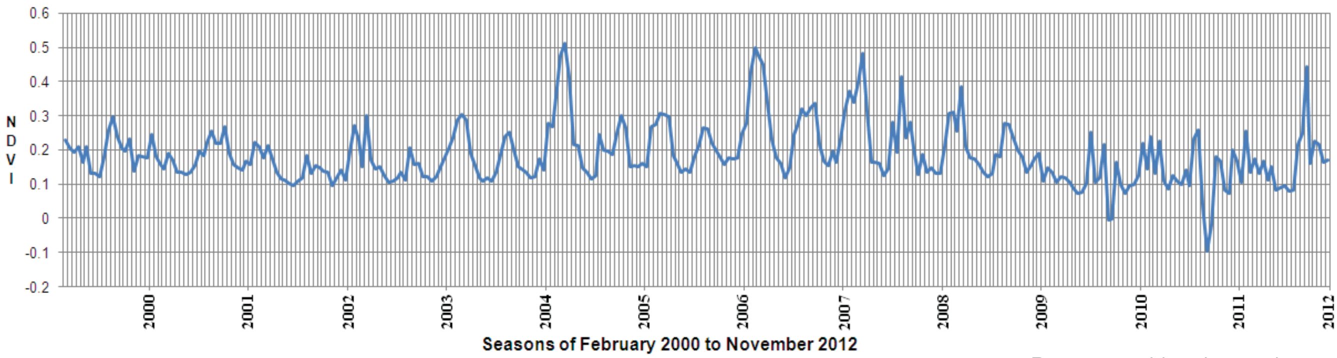

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Figure 15 : Time-series variation profile for Bodal Khaneke, District Kasur.

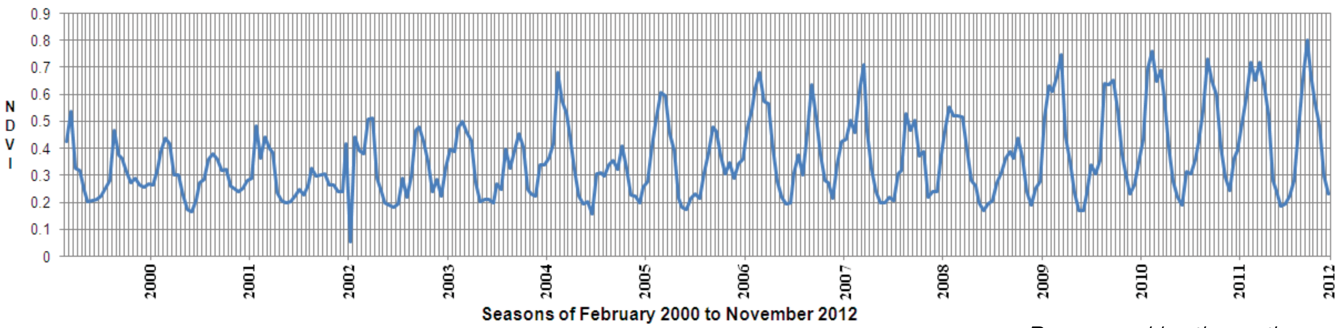

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Figure 16 : Time-series variation profile for Asrur, District Sheikhupura.

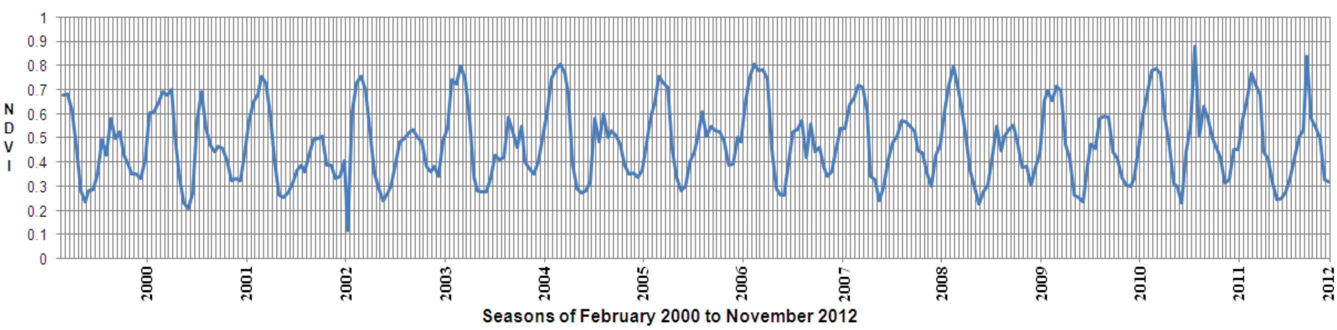

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Figure 17 : Time-series variation profile for Katlohi Kallan, District Kasur.

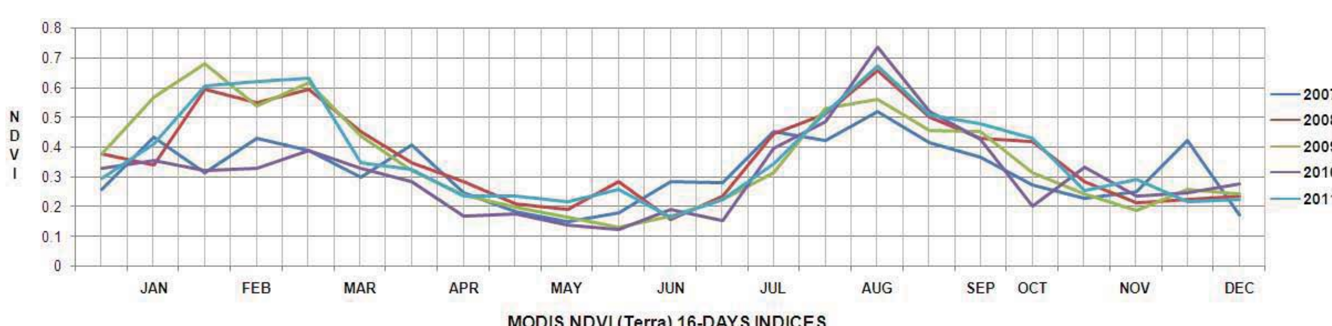

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Figure 18 : Phenological temporal comparison for Thatha Khudayar, District Sheikhupura, Year 2007 to 2011.

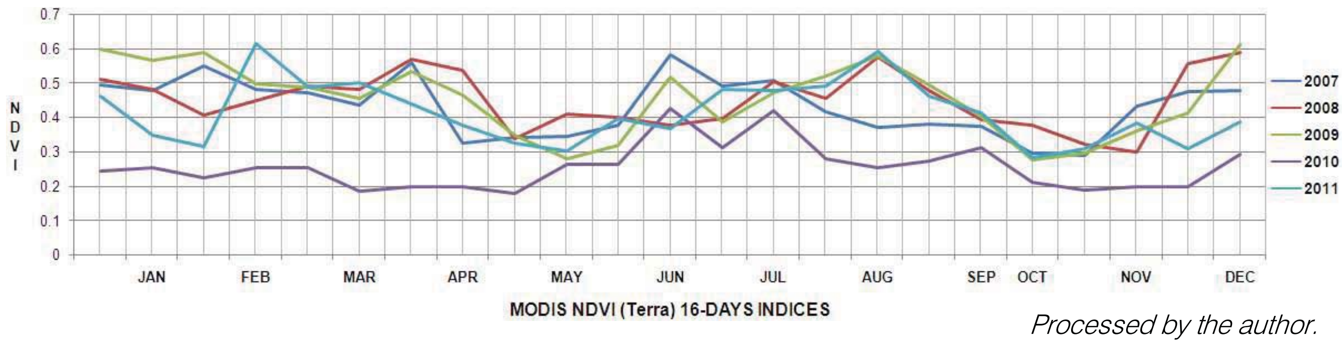

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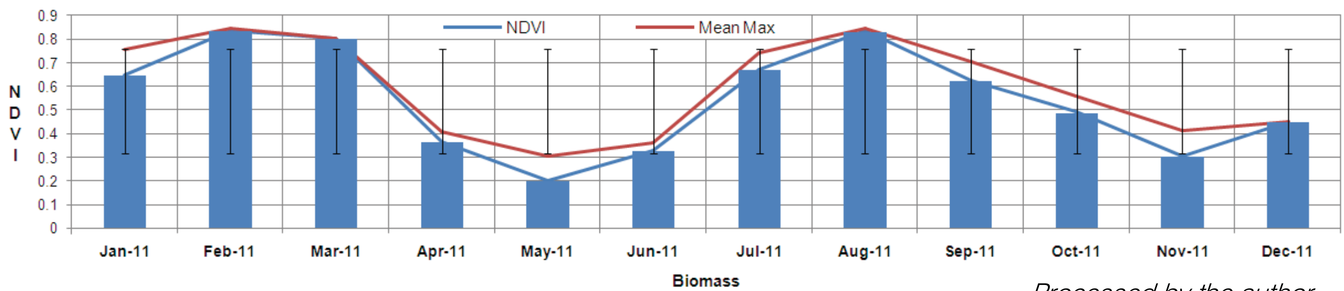
Figure 19 : Phenological temporal comparison for Haveli, District Okara, Year 2007 to 2011.



Processed by the author.

Figure 20 : Biomass versus NDVI and Mean maximum from January 2011 to December 2011 for Bahak Maqaiyaddin, District Hafizabad. (The error bars of biomass are shown with 1 standard deviation).

V. Discussion and Conclusions

As the use of space and computer technology developed, humankind has a great advantage of produce this much important research projects with the help of technology in an easier, more accurate way within less time than other ways. As a result all these can have a very effective role in helping the country to increase the amount and the quality of agricultural products (Akkartala et al., 2004; Ahmad, 2012b). Ground cover as estimated did not take into account the physiological status of the vegetation in the sense that we did consider as cover all vegetation whatever its status. The use of NDVI, in general, takes into account mostly the green living vegetation (Cyr et al., 1995; Ahmad, 2012b).

The comparison between the NDVI and biomass indicates that MODIS NDVI data products are suitable for monitoring vegetation condition in the Punjab province. The climatic variation is the major contributor to inter-annual NDVI variation. Precipitation has stronger effects on NDVI than temperature (Li and Guo, 2012). Vegetation phenology derived from remote sensing is important for a variety of scientific applications (Hufkens et al., 2010), and can provide a useful signal for classifying vegetated land cover (Dennison and Roberts, 2003).

This communication presents a new methodology for studying vegetation phenology using remote sensing (Charbonneau and Kondolf, 1993). The methodology provides a flexible means to monitor vegetation dynamics over large area using remote sensing. Initial results using MODIS NDVI data products for the north-eastern Punjab province of Pakistan demonstrate that the method provides realistic results that are geographically and ecologically consistent with the known behaviour of vegetation. In particular, the MODIS NDVI based estimates of green up onset, maturity onset, and dormancy onset show strong spatio-temporal patterns that also depend on land cover type (Baret and Guyot, 1991; Charbonneau and Kondolf, 1993; Justice et al., 1998).

The results of this research are encouraging and the techniques described provide an improved method for estimating the quantity of vegetative cover across large and complex environment of the north-eastern Punjab province of Pakistan with MODIS NDVI data products. This study also identified several data acquisition and processing issues that warrant further investigation. Studies are under way to assess the importance of coordinating and timing field data collection and image acquisition dates as a means of improving the strength of the relationships between MODIS NDVI data products and land condition trend analysis (Senseman et al., 1996; Ahmad, 2012b) ground-truth data. Due to the continuous provision of information to present days, the MODIS data has been used for many other purposes in geophysical, environmental or agricultural sciences and vegetation change (Chuvieco et al., 2003; Stöckli and Vidale, 2004; Baldi et al., 2008; Ahmad, 2012).

The study demonstrates the successful application of MODIS NDVI products on climatic variation. Through the application and analyses of time series data, this research provides valuable understanding of the impact of environmental drivers on the spatial, annual and interannual variation of vegetation dynamics in the north-eastern Punjab province of Pakistan (Ahmad, 2012). The approaches used in this study can be applied to other areas to investigate vegetation response to climate variation.

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References Références Referencias

1. Aber, J.D., Ollinger, S.V., Federer, C.A., Reich, P.B., Goulden, M.L., Kicklighter, D.W., Melillo, J.M. and Lathrop, R.G. (1995). Predicting the effects of climate change on water yield and forest production in the northeastern United States. Climate Research, Vol. 5, pp.207-222.
2. Ackerman, S.A., Strabala, K.I., Menzel, W.P., Frey, R.A., Moeller, C.C., Gumley, L.E., Baum, B., Seemann, S.W. and Hong, Z. (2006). Discriminating clear sky from clouds with MODIS, Algorithm theoretical basis document (MOD35). URL: http://modis.gsfc.nasa.gov/ (Accessed on December 14, 2012).
3. Ackerman, S.A., Strabala, K.I., Menzel, W.P., Frey, R.A., Moeller, C.C. and Gumley, L.E. (1998). Discriminating clear sky from clouds with MODIS. Journal of Geophysical Research, Vol. 103(D24), pp.32,141-32,157.
4. Aguilar, C., Zinnert, J.C., Polo, M.J. and Young, D.R. (2012). NDVI as an indicator for changes in water availability to woody vegetation. Ecological Indicators, Vol. 23, pp.290-300.
5. Ahmad, F. (2012). NOAA AVHRR satellite data for evaluation of climatic variation and vegetation change in the Punjab Province, Pakistan. Journal of Food, Agriculture & Environment, Vol. 10(2), pp.1298-1307.
6. Ahmad, F. (2012a). A review of remote sensing data change detection: Comparison of Faisalabad and Multan Districts, Punjab Province, Pakistan. Journal of Geography and Regional Planning, Vol. 5(9), pp.236-251.
7. Ahmad, F. (2012b). Spectral vegetation indices performance evaluated for Cholistan Desert. Journal of Geography and Regional Planning, Vol. 5(6), pp.165-172.
8. Ahmad, F. (2012c). Detection of change in vegetation cover using multi-spectral and multi-temporal information for District Sargodha. Revista Sociedade & Natureza, Vol. 24(3), pp.557-571.
9. Akiyama, T., Kawamura, K., Fukuo, A. and Chen, Z.Z. (2002). Sustainable grassland management using GIS, GPS and remote sensing data in Inner Mongolia. In: Uchida, S., Youqi, C. and Saito, G. (Eds.), Application on remote sensing technology for the management of agricultural resources, Beijing' China Agricultural Scientech Press, pp.13-19.
10. Akkartala, A., Türüdüa, O. and Erbekb, F.S. (2004). Analysis of changes in vegetation biomass using multitemporal and multisensor satellite data. Proceedings of XXXV ISPRS Congress, 12-23 July 2004, Istanbul, Turkey. URL: http://www.isprs.org/proceedings/XXXV/congress/yf/papers/946.pdf. (Accessed on September 17, 2011).
11. Anyamba, A. and Eastman, J. (1996). Interannual variability of NDVI over Africa and its relationship to El Ninõ/Southern Oscillation. International Journal of Remote Sensing, Vol. 17(13), pp.2533-2548.
12. Baldi, G. and Paruelo, J.M. (2008). Land use and land cover dynamics in South American temperate Grasslands. Ecology and Society, Vol. 13(2), Art 6. URL:http://www.ecologyandsociety.org/vol13/iss2/art6/ (Accessed on January 11, 2012).
13. Baldi, G., Nosetto, M.D., Aragón, R., Aversa, F., Paruelo, J.M. and Jobbágy, E.G. (2008). Long-term satellite NDVI datasets: Evaluating their ability to detect ecosystem functional changes in South America. Sensors, Vol. 8, pp.5397-5425.
14. Baldocchi, D.D., Black, T.A., Curtis, P.S., Falge, E., Fuentes, J.D., Granier, A., Gu, L., Knohl, A., Pilegaard, K., Schmid, H.P., Valentini, R., Wilson, K., Wofsy, S., Xu, L. and Yamamoto, S. (2005). Predicting the onset of net carbon uptake by deciduous forests with soil temperature and climate data: a synthesis of FLUXNET data. International Journal of Biometeorology, Vol. 49, pp.377-387.
15. Baret, F. and Guyot, G. (1991). Potentials and limits of vegetation indices for LAI and APAR assessment. Remote Sensing of Environment, Vol. 35, pp.161-173.
16. Barnes, W.L. and Salomonson, V.V. (1993). MODIS: A global image spectroradiometer for the Earth Observing System. Critical Reviews of Optical Science and Technology, CR47, pp.285-307.
17. Barnes, W.L., Pagano, T.S. and Salomonson, V.V. (1998). Prelaunch characteristics of the Moderate Resolution Imaging Spectroradiometer (MODIS) on EOS-AM1. IEEE Transactions on Geoscience and Remote Sensing, Vol. 36, pp.1088-1100.
18. Budde, M.E., Tappan, G., Rowland, J., Lewis, J. and Tieszen, L.L. (2004). Assessing land cover

performance in Senegal, West Africa using 1-km integrated NDVI and local variance analysis. Journal of Arid Environments, Vol. 59(3), pp.481-498.

19. Canziani, G.A., Ferrati, R.M., Rossi, C. and Ruiz-Moreno, D. (2006). The influence of climate and dam construction on the Iberá wetlands, Argentina. Regional Environmental Change, Vol. 6, pp.181-191.
20. Campbell, J.B. (1987). Introduction to remote sensing. The Guilford Press, New York, p.281.
21. Carrão, H., Gonçalves, P. and Caetano, M. (2008). Contribution of multispectral and multitemporal information from MODIS images to land cover classification. Remote Sensing of Environment, Vol. 112(3), pp.986-997.
22. Chandola, V., Hui, D., Gu, L., Bhaduri, B. and Vatsavai, R.R. (2010). Using time series segmentation for deriving vegetation phenology indices from MODIS NDVI data. IEEE International Conference on Data Mining Workshops, 13th December 2010, Sydney, Australia. pp.202-208.
23. Chen, P.Y., Fedosejevs, G., Tiscareño-LóPez, M. and Arnold, J.G. (2006). Assessment of MODIS-EVI, MODIS-NDVI and VEGETATION-NDVI composite data using agricultural measurements: An example at corn fields in western Mexico. Springer, Netherlands, Environmental Monitoring and Assessment, Vol. 119(1-3), pp.69-82.
24. Chen, P.Y., Srinivasan, R., Fedosejevs, G., Báez-González, A.D. and Gong, P. (2002). Assessment of NDVI composite using merged NOAA-14 and NOAA-15 AVHRR data. Geographic Information Sciences, Vol. 8(1), pp.31-38.
25. Charbonneau, R. and Kondolf, G.M. (1993). Land use change in California, USA: Nonpoint source water quality impacts. Environmental Management, Vol. 17(4), pp.453-460.
26. Choudhury, B.J. (1987). Relationship between vegetation indices, radiation absorption, and net photosynthesis evaluated by sensitivity analysis. Remote Sensing of Environment, Vol. 22, pp.209-233.
27. Chris, C.F. and Molly, E.B. (2006). Intra-seasonal NDVI change projections in semi-arid Africa. Remote Sensing of Environment, Vol. 101, pp.249-256.
28. Chuvieco, E., Aguado, I., Cocero, D. and Riano, D. (2003). Design of an empirical index to estimate fuel moisture content from NOAA-AVHRR images in forest fire danger studies. International Journal of Remote Sensing, Vol. 24, pp.1621-1637.
29. Cyr, L., Bonn, F. and Pesant, A. (1995). Vegetation indices derived from remote sensing for an estimation of soil protection against water erosion. Ecological Modelling, Vol. 79(1-3), pp.277-285.
30. Dabrowska-Zielinska, K., Kogan, F., Ciolkosz, A., Gruszczynska, M. and Kowalik, W. (2002). Modelling of crop growth conditions and crop yield in Poland using AVHRR-based indices. International Journal of Remote Sensing, Vol. 23, pp.1109-1123.
31. Dennison, P.E. and Roberts, D.A. (2003). The effects of vegetation phenology on endmember selection and species mapping in southern California chaparral. Remote Sensing of Environment, Vol. 87(2-3), pp.123-135.
32. Dong, J., Kaufmann, R.K., Myneni, R.B., Tucker, C.J., Kauppi, P.E., Liski, J., Buermann, W., Alexeyev, V. and Hughes, M.K. (2003). Remote sensing estimates of boreal and temperate forest woody biomass, carbon pools, sources and sinks. Remote Sensing of Environment, Vol. 84, pp.393-410.
33. Dorman, J.L. and Sellers, P.J. (1989). A Global climatology of albedo, roughness length and stomatal resistance for atmospheric general circulation models as represented by the Simple Biosphere Model (SiB). Journal of Applied Meteorology, Vol. 28(9), pp.833-855.
34. Farooq, U., Ahmad, M. and Jasra, A.W. (2007). Natural resource conservation, poverty alleviation, and farmer partnership. The Pakistan Development Review, Vol. 46(4), pp.1023-1049.
35. Fearnside, P.M. (2005). Deforestation in Brazilian Amazonia: History, rates, and consequences. Conservation Biology, Vol. 19, pp.680-688.
36. Fontana, F.M.A. (2009). From single pixel to continental scale: using AVHRR and MODIS to study land surface parameters in mountain regions. Ph.D. dissertation, Institute of Geography, University of Bern, Switzerland. URL: http://www.climatestudies.unibe.ch/students/theses/phd/31.pdf. (Accessed on October 15, 2012).
37. Fuller, D.O. (1998). Trends in NDVI time series and their relation to rangeland and crop production in Senegal. International Journal of Remote Sensing, Vol. 19, pp.2013-2018.
38. Gao, B.C. (1996). NDWI - A normalized difference water index for remote sensing of vegetation liquid water from space. Remote Sensing of Environment, Vol. 58, pp.257-266.
39. Gao, Y. and Mas, J.F. (2008). MODIS EVI as an ancillary data for an object-based image analysis with multi-spectral MODIS data. URL: http://www.isprs.org/proceedings/XXXVIII/4-C1/Sessions/Session5/6590_YGao_Proc_poster.pdf. (Accessed on September 07, 2011).
40. Glenn, E.P., Huete, A.R., Nagler, P.L. and Nelson, S.G. (2008). Relationship between remotely-sensed vegetation indices, canopy attributes and plant physiological processes: What vegetation indices can and cannot tell us about the landscape. Sensors, Vol. 8, pp.2136-2160.
41. Groeneveld, D.P. and Baugh, W.M. (2007). Correcting satellite data to detect vegetation signal

for eco-hydrologic analyses. Journal of Hydrology, Vol. 344(1-2), pp.135-145.
42. Grau, H.R., Gasparri, N.I. and Aide, T.M. (2005). Agriculture expansion and deforestation in seasonally dry forests of north-west Argentina. Environmental Conservation. Vol. 32, pp.140-148.
43. GSFC/NASA (2003). MODIS technical specifications. URL: http://modis.gsfc.nasa.gov /about/specs.html. (Accessed on September 05, 2011).
44. Guenther, B., Godden, G., Xiong, X., Knight, E., Qiu, S., Montgomery, H., Hopkins, M., Khayat, M. and Hao, Z. (1998). Prelaunch algorithm and data format for the level 1 calibration products for the EOS-AM1 Moderate Resolution Imaging Spectroradiometer (MODIS). IEEE Transaction on Geoscience and Remote Sensing, Vol. 36(4), pp.1142-1151.
45. Guo, X. (2003). Relationships between NDVI and climatological variability in the Prairie ecozone of Canada. Prairie Perspectives, Vol.6, pp.32-46.
46. Hamel, S., Garel, M., Festa-Bianchet, M., Gaillard, J-M. and Côté, S.D. (2009). Spring Normalized Difference Vegetation Index (NDVI) predicts annual variation in timing of peak faecal crude protein in mountain ungulates. Journal of Applied Ecology, Vol. 46, pp.582-589.
47. Hashemi, S.A. (2010). Evaluating phenological events of shrubs land by AVHRR data. American Journal of Scientific Research, Issue 12, pp.23-31.
48. Huang, C., Kim, S., Altstatt, A., Townshend, J.R.G., Davis, P., Song, K., Tucker, C.J., Rodas, O., Yanosky, A., Clay, R. and Musinsky, J. (2007). Rapid loss of Paraguay's Atlantic forest and the status of protected areas: A Landsat assessment. Remote Sensing of Environment, Vol. 106, pp.460-466.
49. Huete, A.R. (2005). Global variability of terrestrial surface properties derived from MODIS visible to thermal-infrared measurements. Proceedings of IGARSS 05 Geoscience and Remote Sensing Symposium, 25-29 July 2005. URL: http://ieeexplore .ieee.org/iel5/10226/32601/01526782.pdf. (Accessed on September 05, 2011).
50. Huete, A.R., Didan, K., Miura, T., Rodriguez, E.P., Gao, X. and Ferreira, L.G. (2002). Overview of the radiometric and biophysical performance of the MODIS vegetation indices. Remote Sensing of Environment, Vol. 83(1-2), pp.195-213.
51. Huete, A.R., Didan, K., Shimabukuro, Y.E., Ratana, P., Saleska, S.R., Hutyra, L.R., Yang, W., Nemani, R.R. and Myneni, R. (2006). Amazon rainforests green-up with sunlight in dry season. Geophysical Research Letters, Vol. 33(L06405), 4 p.
52. Huete, A.R., Justice, C. and Leeuwen, van W. (1999). MODIS vegetation index (MOD 13) algorithm theoretical basis document version 3. URL: http://modis.gsfc.nasa.gov/data/atbd/atbd_mod13.pdf. (Accessed on September 17, 2011).
53. Hufkens, K., Friedl, M.A., Richardson, A., Milliman, T. and Migliavacca, M. (2010). Vegetation phenology from MODIS/AVHRR/PhenoCam: Scaling and validation possibilities. URL: http://modis.gsfc.nasa.gov/sci_team/meetings/201001/presentations/posters/land/hufkens.pdf. (Accessed on November 10, 2011).
54. Isaacman, A., Toller, G., Guenther, B., Barnes, W.L. and Xiong, X. (2003). MODIS level 1B calibration and data products. In: Huang, H., Lu, D. and Sasano, Y. (Eds.), Earth Observing Systems VIII, Proceedings of SPIE, Vol. 5151, pp.552-562.
55. Jakubauskas, M.E., David, R. and Kastens, J.H. (2002). Crop identification using harmonic analysis of time-series AVHRR NDVI data. Computers and Electronics in Agriculture, Vol. 37(1-3), pp.127-139.
56. Jenkins, J.P., Braswell, B.H., Frolking, S.E. and Aber, J.D. (2002). Detecting and predicting spatial and interannual patterns of temperate forest springtime phenology in the eastern U.S. Geophysical Research Letters, Vol. 29(24), pp.54,1-54,4.
57. Jensen, J.R. (2005). Introductory digital image processing: A remote sensing perspective. 3rd Edition, Englewood Cliffs, New Jersey, Prentice-Hall, pp.34-67.
58. Ji, L. and Peters, A.J. (2003). Assessing vegetation response to drought in the northern Great Plains using vegetation and drought indices. Remote Sensing of Environment, Vol. 87, pp.85-98.
59. Jianya, G., Haigang, S., Guorui, Ma. and Qiming, Z. (2008). A review of multi-temporal remote sensing data change detection algorithms. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Vol. XXXVII. Part B7, pp.757-762. URL: http://www.isprs.org/ proceedings/XXXVII/congress/7_pdf/5_WG-VII-5/05.pdf. (Accessed on November 15, 2012).
60. Jin, S.Mg. and Steven, A.S. (2005). MODIS time-series imagery for forest disturbance detection and quantification of patch size effects. Remote Sensing of Environment, Vol. 99(4), pp.462-470.
61. Justice, C., Vermote, E., Townshend, J.R.G., DeFries, R., Roy, D.P., Hall, D.K., Salomonson, V.V., Privette, J., Riggs, G., Strahler, A., Lucht, W., Myneni, R., Knjazihhin, Y., Running, S., Nemani, R., Wan, Z., Huete, A.R., Leeuwen, van W., Wolfe, R., Giglio, L., Muller, J.P., Lewis, P. and Barnsley, M. (1998). The Moderate Resolution Imaging Spectroradiometer (MODIS): Land remote sensing for global change research. IEEE Transactions on Geoscience and Remote Sensing, Vol. 36, pp.1228-1249.
62. Justice, C.O., Townshend, J.R.G., Holben, B.N. and Tucker, C.J. (1985). Analysis of the phenology of global vegetation using meteorological satellite data. International Journal of Remote Sensing, Vol.

63. Justice, C.O., Townshend, J.R.G., Vermote, E.F., Masuoka, E., Wolfe, R.E., Saleous, N., Roy, D.P. and Morisette, J.T. (2002). An overview of MODIS land data processing and product status. Remote Sensing of Environment, Vol. 83, pp.3-15.
64. Karaburun, A. (2010). Estimation of C factor for soil erosion modeling using NDVI in Büyükçekmece watershed. Ozean Journal of Applied Sciences, Vol. 3(1), pp.77-85.
65. Kawabata, A., Ichii, K. and Yamaguchi, Y. (2001). Global monitoring of the inter-annual changes in vegetation activities using NDVI and its relationships to temperature and precipitation. International Journal of Remote Sensing, Vol. 22(7), pp.1377-1382.
66. Khan, J.A. (1993). The Climate of Pakistan. Rehbar Publishers, Karachi, Pakistan, pp.9-13.
67. Khlopenkov, K.V. and Trishchenko, A.P. (2008). Implementation and evaluation of concurrent gradient search method for reprojection of MODIS level 1B imagery. IEEE Transaction on Geoscience and Remote Sensing, Vol. 46(7), pp.2016-2027.
68. Kogan, F.N. (1987). Vegetation index for areal analysis of crop conditions. Proceedings of 18th Conference Agricultural and Forest Meteorology and 8th Conference Biometeorology and Aerobiology, September 15-18, 1987, W. Lafayette, Indiana, AMS Publisher, pp.103-106.
69. Kogan, F.N. (1997). Global drought watch from space. Bulletin of the American Meteorological Society, Vol. 78(4), pp.621-636.
70. Li, Z. and Guo, X. (2012). Detecting climate effects on vegetation in northern mixed prairie using NOAA AVHRR 1-km time-series NDVI data. Remote Sensing, Vol. 4, pp.120-134.
71. Liu, H.Q. and Huete, A.R. (1995). A feedback based modification of the NDV I to minimize canopy background and atmospheric noise. IEEE Transactions on Geoscience and Remote Sensing, Vol. 33, pp.457-465.
72. Lloyd, D. (1990). A phenological classification of terrestrial vegetation cover using shortwave vegetation index imagery. International Journal of Remote Sensing, Vol. 11(12), pp.2269-2279.
73. Logan, T.L. (1999). EOS/AM-1 Digital Elevation Model (DEM) Data Sets: DEM and DEM auxiliary datasets in support of the EOS/Terra platform. JPL D-013508. Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA.
74. Los, S.O., Collatz, G.J., Bounoua, L., Sellers, P.J. and Tucker, C.J. (2001). Global interannual variations in sea surface temperature and land surface vegetation, air temperature, and precipitation. Journal of Climate, Vol. 14, pp.1535-1549.
75. Los, S.O., North, P.R.J., Grey, W.M.F. and Barnsley, M.J. (2005). A method to convert AVHRR normalized difference vegetation index time series to a standard viewing and illumination geometry. Remote Sensing of Environment, Vol. 99(4), pp.400-411.
76. Lucht, W., Prentice, I.C., Myneni, R.B., Sitch, S., Friedlingstein, P., Cramer, W., Bousquet, P., Buermann, W. and Smith, B. (2002). Climatic control of the high-latitude vegetation greening trend and Pinatubo effect. Science, Vol. 296(5573), pp.1687-1689.
77. Malo, A.R. and Nicholson, S.E. (1990). A study of rainfall and vegetation dynamics in the African Sahel using normalized difference vegetation index. Journal of Arid Environments, Vol. 19(1), pp.1-24.
78. Meneses-Tovar, C.L. (2011). NDVI as indicator of degradation. Unasylva, Vol. 62(238), pp. 39-46.
79. Menzel, A., Estrella, N. and Fabian, P. (2001). Spatial and temporal variability of the phenological seasons in Germany from 1951 to 1996. Global Change Biology, Vol. 7, pp.657-666.
80. Moran, M.S., Jackson, R.D., Slater, P.N. and Teillet, P.M. (1992). Evaluation of simplified procedures for retrieval of land surface reflectance factors from satellite sensor output. Remote Sensing of Environment, Vol. 41, pp.169-184.
81. Moulin, S., Kergoat, L., Viovy, N. and Dedieu, G. (1997). Global scale assessment of vegetation phenology using NOAA/AVHRR satellite measurements. Journal of Climate, Vol. 10, pp.1154-1170.
82. Musande, V., Kumar, A., Kale, K. and Roy, P.S. (2012). Temporal indices data for specific crop discrimination using fuzzy based noise classifier. International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, XXII ISPRS Congress, 25 August - 01 September 2012, Melbourne, Australia. Vol. XXXIX-B8, pp.289-294.
83. Myneni, R.B., Dong, J., Tucker, C.J., Kaufmann, R.K., Kauppi, P.E., Liski, J., Zhou, L., Alexeyev, V. and Hughes, M.K. (2001). A large carbon sink in the woody biomass of Northern forests. Proceedings of the National Academy of Sciences of the United States of America, Vol. 98, pp.14784-14789.
84. Myneni, R.B. and Asrar, G. (1994). Atmospheric effects and spectral vegetation indices. Remote Sensing of Environment, Vol. 47, pp.390-402.
85. Myneni, R.B., Keeling, C.D., Tucker, C.J., Asrar, G. and Nemani, R.R. (1997). Increased plant growth in the northern high latitudes from 1981-1991. Nature, Vol. 386, pp.698-702.
86. Nicandrou, A. (2010). Hydrological assessment and modelling of the river Fani catchment, Albania. Faculty of Advanced Technology, University of

Glamorgan. URL: http://dspace1.isd.glam.ac.uk/dspace/handle/10265/461 (Accessed on November 11, 2012).

87. Nightingale, J.M., Esaias, W.E., Wolfe, R.E., Nickeson, J.E. and Pedelty, J.A. (2008). Assessing the effect of climate change on honey bees using scale hive records and satellite derived vegetation phenology products. URL: http://www.igarss08.org/Abstracts/pdfs/2282.pdf. (Accessed on November 10, 2011).
88. Ouyang, W., Hao, FH., Skidmore, A.K., Groen, T.A., Toxopeus, A.G. and Wang, T. (2012). Integration of multi-sensor data to assess grassland dynamics in a Yellow River sub-watershed. Ecological Indicators, Vol. 18, pp.163-170.
89. Paruelo, J.M., Epstein, H.E., Lauenroth, W.K. and Burke, I.C. (1997). ANPP estimates from NDVI for the Central Grassland Region of the United States. Ecology, Vol. 78(3), pp.953-958.
90. Pauchard, A., Aguayo, M., Peña, E. and Urrutia, R. (2006). Multiple effects of urbanization on the biodiversity of developing countries: The case of a fast-growing metropolitan area (Concepción, Chile). Biological Conservation, Vol. 127, pp.272-281.
91. Pettorelli, N., Vik, J.O., Mysterud, A., Gaillard, J.M., Tucker, C.J. and Stenseth, N.C. (2005). Using the satellite-derived NDVI to assess ecological responses to environmental change. Trends in Ecology & Evolution, Vol. 20(9), pp.503-510.
92. Piao, S.L, Mohammat, A., Fang, J.Y., Cai, Q. and Feng, J. (2006). NDVI-based increase in growth of temperate grasslands and its responses to climate changes in China. Global Environmental Change, Vol. 16(4), pp.340-348.
93. Piao, S.L., Fang, J.Y. and He, J.S. (2006a). Variations in vegetation net primary production in the Qinghai-Xizang Plateau, China, from 1982 to 1999. Climatic Change, Vol. 74(1-3), pp.253-267.
94. Piao, S.L., Fang, J.Y., Zhou, L.M., Guo, Q.H., Henderson, M., Ji, W., Li, Y. and Tao, S. (2003). Interannual variations of monthly and seasonal NDVI in China from 1982 to 1999. Journal of Geophysical Research, Vol. 108(D14), pp.4401-4413.
95. Potter, C.S., Randerson, J.T., Field, C.B., Matson, P.A., Vitousek, P.M., Mooney, H.A. and Klooster, S.A. (1993). Terrestrial ecosystem production, a process model based on global satellite and surface data. Global Biogeochemical Cycles, Vol. 7, pp.811-841.
96. Prasad, A.K., Sudipta, S., Singh, R.P. and Kafatos, M. (2007). Inter-annual variability of vegetation cover and rainfall over India. Advances in Space Research, Vol. 39(1), pp.79-87.
97. Rahman, Md.R., Islam, A.H.M.H. and Rahman, Md.A. (2004). NDVI derived sugarcane area identification and crop condition assessment. Planplus, Vol. 1(2), pp.1-12.
98. Reed, B.C., Brown, J.F., VanderZee, D., Loveland, T.R., Merchant, J.W. and Ohlen, D.O. (1994). Measuring phenological variability from satellite imagery. Journal of Vegetation Science, Vol. 5 (5), pp.703-714.
99. Richardson, A.D., Hollinger, D.Y., Dail, D.B., Lee, J.T., Munger, J.W. and O'keefe, J. (2009). Influence of spring phenology on seasonal and annual carbon balance in two contrasting New England forests. Tree Physiology, Vol. 29, pp.321-331.
100. Romero, H. and Ordenes, F. (2004). Emerging urbanization in the Southern Andes: Environmental impacts of urban sprawl in Santiago de Chile on the Andean piedmont. Mountain Research and Development, Vol. 24, pp.197-201.
101. Rouse, J.W., Haas, R.H., Schell, J.A. and Deering, D.W. (1973). Monitoring vegetation systems in the Great Plains with ERTS. 3rd ERTS Symposium, NASA SP-351 I, pp.309-317. URL: http://geol.hu/data/online_help/Vegetation_Indices.html. (Accessed on January 10, 2012).
102. Singh, R.P., Roy, S. and Kogan, F. (2003). Vegetation and temperature condition indices from NOAA AVHRR data for drought monitoring over India. International Journal of Remote Sensing, Vol. 24(22), pp.4393-4402.
103. Saito, G., Mino, N., Li, Y.Q. and Yasuda, Y. (2002). Seasonal changes of vegetation index obtained from NOAA/AVHRR data in China and Japan. In: Uchida, S., Youqi, C. and Saito, G. (Eds.), Application on remote sensing technology for the management of agricultural resources, Beijing' China Agricultural Scientech Press, pp.107-114.
104. Sakamoto, T., Yokozawa, M., Toritani, H., Shibayama, M., Ishitsuka, N. and Ohno, H. (2005). A crop phenology detection method using time-series MODIS data. Remote Sensing of Environment, Vol. 96, pp.366-374.
105. Salomonson, V.V. and Toll, D.L. (1991). Execution phase (C/D) spectral band characteristics of the EOS moderate resolution imaging spectrometer-Nadir (MODIS-N) facility instrument. Advances in Space Research, Vol. 11, pp.231-236.
106. Senseman, G.M., Bagley, C.F. and Tweddale, S.A. (1996). Correlation of rangeland cover measures to satellite-imagery-derived vegetation indices. Geocarto International, Vol. 11(3), pp.29-38.
107. Sesnie, S.E., Gessler, P.E., Finegan, B. and Thessler, S. (2008). Integrating Landsat TM and SRTM-DEM derived variables with decision trees for habitat classification and change detection in complex neotropical environments. Remote Sensing of Environment, Vol. 112, pp.2145-2159.
108. Stöckli, R. and Vidale, P.L. (2004). European plant phenology and climate as seen in a 20-year AVHRR land-surface parameter dataset. International Journal of Remote Sensing, Vol. 25, pp.3303-3330.

109. Tan, B., Morisette, J.T., Wolfe, R.E., Gao, F., Ederer, G.A., Nightingale, J.M. and Pedelty, J.A. (2008). Vegetation phenology metrics derived from temporally smoothed and gap-filled MODIS data. URL: www.igarss08.org/Abstracts/pdfs/2347.pdf. (Accessed on November 10, 2011).
110. Thomas, D.S.G. and Leason, H.C. (2005). Dunefield activity response to climate variability in the southwest Kalahari. Geomorphology, Vol. 64(1-2), pp.117-132.
111. Townshend, J.R.G. (1992). Improved Global Data for Land Applications: A proposal for a new high resolution data Set, Report No. 20. International Geosphere–Biosphere Program, Stockholm, Sweden. URL: http://library.wur.nl/WebQuery/clc/916 308. (Accessed on June 04, 2012).
112. Townshend, J.R.G. and Justice, C.O. (1988). Selecting the spatial-resolution of satellite sensors required for global monitoring of land transformations. International Journal of Remote Sensing, Vol. 9(2), pp.187-236.
113. Tarpley, J.D., Schnieder, S.R. and Money, R.L. (1984). Global vegetation indices from NOAA-7 meteorological satellite. Journal of Climate and Applied Meteorology, Vol. 23, pp.4491-4503.
114. Trishchenko, A.P., Cihlar, J. and Li, Z. (2002). Effects of spectral response function on surface reflectance and NDVI measured with moderate resolution satellite sensors. Remote Sensing of Environment, Vol. 81, pp.1-18.
115. Tucker, C.J. (1979). Red and photographic infrared linear combinations for monitoring vegetation. Remote Sensing of Environment, Vol. 8, pp.127-150.
116. Tucker, C.J., Dregne, H.E. and Newcomb, W.W. (1991). Expansion and contraction of the Sahara Desert from 1980 to 1990. Science, Vol. 253, pp.299-301.
117. Tucker, C.J., Gatlin, J., Schnieder, S.R. and Kuchinos, M.A. (1982). Monitoring large scale vegetation dynamics in the Nile delta and river valley from NOAA AVHRR data. Proceedings of the Conference on Remote Sensing of Arid and Semi-Arid Lands, Cairo, Egypt, pp.973-977.
118. Tucker, C.J., Slayback, D.A., Pinzon, J.E., Los, S.O., Myneni, R.B. and Taylor, M.G. (2001). Higher northern latitude normalized difference vegetation index and growing season trends from 1982 to 1999. International Journal of Biometeorology, Vol. 45(4), pp.184-190.
119. USGS (2008). Earth Resources Observation and Science Center. URL: http://glovis.usgs.gov/ (Accessed on December 04, 2008).
120. USGS (2010). What is NDVI? United States Geological Survey: Science for Changing World. URL: http://ivm.cr.usgs.gov/ (Accessed on September 10, 2011).
121. Verbesselt, J., Hyndman, R., Zeileis, A. and Culvenor, D. (2010). Phenological change detection while accounting for abrupt and gradual trends in satellite image time series. Remote Sensing of Environment, Vol. 114(12), pp.2970-2980.
122. Villalba, R., Grau, H.R., Boninsegna, J.A., Jacoby, G.C. and Ripalta, A. (1998). Tree-ring evidence for long-term precipitation changes in subtropical South America. International Journal of Climatology, Vol. 18, pp.1463-1478.
123. Villalba, R., Lara, A., Boninsegna, J.A., Masiokas, M., Delgado, S., Aravena, J.C., Roig, F.A., Schmelter, A., Wolodarsky, A. and Ripalta, A. (2003). Large-scale temperature changes across the southern Andes: 20th century variations in the context of the past 400 years. Climatic Change, Vol. 59, pp.177-232.
124. Wan, Z. (2003). MODIS Land-Surface Temperature products users' guide. URL: http://www.icess.ucsb.edu/modis/LstUsrGuide/usrguide.html. (Accessed on September 07, 2011).
125. Wang, J., Rich, P.M. and Price, K.P. (2003). Temporal responses of NDVI to precipitation and temperature in the central Great Plains, USA. International Journal of Remote Sensing, Vol. 24, pp.2345-2364.
126. Weissteiner, C.J., Strobl, P. and Sommer, S. (2011). Assessment of status and trends of olive farming intensity in EU-Mediterranean countries using remote sensing time series and land cover data. Ecological Indicators, Vol. 11(2), pp.601-610.
127. Wessels, K., Steenkamp, K., Maltitz, von G. and Archibald, S. (2011). Remotely sensed vegetation phenology for describing and predicting the biomes of South Africa. Applied Vegetation Science, Vol. 14(1), pp.49-66.
128. Wolfe, R., Storey, J., Masuoka, E. and Fleig, A. (1995). MODIS Level 1A Earth location algorithm theoretical basis document. URL: http://modis.gsfc.nasa.gov/ (Accessed on December 14, 2012).
129. Wolfe, R.E., Nishihama, M., Fleig, A.J., Kuyper, J.A., Roy, D.P., Storey, J.C. and Patt, F.S. (2002). Achieving sub-pixel geolocation accuracy in support of MODIS land science. Remote Sensing of Environment, Vol. 83(1-2), pp.31-49.
130. Xiao, X., Boles, S., Frolking, S., Salas, W., Moore III, B., Li, C., He, L. and Zhao, R. (2002). Observation of flooding and rice transplanting of paddy rice field at the site to landscape scales in China using VEGETATION sensor data. International Journal of Remote Sensing, Vol. 23(15), pp.3009- 3022.
131. Xiong, J., Toller, G., Chiang, V., Sun, J., Esposito, J.A. and Barnes, W.L. (2005). MODIS level 1B algorithm theoretical basis document. URL: http://modis.gsfc.nasa.gov/ (Accessed on November 12, 2012).

132. Xiong, X., Chiang, K., Guenther, B. and Barnes, W.L. (2003). MODIS thermal emissive bands calibration algorithm and on-orbit performance. In: Huang, H., Lu, D. and Sasano, Y. (Eds.), Optical Remote Sensing of the Atmosphere and Clouds III, Proceedings of the SPIE, Vol. 4891, pp.392-401.
133. Xiong, X., Sun, J., Esposito, J.A., Guenther, B. and Barnes, W.L. (2003a). MODIS reflective solar bands calibration algorithm and on-orbit performance. In: Huang, H., Lu, D. and Sasano, Y. (Eds.), Optical Remote Sensing of the Atmosphere and Clouds III, Proceedings of the SPIE, Vol. 4891, pp.95-104.
134. Yang, L., Wylie, B.K., Tieszen, L.L. and Reed, B.C. (1998). An analysis of relationships among climate forcing and time-integrated NDVI of grasslands over the US northern and central Great Plains. Remote Sensing of Environment, Vol. 65, pp.25-37.
135. Yang, Y., Yang, L. and Merchant, J.W. (1997). An assessment of AVHRR/NDVI-ecoclimatological relations in Nebraska, USA. International Journal of Remote Sensing, Vol. 18(10), pp.2161-2180.
136. Yang, Z., Willis, P. and Mueller, R. (2008). Impact of band-ratio enhanced AWIFS image to crop classification accuracy. The Future of Land Imaging…Going Operational, The 17th William T. Pecora Memorial Remote Sensing Symposium, 16-20 November, 2008, Denver, Colorado. URL: http://www.asprs.org/a/publications/proceedings/pecora17/0041.pdf. (Accessed on December 16, 2012).
137. Zhao, B., Yan, Y., Guo, H.Q., He, M.M., Gu, Y.J. and Li, B. (2009). Monitoring rapid vegetation succession in estuarine wetland using time series MODIS-based indicators: An application in the Yangtze River Delta area. Ecological Indicators, Vol. 9(2), pp.346-356.
138. Zhao, M., Heinsch, F.A., Nemani, R.R. and Running, S. (2005). Improvements of the MODIS terrestrial gross and net primary production global data set. Remote Sensing of Environment, Vol. 95, pp.164-176.
139. Zhou, L.M., Kaufmann, R.K., Tian, Y., Myneni, R.B. and Tucker, C.J. (2003). Relation between interannual variations in satellite measures of northern forest greenness and climate between 1982 and 1999. Journal of Geophysical Research, Vol. 108(D1), 16 p.
140. Zhou, L.M., Tucker, C.J., Kaufmann, R.K., Slayback, D., Shabanov, N.V. and Myneni, R.B. (2001). Variations in northern vegetation activity inferred from satellite data of vegetation index during 1981 to 1999. Journal of Geophysical Research, Vol. 106(D17), pp.20, 069-20,083.
141. Zoran, M. and Stefan, S. (2006). Climatic changes effects on spectral vegetation indices for forested areas analysis from satellite data. Proceedings of the 2nd Environmental Physics Conference, 18-22 February 2006, Alexandria, Egypt, pp.73-83.

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A Comparative Analysis of Morphological and Physico-Chemical Characterization of Soils of Southern Cross River State - Nigeria

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Abstract - One basic requirement of special purpose soil classification is that the soil must be classified in terms of the properties that are relevant to their proposed use. Four transects, each 7km long were established in the eastern, western, southern and northern directions due to break in slope and creek of the land terrain. Nine profiles comprising two in each direction and the starting point were selected along the transects. The profiles were dug and described in accordance with (Soil Survey Staff, 2006 and FAO, 2003) standards. Each profile pit was described with particular reference to the depth, colour, structure, texture, roots, pores/space and other inclusions in the field. The soils of Akpabuyo are well-drained as evidenced by the absence of mottles throughout the subsurface soil horizons with Hue of 10YR being dominant in all the profiles studied while in Bakassi, one of the most striking features of all the soil profiles excavated is poor internal drainage as evidenced by the presence of mottling with dominant colours of soils varied from brown, very dark brown, dark to very dark grey and dark olive grey with predominant 5Y and 10YR hues.

Keywords : *soil morphology, physico-chemical characteristics, transects and southern cross river state.*

GJHSS-C Classification : *FOR Code : 961499*

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Strictly as per the compliance and regulations of:

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Abstract - One basic requirement of special purpose soil classification is that the soil must be classified in terms of the properties that are relevant to their proposed use. Four transects, each 7km long were established in the eastern, western, southern and northern directions due to break in slope and creek of the land terrain. Nine profiles comprising two in each direction and the starting point were selected along the transects. The profiles were dug and described in accordance with (Soil Survey Staff, 2006 and FAO, 2003) standards. Each profile pit was described with particular reference to the depth, colour, structure, texture, roots, pores/space and other inclusions in the field. The soils of Akpabuyo are well-drained as evidenced by the absence of mottles throughout the subsurface soil horizons with Hue of 10YR being dominant in all the profiles studied while in Bakassi, one of the most striking features of all the soil profiles excavated is poor internal drainage as evidenced by the presence of mottling with dominant colours of soils varied from brown, very dark brown, dark to very dark grey and dark olive grey with predominant 5Y and 10YR hues. In all the pedons studied in the hinterland area, mottle was absent as reflected by the non-hydromorphic nature of the soil while the presence of mottle in the soil of the coastal area reflects its hydromorphic nature. Pedon P1 to P5 were observed to have subangular blocky structure within the different depth sequence in Akpabuyo while those of Bakassi were massive (structureless). The soil of the hinterland (Akpabuyo) is acid with means of 5.3 and 5.2 and strongly acidic for those of Bakassi (coastal) (3.5 to 3.1) top and subsoils respectively. In the hinterland area, electrical conductivity (EC) mean values are 0.054 and 0.023dsm-1 and in the coastal area the means are 15.47 and 18.55dsm-1 top and subsoils respectively. In the hinterland area, the mean values for CEC = 5.41 and 6.33cmol/kg, total nitrogen = 0.5 and 28cmol/kg, Avail. P = 28 and 41cmol/kg while those for the coastal area mean values are (CEC = 15.47 and 18.66cmol/kg, total nitrogen = 7.2 and 7.3cmol/kg, Avail. P=5 and 6cmol/kg) for top and subsoils respectively. According to the USDA Soil taxonomy and the FAO/UNESCO system, the soils in Akpabuyo terrain (hinterland) are placed in the Entisols order owing to the absence of diagnostic horizon young (silt/clay ratio > 0.20) with no evidence of morphological profile development. The soil of Bakassi area (coastal) is situated in and environment characterized by peraquic/aquic moisture regimes in most parts of the year. All the pedons underlying the terrain (BP0 - BPST2) have high percentage base saturation in addition to the evidence of clay accumulation in the subsurface and argillic horizons. These attributes qualify the soils as luvisols. The argillic moisture regime further classified the soils as Gleyic Luvisols.

Keywords : soil morphology, physico-chemical characteristics, transects and southern cross river state.

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I. Introduction

One of the basic requirements of any special purpose soil classification is that the soil must be classified in terms of the properties that are relevant to their proposed use (Gibbons, 1965; Gbadegesin, 1986). For instance, it is clearly not sufficient to state that soils are going to be classified for maize or cassava production, unless the soil properties determining the soil's suitability for maize or cassava production have been identified. However, the identification of the soil properties relevant to the proposed use cannot be carried out without relating the soil properties to some external measures of the proposed use, such as the yield of an agricultural crop (Gbadegesin, 1986; Gbadegesin et al., 1990).

According to the soil classification of USDA soil map of the world (Arckerson et al., 1998; USDA, 1995; 2006) classified most of Nigeria soils on basement complex as alfisols and on sand stones as ultisols. This classification of Nigerian soil suggests basic similarities in soil reaction processes which are greatly modified by climatic and vegetation differences. Kang and Osiname (1972), Abiogba (2011), reported that micronutrients are deficient in soils of several parts of Nigeria, thus, most nutrient-balance studies focus on macronutrients and how these macronutrients varied with time and space in the soil. It is against this background that this study intends to draw a comparative analysis of soils of the coastal areas of Southern Cross River State – Nigeria.

II. Objective of the Study

The objectives of the study are:

1. To characterize and classify the soils of the coastal and hinterland areas of Southern Cross River State in terms of morphology, physical and chemical properties;
2. To examine the degree of variability of the physical and chemical properties of soils of the study area.

III. Study Area

Akpabuyo Local Government Area (hinterland) is located between longitudes 8020'E and 8040'E and latitudes 4045'N and 5010'N of Greenwich Meridian. Bakassi Local Government Area (coastal) is located between longitudes 8030'E and 8039'E and latitude 4030'N and 4045'N. Bakassi Local Government is found along the Cross River estuary located at the south-east bank of the estuary characterized by mangrove swamps soil while Akpabuyo Local Government Area extends form the Great Kwa River along the ''Atimbo'' bridge head. The soils of Akpabuyo study site are derived from tertiary coastal plain sands of Pleistocene era while those of Bakassi are formed from alluvium in the quaternary period. Both soils are of the same geological material of sedimentary origin but of different formation (Fig. 1).

IV. Materials and Method

Field Study: Four transects, each, 7km long, were established in the eastern, western, southern and northern directions due to break in slope and creeks of the land terrain. Nine representative profiles comprising two in each direction and the starting point were selected along the transects. The profiles were dug and described according to the provision of (Soil Survey Staff, 2006; and FAO, 2003) standards. Profile were dug to the depth of 150cm or 200cm except where a water table is struck or an impenetrable layer is encountered. Each profile pit was described with particular reference to the depth, colour, structure, texture, roots, pores and other inclusions of each natural horizons or layer present in the field. Soil samples taken from the different horizons were stored in polyethylene bags and transported in the laboratory for analysis.

Laboratory Analysis: The soil samples were air-dried grinded and sieved through a 2mm sieve. Particle size was determined by the hydrometer method (Juo, 1979). Soils reaction (pH) was determined in 1:2 soil/water ratio by use of glass electrode pH meter. Organic carbon was determined by the Walkley and Black (1934) method while total nitrogen was by Kjeldahl digestion methods. Available phosphorus was determined by the Bray No. 1 method. Exchangeable cations were extracted with IN NH4OAc (pH 7); Calcium (Ca) and Magnesium (Mg) were determined by the EDTA titration method while Potassium (K) and Sodium (Na) were determined with a flame photometer (Black et al., 1965). Exchangeable acidity (H+ and Al3+) were determined by leaching the soils with IMKCl and titrating aliquots with 0.01M NaOH. Effective Cation Exchange Capacity (CEC) was determined by ammonium ion displacement method whereby IN NH4OAc, pH 7.0 was used as the extracting solution (Black et al., 1965) while base saturation was estimated by dividing the total exchangeable bases (Ca, Mg, K and Na) by the cation exchange capacity (CEC) obtained by NH4OA6 and the result multiple by 100, given the equation thus:

$$BS = \frac{TEB}{ECEC} \times 100$$

Where
TEB = Total exchangeable bases
ECEC = Effective cation exchange capacity
BS = Base saturation

V. Procedure for Data Analysis

Description statistics such as the range, mean, standard deviation and coefficient of variability (CV) were used. The statistics is relevant here because the samples are independent (do not depend on each other) and are normally distributed while the CV is used for measurements based on ratio scale i.e. a scale with an absolute zero origin and not on other scales of measurement with an arbitrary zero origin. Thus, in this study, the CV was used for comparison of variables measured on a ratio scale. The coefficient of variable (CV) is given as:

$$C.V. = \frac{\delta}{X} \times 100$$

Where:
C.V. = Coefficient of Variability
δ = Standard deviation
X = The mean

VI. Characterization and Classification of Soils in Akpabuyo and Bakassi Areas

This section presents the results obtained from the soil morphological and physico-chemical analysis carried out in transacts one and two representing Akpabuyo and Bakassi study sites under investigation. Morphological description of the nine (9) profiles is presented in Table 2. The soils morphological characterization was described in-situ with reference to the vegetation; drainage condition, soil colours, textures, consistence, horizon boundary, structure and inclusions (roots, ants, worms, charcoal, crickets, etc). The soils of Akpabuyo are well-drained as evidenced by the absence of mottles throughout the subsurface soil horizons in all the profiles studied. Abua and Edet (2007)

One of the most striking features of all the soil profiles excavated in the Bakassi area is poor internal drainage as evident by the colour of the soils. Table III gives account of the nine (9) soil profiles positioned along the starting point (P0), north (P1,P2), west (P7,P8), east (P5,P6) and south (P3,P4) transects of intervals of 3.5km along the transects at varying depth sequence down the profiles. Pedon's P1-P5 and pedon P8 were poorly to very poorly drained dominated by mottling with brown, very dark brown, dark gray to very dark gray and dark olive gray colours within the depth of l00cm.

The surface colour of the soils varied from very dark gray brown (10YR3/2) in profiles P1 and P3 while profiles P4 and P5 had munsell notation of 2.5YR 2.5/0 (black) Profiles P6-P9 had munsell notation of 10R 3/3 (dark brown) in the surface soils excepting profiles P2 with colour notation of 5YR 2.5/2 (dark reddish brown) (Table II). The subsurface soils are characterized by dominant hues of 10YR, 2.5-Y, 7.5YR, 5YR reflecting various shades of yellow (10YR 5/4- yellowish brown; 10YR 2.5/2 - dark yellowish brown; and 10YR 6/8- brownish yellow) and brown (10YR 4/3 - brown; 10YR 3/2-very dark brown; 2.5y 5/4 - light olive brown; 7.5 YR 5/6- strong brown; 10YR 3/3 - dark brown) within 200cm depth sequence (Table II). In all the pedons, mottles were absent as reflected by the non-hydromorphic nature of soils of the area.

In the Bakassi study area. dominant colours of the soils varied from brown, very dark brown, dark to very dark gray and dark olive gray with predominant 5Y and 10YR hues (pedons P1-P5 and P8) with chromas values less than 3 for pedons P1-P6 and 3 to 8 in pedons P7-P9 within 100cm of the pedons (Table I). Pedons 1, 5 and 8 are saturated with water apparently due to the high water table and intermittent tidal inundation which makes them liable to flooding (Akamigbo, 2001; Akpan-Idiok, et al., 2006).

Pedons P1 to P5 were observed to have subangular blocky structure within the different depth sequence in the area (Akpabuyo). Profiles P1 are weak (surface) moderate to coarse-textured within the depth of 40-122cm while it was moderate to medium within 122-200cm depth (Table I). Profile P2 (north transect) were weak and coarse-textured. Thus, profiles P1-P5 are dominated by subangular blocky structure. The remainder (P6-P9) of the profiles had structural classes ranging from subangular blocky structure, crumb to granular structures. Crumbs structures were observed in P6 (32-61cm) of the east transect while granular structures were observed in profiles P8 and P9 of the south transect within the depth of 56-200cm (P9) and 46-200cm (P9). The profiles (P6-P9) were deep, weak, moderate with coarse to fine textures. This indicates that soils of the area are made up of coarse-textured colluvial and alluvia materials.

The soils structure in the Bakassi area was mostly massive (structuresless), reflecting poor drainage conditions of the profiles during the period of sampling as exemplified in pedons P1-P5 and pedon 8 (Table III). Pedons P6, P7 and P9 exhibited varied structural trend probably due to distance away from the water bodies and apparently low water table. Such poorly drained soils showed considerably amounts of clay contents as they were sticky and plastic (Table III). Soil structures in pedons P6, P7 and P9 showed slight variability as they were weakly developed in pedons, albeit with fine clay accumulation beyond 100cm depth. The lack of structural development in the surface and subsurface horizons of pedons P1-P5 and P8 could be ascribed to the effect of ground-water table (Udo et al., l993). Besides, they are weak, fine with sub-angular blocky to granular structures (Table III).

In Akpabuyo study area, the consistency of surface soils was non-sticky and non-plastic; firm and moist to dry and loss, dry and slightly hard (Table II, P1-P9). The subsurface horizons also exhibited consistency at various degrees from non-plastic and non-sticky firm and moist both at wet consistence; loose and slightly hard as dry soils do not contain a reasonable amount of clay fractions.

In terms of consistency, some of the samples collected from the prescribed study site (Bakassi) varied from slightly sticky and plastic (moist conditions); moist and firm at non-waterlogged condition.

In Akpabuyo, the texture of the epipedons varied from sandy loam, sand to loamy sand fractions (Table II) (P1-P9). The texture of subsurface horizons ranged from sandy clay loam, sandy loam, clay loam to gravelly (east transect) in texture (Table II, P1-P9).

Soil textures show mild variability in Bakassi. Surface textures varied from clay through loam to sandy loam, while subsurface textures are commonly clay loam to sandy loam (Table III). Pedons 5 and 8 are dominated by clay contents in all the surface and subsurface horizons (Table I). Albeit few of the profiles showed dissimilar trends variation in terms of textures at different depth sequence in the area. These variations may be due to differences in parent material and topography (Akamigbo,2001).

In term of inclusions, surface soils (P1-P9) profiles had an abundance of roots of all kinds, namely medium, fine and many coarse roots. At the subsurface, coarse, medium, few fine roots were observed along profiles in the east transect. It was observed that the first horizons in the east transect were fibrous roots mat-layers and they possessed many coarse medium and fine roots from the epipedon (Table II). Besides many fine micro and macro pores were seen at the surface soils of the profiles. The occurrence or abundance of pores in soils is significant, because soils with many fine pores are much more aerated, and better drained than one with few, very fine pores (Esu, 1999). Other inclusions observed in the Akpabuyo area were charcoals, ants, crickets, snails, worms to termites. Visual observations of charcoal in some of the profiles strongly indicate the influence of anthropogenic activity in the study site.

Horizon delineation within the nine (9) profiles was based on colour of the soils. The distinctness and the outline of horizons within the surface horizons carried from clear smooth to gradual diffuse boundaries (Table II). Conversely, the subsurface soil horizons boundaries ranged from clear smooth, gradual diffuse to diffuse smooth boundaries within the depth sequence of horizon boundaries across the transects (Table II, P1-P9).

Among soil inclusions in the Bakassi study area were the sapric, common fine roots, (surface soils), few fine roots (subsurface) smell of crab, periwinkle and worms (Table III). Distinctions and the outline of horizons within the profiles to diffuse smooth boundaries (Table III).

VII. Soil Classification

Using both field and laboratory analytical results, the soils are classified according to the American system of Soil Taxonomy (Soil Survey Staff, 1992, 1998, 2006) and the FAO/UNESCO (1988) of the world soil map legend. Consequently, the present study aptly attempts a classification of the soils underlying Akpabuyo and Bakassi terrain given their morphological description in the foregoing sections (see Tables 2 and 3).

According to the criteria of the USDA system, pedons AP0, APNT1, APET1, APST1, and APST2 located about 0km, 3.5km and 7km on either transects within Akpabuyo terrain fits into order Ultisols because of the strong acid condition, low base status, low ECEC and perhaps, absence of argillic horizons. With yellowish brown soil colour particularly in pedons AP0 (40-200cm depth), APNT (within the depth of 27-105cm), hue of 10YR coupled with medium organic carbon content, the pedons are placed in the suborder Ustults.

Due to the warm soil temperature of the region, the pedons are placed in Tropustults great group and Typic Tropustults Subgroup. The FAO/UNESCO soil legend classification equivalent of Typic Tropustults is Dystric Acrisols.

Moreso, pedons AP0, APNT1, APNT2, APWT1, APWT2, APET1, APET2, APST1 and APST2 located along the transects within the Akpabuyo terrain are placed in the Entisols order owing to the absence of diagnostic horizon young (silt/clay ratio>0.20) with no evidence of morphological profile development.

Pedon APET2 located 7km east transect within a valley exhibited exceptional attributes as the profile was almost by sand within the depth of 0-57cm of the profile, which may be attributed to the deposition of eroded sediments, albeit it is placed in the Entisols order for little evidence of diagnostic horizon other than an ochric epipedon. According to the criteria of USDA Soil Taxonomy (Soil Survey Staff, 1992, 1998, 2006), the soils are qualified Typic Ustifluvents due to little evidence of diagnostic horizons, organic carbon above 0.20% of the varying depth sequence, Ustic moisture regime of the terrain and warm soil temperature. The soil equivalent according to the criteria of the FAO/UNESCO (1988) legend is Eutric Fluvisols due to little evidence of pedogenic horizons, organic carbon content greater than 0.20% and the Ustic moisture regime of the ecological zone.

Conversely, pedons BP0, BPNT1, BPNT2, BPWT1, BPWT2, BPET1, BPET2, BPST1 and BPST2 located along the starting point, north, west, east and south transects measured 0km, 3.5km and 7.0km on either transects were studied at Bakassi axis. The prescribed area albeit is situated in an environment characterized by peraquic/aquic moisture regimes in most parts of the year. All the pedons underlying the terrain (BP0-BPST2) have high percentage base saturation in addition to the evidence of clay accumulation in the subsurface and argillic horizons. The aquic moisture soil regime further places these soils in the suborder, Aqualf. Pedons BPWT1, BPWT2, BPET1 and BPST1 located 3.5km, 7.0km and 3.5km respectively along west, east and south transects and qualified Typic Fluvaquent and Typic Endoaquent according to the criteria of the USDA Soil Taxonomy (Soil Survey Staff, 1992, 2006) and Eutric Fluvisols owing to the absence of diagnostic horizons, aquic moisture regime, reduced matrix below Ap horizons, hue of 10YR and low chroma of 2 or less, irregular decrease of organic carbon and clay contents decrease with the profile depth, and low pH values within the profiles. Pedons BPo, BPNT1, BPNT2, and BPST2 were placed Aeric Endoaquent because of the gleyed horizons (2. 5Y) though of varying depth sequence probably as a result of the influence of the groundwater table. The irregular decrease/increase in the organic carbon content within the profile placed these pedons under the great group of Fluvaquent.

In the FAO/UNESCO (1988) soil legend, pedons BPo-BPST2 (all pedons in the terrain) are qualified Luvisols owing to the high base saturation status coupled with the presence of arqillic horizon. They are further classified as Gleyic Luvisols because of the hydromorphic characteristics, albeit at varying depth sequence of the profiles (Fitz Patrick, 1980). Pedons BP0, BPNT1, BPNT2 and BPST2 along designated transects of Bakassi region qualified as Gleysol and Eutric Regosol because it is derived from unconsolidated parent materials exclusive of recent alluvial deposits, and having hydromorphic properties at different depth sequence. Besides, it is further classified as Eutric Gleysol on account of percentage base saturation exceeding 50.

VIII. Physico-Chemical Characteristics of Soils

Whereas in the coastal area the EC values varies from 0.88 to 30.65 dsm'1 (surface soils) and 38.70 dsm-1 subsurface soils). Organic Carbon Contents with mean values of 1.83% and 0.65 for surface and subsurface soils respectively while total nitrogen had means of 0.72% and 0.73% respectively for surface and subsurface soils with SD = 0.18 surface and 0.12 for subsurface soils. The available p (means = 5Mgkg-1 and 6mgkg-1) for surface and subsurface soils respectively with SD = 0.73 - 0.80, CV = 30.05, SD = 2.64 and 1.31 with the corresponding CV of 52.70% and 21.92% respectively. In the hinterland area, exchangeable bases were as follows: Ca with means of 2.44 Cmol/kg-1 and 2.33 Cmol/kg-1, mg (means = 1.15 and 1.08 Cmol/kg-1), k (means = 0.14 and 0.10 Cmol/kg-1), Mg (means = 0.06 and 0.05 Cmol/kg-1) in both the surface and subsurface soils respectively. Exchangeable bases contents of soils in the hinterland include Ca (means = 9.54 and 9.99 Cmol/kg-1), k (means = 0.10 and 43.01), Na (means = 0.30 and 0. 55 Cmol/kg-1) and Mg (means = 59% and 55%) for surface and subsurface soils respectively.

Base saturation in the hinterland area ranged from 39% to 75% surface and between 36% to 74% subsurface soils with means of 59% and 55% respectively (SD = 12.61 - 10.32; CV = 21.37 - 18.76%) respectively for surface and subsurface soils. The base saturation values for the coastal area varied from 81 to 97% (surface soil) and between 74 to 97 sub soils respectively with mean values of 90% and 88% surface and subsurface soils, while the SD = 5.29 and 6.74% and CV = 5.88% and 7.66% for surface and subsurface soils respectively. Base saturation was high (> 60%) in most soil sampled. This indicates that the soils are prolific to sustain arable crop production in the area under consideration. With such levels of base saturation, basic nutrients must have occurred in available forms in the soils solution regardless of the mean cation (range: 59 - 55%) reserves in the soils.

In the hinterland area, the soils are moderately coarse-textured in the surface while the subsurface has light accommodation of fine clay fraction. With high sand fraction exceeding 70%, mean salt content below 15%, the soil have weak surface aggregation. Such soil may lack adsorptive capacity for basic plant nutrients and may be susceptible to erosion menace. In the coastal area, the sand fraction accounted for more than 50% in both top and sub soil. With silt fraction greater than 15% for both top and sub soils indicate that the soils have strong surface aggregation and may not be vulnerable to erosion hazard.

The mean surface and subsurface values for bulk density in the hinterland (1.18mgm-3 and 1.42mgm-3) and its corresponding pore space of 55.51% and 62.26% respectively reflect the textural classes of the study sites. Being soils with weak surface aggregation, adequately aerated and good drainage conditions, it is recommended for the cultivation of arable crops including cassava production while in the coastal area, the mean values of bulk density are 1.22 and 1.54mgm for surface and subsurface soils respectively. In the hinterland area, moisture content increases with depth in both the surface and subsurface soils from 10.63 to 19.20% and 8.19 to 19.42% respectively. Such moisture levels are moderate for crops production in the ecological zone while in the coastal area, moisture contents of the study site under investigation ranged from 18.10 to 44.18% with means of 31.10 and 24.81% respectively in the surface and subsurface soils (Table I). Such moisture contents are appreciable though may be lethal to some arable crops in the ecological zone.

The soil reaction in the hinterland is acid with means of 5.3 and 5.2 in the surface and subsurface soil respectively. The standard deviation and the coefficient of variability ranged from 0.24 to 0.18% and 4.52 to 3.46% in surface and subsurface soils respectively. In the coastal area the soil pH is strongly acidic with means of 3.5 and 3.1 respectively in surface and subsurface soils. The standard deviation (SD) and the coefficient of (CV) of 0.78 and 0.46% and 22.27 and 14.71% respectively for surface and subsurface soils.

In the hinterland area, electrical conductivity (EC) values ranged from 0.30 to 0.088dsm-1 (surface) and 0.011 to 0.078dsm-1 (subsurface). Organic carbon had mean values of 7.95 and 7.6% for surface and subsurface soils respectively. Total nitrogen contents for surface and subsurface soils had means of 0.08% and 0.05% respective with (SD = 0.02). Available Phosphorus (means= 28Mgkg 1 and 41MgKg-1) surface and subsurface soils respectively with SD of 18.08 surface and 18Mgkg-1) surface and subsurface soils and (CV = 52.70% and 21.92%) surface and subsurface soils respectively.

IX. Conclusion

The morphological features of the prescribed soil of Southern Cross River State exhibited dissimilar pedological trends in terms of soil colour, consistency, structure, drainage pattern etc. The physical and chemical properties of the soils are dissimilar in many respect. The soils could be made productive in terms of crop cultivation if proper management system is advocated.

References Références Referencias

1. Abiogba, O. A. (2011): Spotio-temporal variation of soil nutrients and the effect on cassava cultivation in Alfisol and Ultisol zones in South-Western Nigeria. Ph.D. Thesis, Department of Geography, University of Ibadan
2. Abua, M. A. and Edet, E. O. (2007): Morphological and Physico-Chemical Characteristics of Coastal Plain Soils of Southern Cross River State – Nigeria. Nigeria Geographical Journal, Vol. 5, No. 1, pp. 109-114
3. Akamigbo, F. O. R. (2001): Survey, Classification and Landuse of Wetland Soils in Nigeria. Invited paper presented at 27th Annual Conference of the

Soul Science Society of Nigeria. 5th – 9th November, Calabar, Nigeria
4. Akpan-Idiok, A. K. and Antigha, N. R. B. (2006): Soil Survey Irrigation/Drainage and Flood Control Project. Nsecal Engineering Services, Calabar
5. Arkcerson, T. K.; Rourke D. L., Vessel A. J. (1998): Soil of the World (map) U.S.A., Government Printing Offices, Washington D.C.
6. Esu, I. E. (1999): Fundamental of Pedology. Stirling-Horden Publishers (Nig.) Ltd. Lagos, Ibadan, Benin City, Jattu Uzairue, pp. 136
7. Food and Agricultural Organisation, FAO (2003): Production Yearbook: FAOSTAT Database. http://apps/fao.org (Consulted February, 2003)
8. Food and Agricultural Organisation (FAO/UNESCO) (1998): Soil Map of the World Legend. Paris FAO/UNESCO
9. Gbadegesin, A. S. and Nwagwu, U. (1990): On the suitability assessment of the forest and savanna ecological zones of south-western Nigeria for maize production. Agric Ecosystems Environ., 31: 99-133. Elsevier Science Publishers B.V., Amsterdam Netherlands
Gbadegesin, A. S. (1986): Predicting Maize Yield from Plants Characters in the Savanna Belt of Oyo State, Nigeria. Journal of Tropical Agriculture, Vol. 64, No. 3 pp. 109-117
10. Gibbons, F. R. (1965): Limitations to the Usefulness of Soil Classification. Trans-International Congress son Soil Science, Adelaide, Vol. 4, pp. 159-167
11. Juo, A.S.R. (1979): Selected methods for soils and plants analysis. International Institute of Tropical Agriculture (IITA), Manual Series No. 1 in Method of Making Mechanical Analysis of Soils. Soil Science Society of Nigeria. 68: 15-24
12. Kang, B. T. and Osiname O. A. (1972): Micronutrients Investigation in West Africa. Proceedings of the Ford/IITA/RAT International Seminar on Tropical Soil Research, Ibadan, Nigeria
13. Ndo, E. J. and Ibia, T. O. (1993): Phosphorus Forms and Fixation Capacity of Representative Soils in Akwa Ibom State of Nigeria. Geodarma, Vol. 58, pp. 96-106
14. Soil Survey Staff (1992): Keys of Soil Management Support Services 5th Monograph, No. 19 Blacksburg, Virginia
15. Soil Survey Staff (1998): Key to Soil Taxonomy. USDA Soil Conservation Services, 8th edition. Washington DC
16. Soil Survey Staff (2006): Keys to Soil Taxonomy, 10th edition United State Department of Agriculture, National Resources Conservation Services, Washington DC
17. Walkey, A. and Black, I. A. (1934): An Examination of the Digestive Method for Determining Soil Organic Matter and Proposed Modification of the Chronic Acid Tillage Method, pp. 10-18.

Table 1 : Summary results showing variation in physico-chemical characteristics of soils sampled along transects in Akpabuyo and Bakassi Local Government Area, Cross River State.

Parameter	sample type	Akpabuyo Soils Range	Mean	SD	CV (%)	Bakassi Soils Range	Mean	SD	CV (%)	Maximum Permissible limit
A) Physical Parameters:										
(i) Sand (g/kg)	S	785.4-915.6	885.6	37.9	43.0	116.0-681.0	337.2	198.0	587.2	NL
	SS	718.4-898.4	819.8	49.8	60.4	94.0-652.0	290.4	152.5	525.3	NL
(ii) Silt (g/kg)	S	18.8-88.7	46.3	19.6	423.3	192.0-396.0	282.0	69.9	248.1	NL
	SS	38.8-117.8	63.5	19.9	313.4	200.0-422.0	329.1	43.9	132.2	NL
(iii) Clay (g/kg)	S	44.4-195.8	75.4	45.6	604.8	127.0-561.0	380.8	147.8	147.2	NL
	SS	63.8-183.8	116.8	34.1	292.0	148.0-552.0	380.5	126.3	126.3	NL
(iv) Textural Class	S	s, ls, sl	-	-	-	c, l, sl	-	-	-	-
	SS	sl, ls, s	-	-	-	c, cl, sl, l	-	-	-	-
(v) Pore Space (%)	S	10.0-13.0	118.0	12.0	1021.0	128.0-197.0	178.0	29.0	1632.0	NL
	SS	10.0-17.0	142.0	19.0	1338.0	110.0-199.0	176.0	29.0	1668.0	NL
(vi) Moisture Contents (g/kg)	S	509.4-622.6	555.1	45.5	82.0	252.8-517.0	327.1	109.6	313.2	NL
	SS	358.5-622.6	465.2	71.3	153.2	249.1-532.1	335.2	110.8	330.4	NL
B) Chemical Parameters:										
(i) pH (H_2O)	S	5.0-5.8	5.3	0.24	4.52	2.1-4.6	3.5	0.78	22.27	5.1-6.5
	SS	5.0-5.8	5.2	0.18	3.46	2.0-3.9	3.1	0.46	14.71	
(ii) EC (dSm^{-1})	S	0.030-0.088	0.054	0.021	38.98	0.88-30.65	15.47	9.27	59.91	$2\text{-}4dSm^{-1+}$
	SS	0.011-0.078	0.023	0.014	59.96	0.89-38.70	18.66	9.09	48.72	
(iii) Org. M (g/kg)	S	94.9-200.7	129.5	18.8	237.0	18.2-48.0	38.3	5.40	296.9	2.0^{++}
	SS	88.1-182.3	96.1	15.6	205.2	3.4-30.8	28.5	4.81	483.0	
(iv) Total N (g/kg)	S	0.05-1.1	0.8	0.2	237.5	4.8-11.1	7.2	1.8	254.4	$0.2\%^{++}$
	SS	0.1-0.9	0.5	0.2	363.7	5.0-10.1	7.3	1.2	163.8	
(v) Avail P ($mgkg^{-1}$)	S	10-63	28	18.08	64.57	2-9	5	2.64	52.70	$2.0mgkg^{-1+++}$
	SS	4-80	41	18	44	3-9	6	1.31	21.92	
Exchangeable Bases ($cmol/kg^{-1}$):										
(vi) Ca	S	1.40-3.40	2.44	0.73	30.05	5.06-14.20	9.54	3.20	33.50	$10\text{-}20cmol/kg^{-1+++}$
	SS	1.00-4.00	2.33	0.80	34.37	5.04-16.87	9.99	3.48	34.84	
(vii) Mg	S	0.50-2.00	1.15	0.43	37.72	9.04-19.21	15.30	3.56	23.26	$3\text{-}8cmol/kg^{-1+++}$
	SS	0.40-1.80	1.08	0.32	29.86	7.81-26.11	16.47	5.73	34.79	
(viii) K	S	0.06-0.27	0.14	0.07	53.03	0.06-0.14	0.10	0.02	21.21	$0.6\text{-}1.2cmol/kg^{-1+++}$
	SS	0.04-0.23	0.10	0.06	55.74	0.04-0.21	0.10	0.04	43.01	
(ix) Na	S	0.04-0.07	0.06	0.11	18.63	0.12-0.61	0.30	0.19	62.59	$0.7\text{-}1.2cmol/kg^{-1+++}$
	SS	0.03-0.08	0.05	0.02	31.29	0.11-1.30	0.55	0.34	61.53	
Exchange Acidity ($cmol/kg^{-1}$):										
(x) Al^{3+}	S	1.05-2.81	1.69	0.53	31.41	0.24-0.92	0.42	0.22	54.72	$4.1cmol/kg^{-1+++}$
	SS	0.60-2.85	1.65	0.59	36.03	0.16-0.38	0.26	0.06	22.35	
(xi) H	S	0.30-3.20	1.14	0.88	77.19	0.18-6.54	0.27	1.88	82.82	$2.1\text{-}4cmol/kg^{-1+++}$
	SS	0.45-1.90	1.14	0.42	36.84	0.69-9.61	3.16	2.25	71.17	
(xii) ECEC ($cmol/kg^{-1}$):	S	4.54-9.03	6.41	1.52	23.68	16.98-36.08	27.94	6.76	24.19	-
	SS	3.98-9.11	6.33	1.26	19.85	15.84-46.03	30.53	8.47	27.74	
(xiii) Base Saturation (%)	S	39-75	59	12.61	21.37	81-97	90	5.29	5.88	$10cmol/kg^{-1+++}$
	SS	36-74	55	10.32	18.76	74-97	88	6.74	7.66	
C) Fertility Indices:										$60\text{-}80\%^{+++}$
(i) Ca:Mg Ratio	S	1.50-2.86	2.25	0.48	21.16	0.46-0.85	0.62	0.13	20.97	3:1-5:1**
	SS	1.25-2.86	2.15	0.37	17.14	0.36-1.31	0.62	0.65	35.38	
(ii) Mg:K Ratio	S	2.61-22.22	10.20	6.77	66.36	90.40-303-33	157.40	157.40	41.66	1:2**
	SS	1.74-28.00	13.94	6.87	49.28	51.71-452.50	210.49	210.49	56.58	
(iii) C:N Ratio	S	17-25	22	2.78	12.64	7-17	12	12	26.42	25*
	SS	12-25	18	3.92	21.75	7-14	11	11	15.55	

Notes :

S = Surface soils; SS = Subsurface soils; S1 = Sand; Ls = Loamy sand; sl = Sandy loam + = Miller and Donahue (1995); ++ = FPDD (1990); +++ = Holland et al (1989)

Table 2 : Field Morphological characterization of soils sampled in Akpabuyo study area, Cross River State.

Horizon depth (cm)	Pedon	Munsell colour (wet condition)	Texture	Structure	Consistence	Inclusion	boundary
Level or nearly level: 0-2% (1): Reference point, AP_0 (N04^0 56.648; E 008^0 24.193)							
0-14	P_1	10YR3/2;vdg	sl	1, 4, sbk	wns, wnp, mf	ccr, ai, mmp	cs
14-40		2.5Y5/4;lob	scl	2, 4, sbk	wss, wsp, mf, dsh	ffr, ai, mmp	cs
40-82		10YR5/4;yb	sl	3, 4, sbk	wss, wsp, mf, dl	ffr, c, mmp	cs
82-122		10YR5/6;yb	scl	3, 4, sbk	wss, wsp, mf, dh	ffr, c, mmp, a	cs
122-200		10YR6/8;yb	scl	3, 2, sbk	wss, wsp, mf, dh	ffr, a, mmp	cs
Moderately to strong sloping: 4-7% (3); North transect, APNT $_{1-1}$ (N 04^0 56.794; E008^0 xxxx)							
0-22	P_2	5Y 2.5/2;drb	s	1, 4, sbk	wns, wnp, mf, dl	mcr, ai, ck, mmp	cs
22-41		10YR 4/4;dyb	sl	1, 2, sbk	wns, wnp, mf, dl	mcr, ai, ck, mmp	cs
41-122		10YR 6/8;by	scl	1, 4, sbk	wns, wnp, mf, dl	mfr, ai, ck, mmp	cs
122-151		2.5Y 5/6;lob	sl	1, 4, sbk	wns, wnp, mf, dl	mfr, a, ck, mmp	cs
151-200		2.5Y 4/2; dgb	ls	1, 4, sbk	wns, wnp, mf, dl	mfr, ai, ck	
Moderately to strong sloping: 4-7% (3); North transect, APNT $_{2-2}$ (N 04^0 56.906; Exxxxxxxxxx)							
0-28	P_3	10YR 3/1; vdg	sl	1, 2, sbk	wns, wnp, mf, dl	mfr, ai, c, tm, mmp	gd
27-65		10YR 5/6; yb	scl	1, 2, sbk	wns, wnp, mf, dl	mfr, a, mmp	gd
65-105		10YR 5/4; yb	scl	3, 2, sbk	wss, wsp, mf, dsh	ffr, c, a, mmp	cs
105-155		10YR 6/6; by	sc	3, 2, sbk	wvs, wsp, mf, dsh	ffr, mmp	gd
152-200		10YR 5/8; yb	sc	4, 3, sbk	wvs, wsp, mf, dsh		gd
Level or nearly level: 0-2% (1); West transect, APNT $_{1-1}$ (N 04^0 56.760; E 08^0 24. xxxx)							
0-27	P_4	2.5YR 2.5/0; bl	sl	1, 2, sbk	wns, wnp, mf, dl	mcr, ai, w, sn, tm, mmp	gd
27-56		5YR 3/2; drb	sl	1, 2, sbk	wns, wnp, mf, dl	mfr, ai, w, sn, mmp	gd
56-115		5YR 3/2; drb	cl	3, 2, sbk	wns, wnp, mf, dl	fcr, ai, w, c, mmp	gd
115-152		7.5YR 4/4; b	sl	3, 2, sbk	wss, wsp, mf, dsh	fcr, ai, c, mmp	gd
152-200		10YR5/8; yb	sc	3, 2, sbk	wss, wsp, mf, dl	ffr, ai, c, mmp	gd
Level or nearly level: 0-2% (1): West transect, APNT $_{2-2}$ (N 04^0 56.910;E008^0 xxxx)							
0-27	P_5	5YR 2.5/1; bl	sl	1, 2, sbk	wns, wnp, mf, dl	mrc, ai, c, mmp	cs
27-56		7.5YR 3/2; db	sl	3, 2, sbk	wns, wnp, mf, dl	mfr, c, mmp	cs
56-103		5YR 2.5/1; bl	sl	3, 2, sbk	wns, wnp, mf, dl	ffr, c, mmp	gd
152-200		10YR 4/3; b	scl	3, 2, sbk	wss, wsp, mf, dh	ffr, c, ai, mmp	cs
Moderately to strong sloping: 4-7% (3);East transect T, APNT $_{1-1}$ (N 04^0 56.603; E008^0 xxxxxxx)							
0-32	P_6	2.5YR 5/6	sl	1, 4, skb	wns, wnp, mf, dl	mfr, ai, c, mmp	cs
32-61		10YR 3/2	sl	1, 2, cr	wns, wnp, mf, dl	ffr, ai, c, mmp	cs
61-117		7.5YR 3/2	sl	1, 2, sbk	wns, wnp, mf, dl	ffr, ai, mmp	cs
117-200		5YR 3/2	ls	3, 2, sbk	wss, wsp, mf, dh	ffr, ai, mmp	cs
Steepy sloping and hilly: 12-18% (5); East transect, APNT$_{2-2}$ (N 04^0 56.521; E008^0 xxxxxxxxxx)							
0-21	P_7	10YR 3/5	ls	3, 2, sbk	wns, wnp, mf, dsh	ccr, ai	gd
21-27		2.5YR 5/4	scl	3, 2, sbk	wss, wsp, mf, dh	mcr, st, c, ai	gd
57-200		10YR 6/8	sc, gr	3, 2, sbk	wns, wnp, mf, dvh	fcr, gr	cs
Level or nearly level: 0-2% (1); South transect, APNT$_{1-1}$ (N 04^0 56.370; E008^0 xxxxxxxx)							
0-22	P_8	5YR 3/4	ls	1, 5, sbk	wns, wnp, mf, dl	mfr, wm, ai, mmp	gd
22-56		10YR 3/6	scl	3, 5, sbk	wns, wnp, mf, dl	mfr, wm, c, mmp	gd
56-110		7.5YR 4/2	sl	3, 5, g	wns, wnp, mf, dl	ffr, c, mmp	cs
110-200		10YR 5/8	sc	3, 5, g	wns, wnp, mf, dsh	ffr, ai, mmp	cs
Level or nearly level: 0-2% (1): SOUTH TRANSECT APNT$_{2-2}$ (N 04^0 56.210;E0 xxxxxx)							
0-14	P_9	10YR 4/6	sl	1, 2, sbk	wns, wnp, mf, dl	mfr, c, ai, mmp	cs
14-46		2.5Y 5/6	scl	3, 5, sbk	wss, wsp, mf, dsh	ffr, ai, mmp	cs
46-89		7.5YR 4/4	scl	3, 5, g	wss, wsp, mf, dl	ffr, ai, mmp	ds
89-200		10YR 5/7	scl	3, 5, g	wss, wsp, mf, dh	ffr, c, mmp	ds

Legends : vdg = very dark gray; yb= yellowish brown; b = brown; db = dark brown; bl= black; dgb=dark gray brown; drb= dark reddish brown

Colours : lob= light olive brown; vdg=very dark gray brown; by= brownish yellow; dyb=dark yellowish brown; cr=crumb

Structure : 1=weak; 2=medium; 3=moderate; 4=coarse; 5=fine; sbk=subangular blocky; g=granular dh=dry, hard; dvh=dry, very hard; wvs= wet, very sticky.

Texture : sl=sandy loamy; scl=sandy clay loamy; sc=sandy clay;ls=loamy sand; gr=gravelly; s=sand

Inclusion : mcr= many coarse root; ai=ants, insects; mfr=many fine roots; c=charcoal; mmp=many micro and macro pores, ffr=few fine roots; fcr=few coarse roots;

w=worms; sn=snails; tm=termites; ccr=common coarse roots; a=ants; ck=crickets;

5=Class E (Steepy sloping and hilly)

Table 3 : Morphological characterization of soils sampled in Bakassi study area, Cross River State

Horizon depth (cm)	Pedon	Munsell colour (wet condition)	Texture	Structure	Conolotonce	Inclusion	boundary
	P_1	REFERENCE POINT, BP_0 (N04^0 33.661; E 08^0 35.528)					
0-21		5Y2 5/1:b	c	u	wsp, mf	cfr, aw, H_2 S, m, sap perriwinkle, crab	cs
21-40		5Y2 5/1:b	cl	u	wsp, mf	ffr, H_2 S, m, sap many pores	cs
40-62		5Y3/1,vgd	cl	u	wsp, mf	ffr, H_2 sap medium pores	gs
62-100		5Y3/2:dog	cl	u	wsp, mf		
	P_2	NORTH TRANSECT T_1,BNT $_{1,1}$ (N 04^0 35.561; E08^0 35.527)					
0-20		5Y 2.5/1:b	c	u	wsp, mf	cfr:aw, periwinkles	cs
20-40		5Y 2.5/1:b	c	u	wsp, mf	ffr	gs
40-60		5Y 3/2: dog	cl	u	wsp, mf	ffr	gs
60-80		5Y 3/2. dog	cl	u	wsp, mf	ffr	ds
80-100		5Y 3/2: dog	cl	u	wsp, mf		
	P_3	NORTH TRANSECT T_1(BNT_{1-2} (N 04^0 37, 401: 1 08^0 36..626					
0-20		5Y 3/1: vdg	c	u	wsp, mf	cfr:aw, periwinkles	cs
20-40		5Y 4/1: dg	sl	u	wsp, mf	ffr	gs
40-60		5Y 4/1: dg	sl	u	wsp, mf	ffr	gs
60-80		5Y 3/1: dg	cl	u	wsp, mf	ffr	ds
80-100		5Y2.5/1: dg	sl	u	wsp, mf		
	P_4	WEST TRANSECT T_1($BWT_{1.1}$ (N 04^0 31.762;E 08^0 35.529					
0-20		5Y 3/0: vdg	l	fg	wsp, mf	cfr:aw	cs
20-40		5Y2.5/1:vdg	c	u	wsp, mf	ffr	cs
40-60		5Y 3/2: dog	c	u	wsp, mf	ffr	gs
60-80		5Y 3/2: dog	c	u	wsp, mf	ffr	gs
80-100		5Y3/1: dog	cl	u	wsp, mf		
	P_5	WEST TRANSECT T_2(BWT_{2-2} (N 04^0 29.862; E08^0 29.862; E08^0 35.530)					
0-20		5Y 3/1: dog	c	u	wsp, mf	cfr:aw, periwinkles	cs
20-40		5Y 4/1: dg	c	u	wsp, mf	ffr	cs
40-60		5Y 5/1: dg	c	u	wsp, mf	ffr	gs
60-80		5Y 5/1: dg	c	u	wsp, mf	ffr	gs
80-100		5Y2.5/1: dg	c	u	wsp, mf		
	P_6	EAST TRANSECT T_1($BPET_1$ $BPET_{1.1}$ (N 04^0 35.600; E08^0 33.635					
0-20		5Y 3/1: vdg	sl	l.fg	wsp, mf	H_20 evolved, cf, aw	cs
20-46		2.5Y3/2:vdgb	l	l.fg	wsp, mf	ffr	cs
46-58		2.5Y 4/0: dg	c	o	wsp, mf	ffr	gs
58-84		2.5Y 4/0: dg	c	u	wsp, mf	ffr	cs
84-138		2.5Y4/0: dg	c	u	wsp, mf		
	P_7	EAST TRANSECT T_2, $BPET_{2-2}$ (N 04^0 33.659; E08^0 33.659; E08^0 31.742					
0-20		10YR4/3: vdb	c	u	wsp, mf	H_2S evolved periwinkles, cfr, aw	cs
20-40		10YR5/3: vdb	cl	l.fg	wsp, mf	ffr	gs
40-83		10YR 5/3:vdb	cl	1.fg	wsp, mf	ffr	gs
83-121		7.5YR 5/6:b	cl	u	wsp, mf		
	P_8	SOUTH TRANSECT T_1($BPST_{1-1}$ (N 04^0 33.663; E08^0 37.421)					
0-20		10YR4/2:db	c	u	wsp, mf	cfr:aw, periwinkles, crabs	cs
20-40		10YR4/3:vdb	c	u	wsp, mf	ffr	cs
40-60		10YR 5/3:b	c	u	wsp, mf	ffr	cs
60-80		10YR5/3:b	c	u	wsp, mf	ffr	gs
80-100		10YR5/3:b	c	u	wsp, mf		
	P_9	SOUTH TRANSECT T_1($BPST_{2-2}$ (N 04^0 33.663; E08^0 39.314)					
0-20		10YR4/2:db		u	wsp, mf	cfr; aw	cs
20-40		10YR4/3:db		l.fg	wsp, mf	ffr	cs
40-60		7.5YR 5/6:b		1.fg	wsp, mf	ffr	gs
60-80		10YR 6/8:b		l.fg	wsp, mf	ffr	gs
80-100		10YR6/2:b		u			

Texture: c = clay, cl = clay loam, sandy, l = loam
Structure: u = massive o = sub-angular blocky structure, l = weak, f = fine, g, g =granular
Inclusions: m = many soap = sapric
Boundary: cs = clear smooth gs* gradual smooth: ds = diffuse smooth; cfr = common fine roots: ffr = fine line roots
Color: vdb = very dark brown: db = dark brown, b = brown, vdg* very dark gray; vdgb: = very gray dark brown
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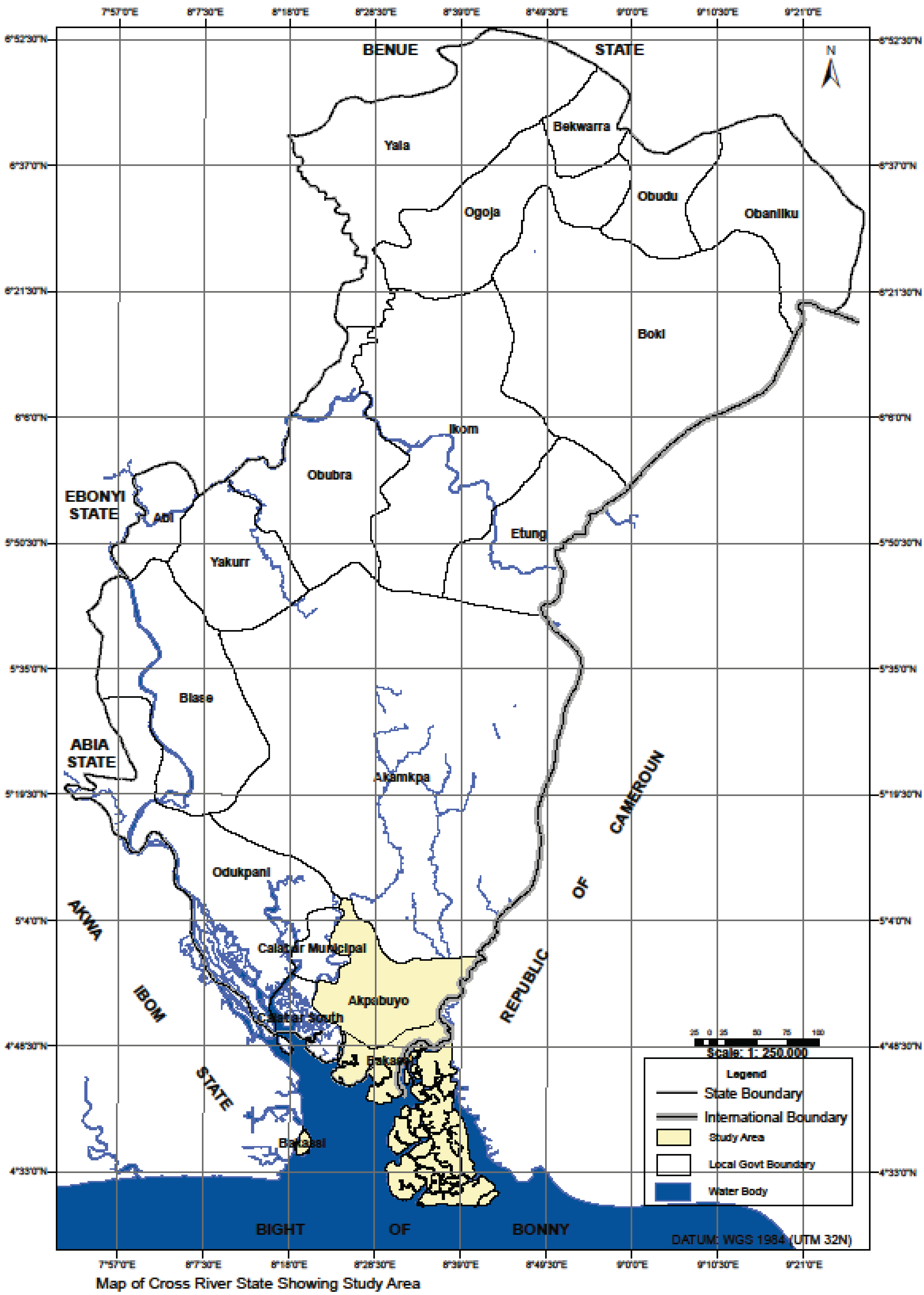
Figure 1 : Cross River State showing study area.



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7. Use right software: Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

8. Use the Internet for help: An excellent start for your paper can be by using the Google. It is an excellent search engine, where you can have your doubts resolved. You may also read some answers for the frequent question how to write my research paper or find model research paper. From the internet library you can download books. If you have all required books make important reading selecting and analyzing the specified information. Then put together research paper sketch out.

9. Use and get big pictures: Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

10. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right! It is a good habit, which helps to not to lose your continuity. You should always use bookmarks while searching on Internet also, which will make your search easier.

11. Revise what you wrote: When you write anything, always read it, summarize it and then finalize it.

12. Make all efforts: Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

13. Have backups: When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

14. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. **Pick a good study spot:** To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. **Think technically:** Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page

- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.
- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.

- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

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Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

Segment Draft and Final Research Paper: You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.

- Do not give permission to anyone else to "PROOFREAD" your manuscript.

- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

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	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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