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Global Climatic Change in Nigeria: A Reality or Mirage

By Ojekunle Z. O., Oyebamji F. F., Olatunde K. A., Amujo B. T., Ojekunle V. O. & Sangowusi O. R.

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These were analysed using time series, correlation and percentages among other statistical tools. The result shows that while temperature at inverse relationship in Nigeria i.e. temperature is increasing, the rainfall is decreasing. While global temperature for the past 100 years is 0.72-0.74 OC that of Nigeria between the two climatic periods under study is 1.80 OC. Major spatial shifts were observed for example, southward shift in the divide between the double rainfall peak and single rainfall peak, and temporal shift in short-dry-season from August to July in Southern Nigeria.

Keywords: global warming, climate change, short-dry-season, temperature, rainfall peak, sustainable development policies and measures

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Global Climatic Change in Nigeria: A Reality or Mirage

Ojekunle Z. O. [α], Oyebamji F. F. [σ], Olatunde K. A. [ρ], Amujo B. T. [ω], Ojekunle V. O.[¥] & Sangowusi O. R.[§]

Abstract- Emphasis on climate change studies have been more on global whereas the effects are mainly at regional and national levels. It is on this premise that this study investigated the effect on climate change and global warming from the Nigerian perspective. Climatic data (Mean annual and monthly rainfall and temperature) from 30 synoptic stations, for 80 years were collected from the Nigerian Meteorological Agency, Lagos, between 1901-1938 and 1971-2012. Secondary data from different sources were also collected.

These were analysed using time series, correlation and percentages among other statistical tools. The result shows that while temperature at inverse relationship in Nigeria i.e. temperature is increasing, the rainfall is decreasing. While global temperature for the past 100 years is 0.72-0.74 ^{O}C that of Nigeria between the two climatic periods under study is 1.80 ^{O}C. Major spatial shifts were observed for example, southward shift in the divide between the double rainfall peak and single rainfall peak, and temporal shift in short-dry-season from August to July in Southern Nigeria.

The result also shows that although rainfall is generally decreasing in Nigeria, recently, the coastal region is experiencing slightly increasing rainfall. The current available pieces of evidence show that Nigeria, like most parts of the world, is experiencing not only regional warming but also the basic features of climate change. To reverse the trend, sustainable developmental policies and measures were recommended.

Keywords: global warming, climate change, short-dry-season, temperature, rainfall peak, sustainable development policies and measures.

I. Introduction

Intergovernmental Panel on Climate (IPCC, 2007) defines climate change as a change in the state of the climate that can be identified (eg., by using statistical tests) by changes in the mean and /or the variability of its properties, and that persists for an extended period typically decades or longer. Although the length of time it takes the changes to manifest matters, the level of deviation from the normal and its impacts on the ecology and environment are most paramount (Odjugo, 2010). Climate change via global warming is the end product of a changing climate.

Climate change is said to exist when the level of climatic deviation from the normal is very significant over a long period of time (preferably centuries) and such deviations have clear and permanent impacts on the ecosystem (Odjugo, 2009a; 2009b). It should be emphasized that global or regional climate has never been static but variability is an inherent characteristic of climate. Climate change is different from the generally known term as climatic variability which means variation in the mean state and other statistics of climate on all spatial and temporal scales beyond that of individual weather event. Such temporal scale variations could be monthly, seasonal, annual, decadal, periodic, quasi-periodic or non-periodic. Climate change is of two facets namely global warming and global cooling. Global warming is a gradual but systematic increase in average global temperatures experienced for a very long period of time while the reverse is true for global cooling. The ongoing global warming has taken about four decades without reversing. IPCC (2007) shows that the current warming of the earth's climate is unequivocal caused by anthropogenic forces as is now evident from observations of increases in global average air and ocean and atmospheric temperatures. If the current warming continues unabated for a prolonged period, it will attain a new climatic status – warm or hot climate – with its effects on man and the ecosystem.

Climate change is caused by two basic factors namely natural processes (bio-geographical) and human activities (anthropogenic). The extraterrestrial or extragenic factors include solar radiation quantity (sunspot), quality (ultra violet radiation change) and meteor (emphasized mine). A high solar quality and quantity and period of perihelion (when the earth is nearest to the sun), result in heating up of the earth surface which lead to global warming. The incident radiation on the earth during aphelion (when the earth is farthest away from the sun) is always low and if this combines with low solar quality and quantity, global cooling is experienced. Volcanic eruptions also lead to both global warming and cooling. Through volcanic eruptions, lot of gases, vapour and particulate matter are emitted into the atmosphere. Such emissions influence the atmospheric chemistry thereby creating short–term cooling and long-term heating of the atmosphere. Prominent examples of such eruptions of great magnitude were Krakatoa eruption in 1883, Mount Agung in 1963 and Mount Pinatubo in 1992 and many more recent events.

The greenhouse gases (GHGs) which include carbon dioxide (CO_2), methane (CH_4), nitrous oxide

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(N_2O), hydro fluoro carbons (HFCs), per fluoro carbons (PFCs), chlorofluorocarbons (CFCs) and sulphur hexa fluoride (SF6). Global GHGs emissions due to human activities have grown since pre-industrial times, with the increase of 82 % between 1970 and 2011 (Fig 1). As at 1970 and 2011, the contributions of each of the GHGs by gas to the atmosphere are shown in Figure 2 and 3 respectively. It is obvious that CO_2 is the most important contributor to the GHG with anthropogenic activities contributing to 53.6% and 55.2% for 1970 and 2011 respectively. The contribution of different anthropogenic sectors to GHGs as at 2011 is presented in Table 1 while for Nigeria Land Use and Change and Forestry (LUCF) topped the list and that of the World, energy supply topped the list, waste and wastewater emitted the least GHGs into the atmosphere. Like CO_2 the contribution of CH_4 grew sharply after the pre-industrial period of the 18th century (Fig 4). The pre-industrial value of CH_4 was 700ppbv (part per billion by volume). This increased to 1774 ppbv by 2005 and it is expected to rise to 3700ppbv by 2100 (Fig 4). There is high level of agreement and much evidence to show that with the current climate change mitigation policies and related sustainable development practices, global GHGs emissions will continue to grow over the next few decades. The IPCC Special Report on Emissions Scenarios (SRES, 2000) projects an increase of global GHGs emissions by 25% to 90% between the year 2000 and 2030, with fossil fuels maintaining their dominant position of the global energy mix to 2030 and beyond (IPCC, 2007). Gas flaring which is also term as fugitive gas is another source of GHGs emission in Nigeria. Nigeria is the largest gas flaring nation in the world. She flares more than 70% of her natural gas (Odjugo, 2005b; 2007a). A drastic change in the climate systems either due to natural forces or unsustainable human activities results in climate change. The latter is regarded as the basic cause of on-going climate change and the advanced countries are most responsible (DeWeerdt, 2007). As vividly study by IPCC (2007) which shows that observed climatic data from developed countries reveal significant change in many physical and biological systems in response to global warming but there is remarkable lack of geographic balance in data and literature on observed changes with marked scarcity in developing countries. It is thus to assess the causes, rate and effects of climate change and global warming with emphasis on Nigeria.

II. Review

The increasing evidence for climate change, and the lack of adequate action, has brought keen interest on adaptation policies. The IPCC Fourth Assessment of mitigation efforts which shows that with the current commitment including Kyoto Protocol agreement would may not lead to stabilization of the atmospheric greenhouse concentration as agreed by the Cophengan Convention of 2008 and that it is due to lag times in the climate system. 'No mitigation efforts, no matter hoe rigorous and relentless, will prevent climate change from happening in the few decades'

As a matter of identity no country is left out in the acceleration of global warming and consequent climate change. Nigeria be it small in the global context cannot detached herself from the little ways it is contributing to climate change. Nigeria is emitting 183.92 $MTCO_2$-eq as at 2011 of total CO_2 in the world even though that account for less than 1 % of the world total as shown in table 2. Given the data as at 2011, Nigerian total emission of GHGs exluding Land-Use Change (LUCF) and Forestry and GHGs including Land-Use Change and Forestry (LUCF) are 324.51 $MTCO_2$-eq and 496.13 $MTCO_2$-eq respectively. Although CO_2 is the is the most contributing gas when we talk of global warming, in Nigeria CH_4 (205.52 $MTCO_2$-eq) accounts for the highest and then follow by CO_2 (83.93 $MTCO_2$-eq), while when we considered emission of GHGs by sub-sector, it shown that the emitter of gas follows this pattern of magnitude, fugitive gas > other gases > transportation. Fugitive gas had been on the rise in Nigeria and by 2011 it has accumulated to 57.33 $MTCO_2$-eq and this will continue as Nigeria is still the number 2 country in the world with great history of gas flaring and in the process release CO_2 to air causing global warming. Also as shown in table 2, the GHGs contribution of gas by sector account for 171.63 $MTCO_2$-eq , 158.50 $MTCO_2$-eq and 100.68 $MTCO_2$-eq for Land-Use Change and Forestry, Energy and Agriculture in the order of magnitude respectively. Depicting that most of our emission is from forestry and agriculture in that combine effect because our society is an agrian one and also for the factor that we are developing though unsustainably might has cause great increase in emission from the energy sector as shown in table 2.

A case was explored from the experiment conducted by environmental experts in Nigeria to know the extent to which global climate change had been realistic in the country and as it was with many countries, Nigeria expert also have divergent view on the reality of climate change.

This was conducted by Olofintoye and Sule (2010) with the major aims of looking into the impact of global warming on the rainfall for some selected cities in the Niger Delta of Nigeria, and deducing if urban water supply is sustainable under the prevailing climate condition. The time series of meteorological data (rainfall and temperature) were analysed with the aim of detecting trends in the variables and vulnerability.

The non-parametric Man-Kendall test was used to detect monotonic trends, and the Sen's slope estimator was used to develop models for the variables.

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The study revealed that there is evidence of global warming in Owerri, and rainfall has significantly increased in Calabar over the years. Though the trends in rainfall at Owerri and Port-Harcourt were not significant, the slope estimates revealed a positive trend in the rainfall of the stations. Thus, it is concluded that water supply is sustainable under the current climate condition.

From the results of the analyses, the temperature at Owerri demonstrates a significantly increasing trend. Thus, it may be concluded that there is sufficient evidence of global warming in Owerri. The rainfall at Calabar also demonstrates a significantly increasing trend. Although the temperature trends at Calabar and Port-Harcourt are not significant, the positive values of slope estimates are indicative of a positive trend. The Sen Slope estimates of the rainfall trends in the three stations are positive and the plots of rainfall against year reveals an upward rise over the years (1983 – 2012).

Thus, it was concluded that since global warming is not having a significant negative effect on the rainfall of the selected cities, urban water supply is still sustainable under the present climate condition of the Niger Delta (Olufintoye and Sule, 2010).

III. Materials and Methods

Mean monthly and annual temperatures and rainfall from 30 synoptic stations between 1901-1938 and 1971-2012 in Nigeria were collected from the Nigerian Meteorological Agency, Lagos and Meteorological Department in some Airports. Although there are more than 30 meteorological stations in Nigeria, the study was limited to 30 stations because of consistency in available climatic data since the establishment of the stations.

Moreover the selected stations are true representative of the various climatic zones of Nigeria. The Two most important climatic elements (temperature and rainfall) were used in this study. These climatic elements were measured regularly in the stations used and these climatic elements best determine the prospects as well as the ecological and socio-economic problems of Nigeria. Data from different secondary sources were also used.

Eighty years period were covered in this research work. This is important because we were able to capture the period when climate change signals were not an issue (1901-1938) and when they are stronger (1971-2012). With 80 years, two climatic periods of 38 and 42 years can be studied and this will provide a better platform to investigate the changes within the climatic periods. The mean annual temperature data were used to construct the isothermal maps of Nigeria, while the rainfall data were used to construct the isohyets maps of Nigeria for the two climatic periods. With these maps, the analysis of the spatial pattern of rainfall and temperature with implication to climate change in Nigeria was carried out. The temporal climatic changes over the years were examined by employing the time series.

Also data from World Resources Institute via Climatic Analysis Indicator Tools (WRI-CAIT) were also employed to analysed recent and current Green House Gases with respect to Nigeria and the World at large.

IV. Results and Discussion

Climate change has started impacting and will continue to affect global temperatures, water resources, ecosystems, agriculture and health among others. Continued GHGs emission at or above the current rates would cause further warming and induce many changes in the global climate system during the 21st century that would very likely be larger than those observed during the 20th century. There had being variation in world temperature since 1860 when direct temperature measurement started as shown in Figure 5. The global temperatures were below average until the late 1930s when alternating cooling and warming started. This trend continued up to the 1980s when a renewed and pronounced warming continued till date. 1998 is recorded as the warmest individual year followed by 2002. Eleven of the last twelve years (1995-2006) rank among the twelve warmest years in the instrumental record of global temperatures since 1860. Between 1906 and 2005, the average global temperature increased by 0.74^{O}C (0.56 to 0.92) (IPCC, 2007).

In Nigeria, temperature has been on the increase. The increase between 1901 and 1938 was not much. The increase became so rapid since the early 1970s. The mean temperature between 1901 and 1938 was 26.04 ^{O}C while the mean between 1971 and 2012 was 27.84. This indicates a mean increase of 1.80 ^{O}C for the two climatic periods. This is significantly higher than the global increase of 0.74 ^{O}C since instrumental global temperature measurement started in 1860. Should this trend continue unabated, Nigeria may experience between the middle (2.5 ^{O}C) and high (4.5 ^{O}C) risk temperature increase by the year 2100.

The result is a clear indication that Nigeria is experiencing global warming at the rate higher than the global mean temperatures. The observed temporal increase is also evident in the spatial increase. Between 1901 and 1938, the southernmost part of the country was marked by 25.5 ^{O}C isotherms while the northernmost was 28.5 ^{O}C. With the global warming becoming more pronounced, the southernmost part was marked by approximately 27 ^{O}C isotherms and the north 30 ^{O}C. The study also noticed that the increase in temperature is more in the northern part of the country than in the southern part. The temporal rainfall pattern in Nigeria shows a declining trend. Between 1901 and

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1938, rainfall decrease was negligible but by 1971-2008 the decline became so pronounced. The mean rainfall value for the 1901-1938 was 1571 mm while a decreased was recorded at 1478 mm in 1971-2008. This shows a decrease of 93 mm between the two climatic periods.

The decreasing rainfall and increasing temperatures are basic features of global warming and climate change. Spatially, a declining trend is also noticed. In the 1901-1938 climatic periods, the 600 mm isohyets engulfed Nguru, but is was replaced by 496 mm during the 1971-2012 climatic period. Moreover, prior to 1938, the 1200 mm isohyets that was found close to Kaduna, has dropped to Minna axis. Odjugo (2005a; 2007b) also observe that the number of rain-days dropped by 53% in the north-eastern Nigeria and 15.5% in the Niger Delta coastal areas while rainfall intensity is increasing across the country.

Although there is a general decrease in rainfall amount in Nigeria, the coastal areas like Warri, Brass, Port-Harcourt, Calabar and Uyo among others have experienced slightly increasing rainfall in recent years. It is expected that the 2800 mm isohyets of the southernmost part of Nigeria in 1901-1938 be replaced by say 2700 or 2600 mm in 1971-1938, but a critical look at the scenario in Port Harcourt and Ikom that were within 2600 mm is now replaced by that of 2800 mm. Another major disruption in climatic patterns of Nigeria which shows evidence of climate change and global warming might be short-dry-season shift (popularly known as August Break). In the 1901-1938 climatic period, short-dry season was experienced more during the month of August but since the 1970s, it is being experienced more in the month of July. Another prominent change in rainfall pattern in Nigeria is that the areas experiencing double rainfall maximal is undergoing gradual shift in the short-dry-season (locally referred to as August Break) from the month of July-August.

The short-dry- season is a brief period of low rainfall (dry spell) that separates the two rainfall peaks. In 1901 – 1938, the short dry season occurred 31 years in the month of August and 7 years in July. By 1971 – 2012, the short dry season occurred 12 years in the month of August, 23 years in the month of July and 4 years for both months. This implies that the dry spell which used to occur in the month of August followed by heavy rains in the month of September (1901-1938) now shifted to July followed by wet period in the months of August and September (1971-2012).

V. Conclusion

The paper shows that climate change is caused by both anthropogenic and natural factors. What we are experiencing now is global warming caused by anthropogenic factor (human activities) and when the on-going warming continue unabated for decades or centuries with significant ecological impacts then, the earth will attain a changed climate (warm or hot climate). The human activities that cause global warming are transportation, industrialization, urbanization, agriculture, deforestation, water pollution and burning of fossil fuel among others. These either emit greenhouse gases into the atmosphere or reduce the rate of carbon sinks.

The implication is that global warming is being experienced with global temperatures rising by 0.74 ^{O}C since 1860 while that of Nigeria increased by 1.80 ^{O}C and rainfall decreased by 93 mm within the two climatic periods. The impacts of climate change are global but it will hit harder on developing countries because of their poor status and low mitigating and adaptive capacity. To reverse the impacts, appropriate measures are needed to reduce the rate of greenhouse gases emissions while adequate adaptation and mitigation strategies should be applied especially with respect to sustainable development policies and measures as applied in many developing countries like China (Motorization), Indian (Electrification), Brazil (Biofuel Production) and South Africa (Carbon Capture and Storage). To do this, efficient and effective energy supply based on solar, wind, geothermal, hydro and bio-energy should be encouraged. Fuel efficient vehicles especially with the European standard and aircrafts alongside mass transportation, light and sub-rail and non-motorised means of transport are needed. While deforestation should be reduced, afforestation and reforestation as well forest management should be encouraged.

Advanced countries like the U.S.A, Canada, United Kingdom and Japan etc., have been putting strategies like developing clean mechanism in place both to reduce the emission of GHGs and mitigate the effects of climate change but there is no evidence that Nigeria has started anything with respect to emission reduction and preparedness for mitigation measures (though adaptive strategies are in place which are not really implemented). We hope that the bill on climate change and the recommendation to establish climate change commission will have appropriate political backing to start GHGs emission cut and mitigation measures against climate change in Nigeria.

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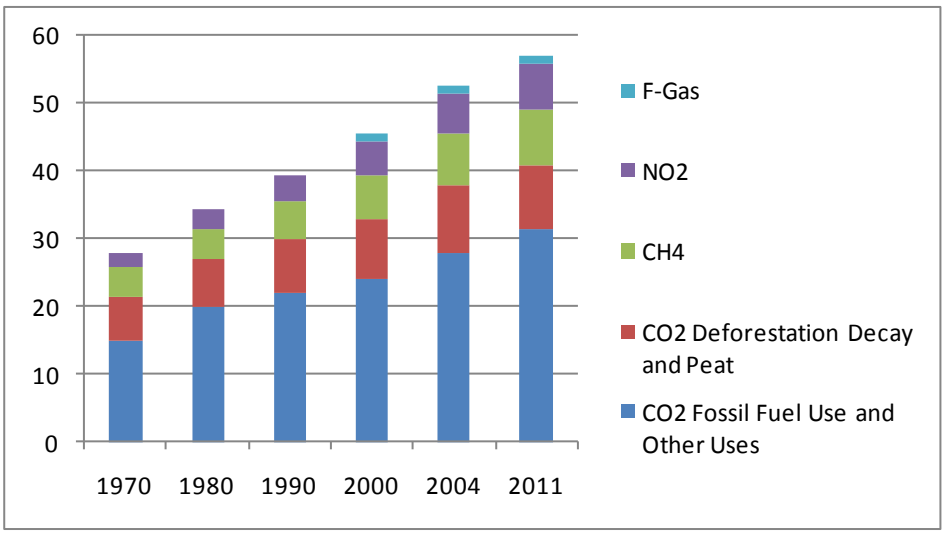
Table 1 : Share of different sectors in total anthropogenic GHGs emissions in 2011 in terms of MTCO_2-eq

	Nigeria	World	Percentage of Nigeria
Energy	158.50	33,338.44	0.48
Industrial Process	n/a	2,588.54	n/a
Agriculture	100.68	6,031.15	1.67
Waste	65.04	1,480.97	4.39
LUCF	171.63	2,074.70	8.27
Bunker	2.87	1,044.22	0.27

Source: World Resource Institute - CAITs 2014

Table 2 : Nigeria's Emission in relative to World global emission as at 2011

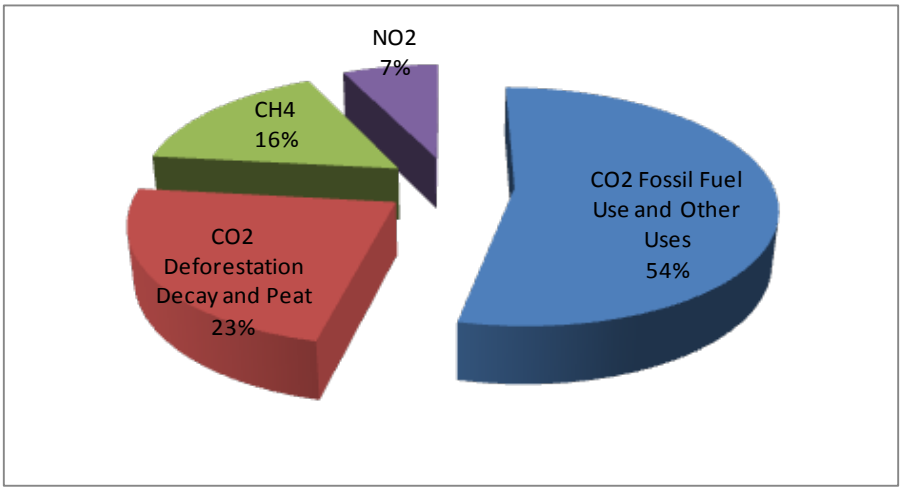
PARAMETRE	SECTOR/SUB SECTOR	NIGERIA MT CO_2-eq	WORLD MT CO_2-eq
Total CO_2	Total CO_2	183.92	32,127.54
Total GHGs	Excluding LUCF	324.51	43,645.77
	Including LUCF	496.13	45,720.46
GHGs by Gas	CO_2	83.93	32,127.84
	CH_4	205.52	7,245.63
	N_2O	34.52	3,550.22
	F-Gas	0.28	722.38
GHGs Emission by Sector	Energy	158.50	33,338.44
	Industrial Process	n/a	2,588.54
	Agriculture	100.68	6,031.15
	Waste	65.04	1,480.97
	LUCF	171.63	2,074.70
	Bunker	2.87	1,044.22
GHGs Emission by Sub-Sector	Heat/Electricity	18.11	14.542.27
	Manufacturing/Construction	4.32	6,489.75
	Transportation	23.58	5,850.32
	Other Fuel	53.16	3,958.37
	Fugitive Emission	57.33	2,523.00
CO_2 Emission by Sub-Sector	Heat/Electricity	18.11	14,542.27
	Manufacturing/Construction	4.32	6,489.75
	Transportation	23.58	5,850.32
	Other Fuel	53.16	3,212.58
	Fugitive Emission	31.07	224.86



Source: IPCC, 2007 and World Resource Institute - CAITs 2014

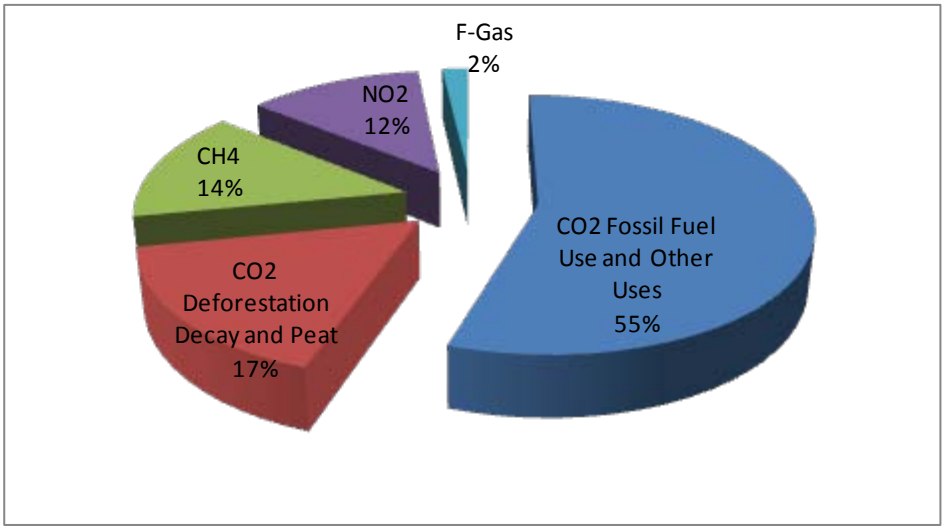
Figure 1 : Global annual emission of anthropogenic GHGs (1970-2011)

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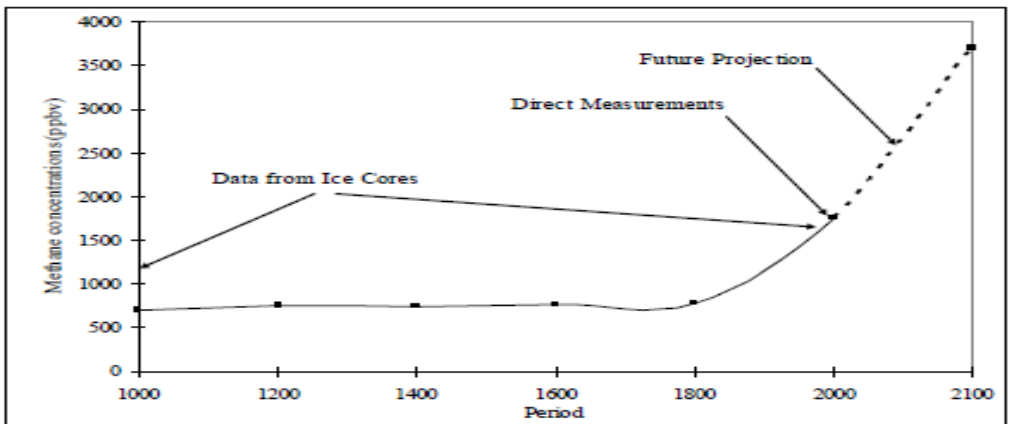
Source: IPCC, 2007

Figure 2 : Share of different anthropogenic GHGs in total emissions in 1970 in term of carbon dioxide equilvalent (CO_2-eq)



Source: World Resource Institute - CAITs 2014

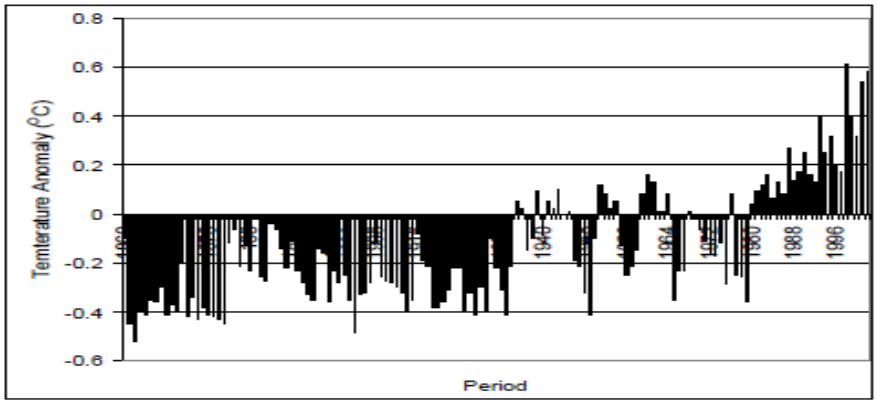
Figure 3 : Share of different anthropogenic GHGs in total emissions in 2011 in term of carbon dioxide equilvalent (CO_2-eq)



Source: Hengeveld et. al (2005)

Figure 4 : Trends in methane concentration over the past millennium and future projections

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Sources: (IPCC, 1996; Danjuma 2006)

Figure 5 : Observed world temperature changes between 1860 and 2005

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Oil Pollution and Water Quality in the Niger Delta: Implications for the Sustainability of the Mangrove Ecosystem

By Emuedo, O. A, Anoliefo, G. O & Emuedo, C. O
Rubber Research Institute of Nigeria, Iyanomo

Abstract- Water pollution from crude oil spills in the mangrove ecosystem was investigated employing water samples obtained from three different locations in the Niger Delta. Focused group discussions were held and comprehensive questionnaires were administered to the residents in the three communities where the water samples were collected. The results of the study showed that oil activities have led to poor water quality in the Niger Delta, negatively impacting on the mangrove ecosystem with extensive depletion of fish stock in the region. The authors recommend the adoption of best practices in the oil activities to minimise the harmful effects of oil operations in the Niger Delta.

GJHSS-B Classification : *FOR Code: 960305, 700401*



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Oil Pollution and Water Quality in the Niger Delta: Implications for the Sustainability of the Mangrove Ecosystem

Emuedo, O. A [α], Anoliefo, G. O [σ] & Emuedo, C. O [ρ]

Abstract- **Water pollution from crude oil spills in the mangrove ecosystem was investigated employing water samples obtained from three different locations in the Niger Delta. Focused group discussions were held and comprehensive questionnaires were administered to the residents in the three communities where the water samples were collected. The results of the study showed that oil activities have led to poor water quality in the Niger Delta, negatively impacting on the mangrove ecosystem with extensive depletion of fish stock in the region. The authors recommend the adoption of best practices in the oil activities to minimise the harmful effects of oil operations in the Niger Delta.**

I. Introduction

The Niger Delta as historically defined comprises the present Delta, Bayelsa and Rivers States in south-south Nigeria (Dike 1956; Willinks *et al.,* 1958; Akinyele 1998). The total area is 25,640 km^2; Low Land Area 7,400km^2, Fresh Water Swamp 11,700 km^2, Salt Water Swamp 5,400 km^2 and Sand Barrier Islands 1,140 km^2 (Ashton-Jones. 1998). The Niger Delta mangrove ecosystem is the largest in Africa and second largest in the world (Awosika, 1995). It is one of the world's most fragile ecosystems (NDES, 1997) and the area with the highest fresh water fish species in West Africa (Ogbe 2005).

Oil activities started in the Niger Delta in 1908. However, commercial oil production began at Oloibiri, Bayelsa State in 1956 but oil exportation started in 1958. Presently, oil accounts for over 80% of state revenues, 90% of foreign exchange earnings and 96% of export revenues (Ohiorhenan 1984; Ikelegbe 2005; UNSD, 2009). About 2.45 million barrels is produced daily that earns the country an estimated $60 billion annually (Ploch, 2011). Over 85% of oil is produced in the Niger Delta (SPDC, 2008) mostly from the mangrove ecosystem. However, oil activities impact adversely on the marine environment (Lee and Page, 1997; Snape *et al.,* 2001; Liu and Wirtz, 2005), with allied severe socio-economic effects (Ibeanu, 1997; Roberts, 1999, 2005; Omoweh, 2005). Oil extraction impacts on ecosystems in a variety of ways; impacts related to climate change, (Fischlin *et al.*, 2007) physical impacts (Swer and Singh, 2004), chemical impacts (Banks *et al.*, 1997) and biological impacts (Meyer *et al.*, 1999).

In the Niger Delta, this has been exacerbated by the oil companies' impunity of operations with no regard for the environment. As, such, oil operation have entailed recurrent oil spillages and massive gas flaring. The impunity of oil operations in the Niger Delta is exemplified by the fact that Shell operations in Nigeria that accounts for just 14% of its oil production worldwide, accounts for a staggering 40% of its oil spills worldwide (Gilbert, 2010). Oil spills records obtained from the Department of Petroleum Resources (DPR) showed that between 1976 and 2005, 3,121.909.80 barrels of oil was spilled into the Niger Delta environment in about 9,107 incidents. Independent researchers have however argued that the volume and incidents of oil spills are under reported (Green Peace, 1994; Banfield, 1998; Iyayi, 2004).

Three main mangrove species exists in Nigeria; R. Racemosa, R. mangle and Rhizophora harrisonni (Adegbehin, 1993). Two others of less abundance, Avincennia germinans and Laguncularia racemosa are also present. The mangrove is a highly productive biotope with a vigorous, rich and endemic wildlife, supporting a wide and varied group of mobile organisms ranging from birds that nest in the trees to fishes that feed and live among submerged prop roots (Odum *et al.,* 1982). Mangroves are the most sensitive of all coastal ecosystems (Hayes and Gundlach, 1979). Hydrocarbons are major threat to mangroves (Hanley, 1992; Kadam, 1992; Tarn and Wong, 1995), as high proportions of heavy metals are retained in mangroves sediment (Tarn and Wong, 1995). The mangrove forests and creeks constitute the main areas of oil exploration and exploitation activities in the Niger Delta.

II. Materials and Method

Water samples were collected for two years from three (3) swamp locations within the crude oil prospecting areas of the mangrove ecosystems two with high oil activities (Nembe and Okrika) and one devoid of oil activities (Okpare). The samples were collected, in January and July and analysed for their physical and

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chemical parameters. The samples for chemical analysis were collected in labelled sterilised plastic bottles, following APHA, 1998 (standard procedures) and transported in an ice chest to the laboratory. The samples for total hydrocarbon content (THC) analysis were placed in pre-labelled glass containers and sealed with aluminium foil. Temperature was recorded in situ using the mercury-in-glass thermometer, pH was determined using a pH meter, while dissolved oxygen (DO) and biochemical oxygen demand (BOD) were determined using the modified Winkler method and the 5 day BOD test respectively (APHA, 1998). Nitrate and salinity were determined using the Brucine and ascorbic acid methods respectively, while phosphate was determined using hand-held refractometer (APHA, 1998).

The questionnaire schedule was administered to respondents in the three communities where the sediment and water samples were collected. The questionnaires were administered to respondents (households) using the Cluster Survey method (Nachmaias and Nachmaias, 1996 and Riley, 1963), based on simple random sampling. The study population is the Niger Delta States (Bayelsa, Delta and Rivers), which account for over 75% of the crude oil production in Nigeria. The crude oil-exploration host communities in Niger Delta served as the sampling units, from which three were randomly selected for the study. The sample size is two hundred prorated based on 2007 population census (NPC, 2007) of the local government areas in which the communities are located. This sample size was considered adequate since they are rural communities. The sampled communities were; Nembe in Nembe local Government Area of Bayelsa State, Okpare in Ughelli North Local Government Area of Delta and Okrika in Okrika Local Government Area of Rivers State. Based on their population figures, the sample size for each community was as follows; Nembe 39, Okpare 95 and Okrika 66. The data obtained from water samples were subjected to an Analysis of Variance (ANOVA), while results from the sample survey were presented in simple statistics (pie charts).

III. Results

Table 1 : Mean values of the physicochemical parameters, and heavy metals concentrations in the water samples from the different locations observed.

Parameters	Nembe	Okrika	Okpare	Grand Mean
	Mean ± SD	Mean ± SD	Mean ± SD	
pH	5.03±0.13	5.23±0.10	5.60±0.14	5.29±0.29
Sal. (mg/l)	12.98±0.43	13.05±0.44	7.90±0.14	11.31±2.95
Temp (^{0}C)	29.63±1.52	29.88±1.36	29.93±0.10	29.81±0.16
Transparency (%)	85.75±0.96	81.50±0.58	84.00±0.82	83.85±2.14
THC(mg/l)	1741.5±22.78	1883.75±24.13	1844.50±10.66	1823.25±73.47
DO mg/l	5.38±0.22	5.75±0.39	6.07±0.15	5.73±0.35
BOD (mg/l)	6.83±0.05	7.20±0.08	7.63±0.19	7.22±0.40
PO_3^-(mg/l)	1.41±0.03	1.25±0.06	0.83±0.10	1.16±0.30
NO^-(mg/l)	0.35±0.01	0.45±0.01	0.38±0.10	0.39±0.05
Heavy metals (mg/l)				
Pb	1.77±0.16	1.84±0.07	1.83±0.10	1.81±0.04
Zn	2.88±0.13	1.78±0.16	2.49±0.09	2.38±0.56
Cr	1.87±0.07	1.74±0.03	1.62±0.09	1.74±0.13
Cd	1.77±0.04	1.86±0.13	1.70±0.04	1.78±0.08
Cu	1.91±0.07	2.65±0.13	1.61±0.09	2.05±0.54

The pH of water samples from the study was acidic with mean pH ranging from 5.07±0.05-5.43±0.04 in wet season and 5.00±0.00-5.20±0.14 in the dry season (Table 1). It was observed that there was no significant difference p≤ 0.05 between the values for wet and dry seasons. The presence of several metals; lead, zinc, chromium, cadmium and copper in high concentration was also, observed in the water samples. Their mean concentration was 1.77±0.11 mg/l, 2.59±0.19mg/l, 1.74±0.17mg/l, 1.76±0.18mg/l and 1.76±0.18mg/l respectively (wet season) and 1.86±0.1mg/l, 2.75±0.19mg/l, 1.78±0.14mg/l, 1.82±0.16mg/l and 1.82±0.16mg/l respectively (dry season). There was no significant difference (p≤ 0.05) in the concentrations of the heavy metals across the three study sites.

IV. Survey Results

Results obtained from the structure questionnaire administered to respondents in the various study communities shows that about 77% of the respondents were of the view that mangrove wood has become scarce, while 7% said there was no scarcity of mangrove wood (Fig.1).

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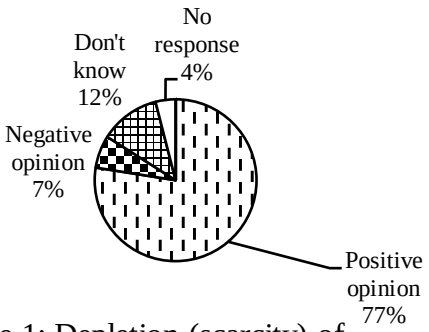


Figure 1: Depletion (scarcity) of mangrove wood

Figure 1

Also, respondents' response to impact of crude oil on fish catch in the shows that about 75% of the respondents held the view that there was decrease in fish catch, while 8% claimed fish catch had actually increased in the region (Fig. 2).

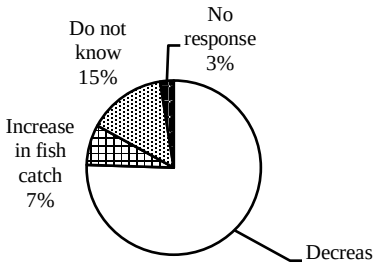


Figure 2: Impact of crude oil on fish catch

Figure 2

V. Discussion

The water quality in an aquatic environment is very important for the survival of its flora and fauna. This is usually assessed by the pH and the heavy metal concentration in the water, which are key parameters in many ecological studies. A strong relationship exists between pH and the physiology of most aquatic organisms (Kinne, 1970). Thus, the range of pH in an environment is used to detect the impacts of pollution (RPI, 1985). The pH of the water samples in this study was acidic ranging from 5.03 in Nembe to 5.6 at Okpare with a mean of 5.29±0.29 (Table 1). The low pH observed in the water samples would seem to indicate the unhealthy nature of water in the Niger Delta region. The pH of the study, when compared to a base study report RPI (1985): 7.50-7.80; and Dublin-Green (1990): 6.90-7.60, seems to show that water quality deteriorated over the years in the Niger Delta. Water quality, as several studies have shown, has impacts on species composition, assemblages and distribution of plankton (Boney, 1983), benthos (Dance and Hynes, 1980; Jones, 1987; Hart and Zabbey, 2005) and fish (Boney, 1983; Kutty, 1987). The pH values obtained in this study are outside the 6.00 to 9.00 range, which were suggested for optimal fish production (Boyd and Lichtkoppler, 1979; Cup, 1986; Onuoha and Nwadukwe, 1987).

Several heavy metals; chromium, zinc, copper, cadmium and lead detected in the water samples (Table 1) had levels higher than the prescribed limits by WHO/FAO (1976). The high concentration of heavy metals coupled with the low pH observed, are indicative of high levels of pollution of the Niger Delta environment. Several studies have associated the high pollution levels to oil spills from oil-related activities in the region (Kinigoma, 2001; Amusan and Adeniyi, 2005; Wogu, and Okaka 2011). Pollution from crude oil especially light crude, besides giving rise to poor water quality is a major threat to mangroves (Hanley, 1992; Kadam, 1992; Tarn and Wong, 1995). Nigeria produces mainly light crude and this has been shown to impacts more adversely on mangroves (Proffitt *et al.,* 1997; Duke *et al.,* 2000) than heavy crude. This is because mangroves sediment retains oil as it behaves like a sink; leading to persistence of oil on or inside the sediments (Maia-Santos *et al.,* 2012). Thus, mangrove sediment retains high proportion of heavy metals (Tarn and Wong, 1995). This acutely impacts mangroves (Garrity *et al.,* 1994) and disrupts the structure of mangroves habitat (Nadeau and Berquist, 1977; Jackson *et al.,* 1989; Duke *et al.,* 1997). The effects of oil pollution are long lasting (Corredor *et al.,* 1990; Teal *et al.,* 1985; Burns *et al.,* 1993, 1994) up to 50 years (Ekekwe, 1981; Duke and Burns, 1999; Brito *et al.,* 2009). Several studies have reported negative impacts of oil pollution on Mangroves. Duke *et al.* (1993) reported that oil pollution impairs the growth of mangrove seedlings, while Emuedo and Anoliefo, (2008) reported that oil impairs root growth in mangroves, leading to eventual death. Crude oil impact has both acute and chronic effects on mangroves (Jackson *et al.,* 1989; Grant *et al.,* 1993; Böer, 1993; Burns *et al.,* 1993; Dodge *et al.,* 1995; Wardrop *et al.,* 1996). Even when oil exposure does not out-rightly kill mangrove, it severely weakens mangroves to a point where they succumb to natural stresses that they would ordinarily have survived (Snedaker *et al.,* 1997). In addition, when trees are impacted upon by oil, there is the loss of benefits previously derived from the trees; such as nursery for fish species and prawns (Cappo, 1995a, b) or in the prevention of shoreline erosion (Furukawa and Wolanski, 1996; Duke *et al.,* 1997).

All these have had grave implications on sustainability of the mangrove ecosystem in the Niger Delta. The mangroves ecosystem provides the major sources of economic activities and food for oil-host communities in the Niger Delta. Crabs, Oysters, Cockles and Periwinkles are easily gathered around the roots of mangroves (Ejituwu, 2003). However, oil pollution

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coupled with the poor water quality has led to the heavy loss of mangroves in the region. This has also been further exacerbated by negative effects of other oil-related activities such as dredging of channels and canals that have led to physical felling and or death of trees (Ohimain *et al.,* 2008). Okonta and Douglas (2001) also reported that by 1999 Shell had cut over 24,000 miles of seismic lines through mangrove forests. These have resulted in huge reduction of mangroves in the Niger Delta. Indeed, a study FAO, (2005) reported that mangroves in the Niger Delta have the most rapid rate of depletion in the world. During the focus group discussions, most participants complained about mangrove wood scarcity. This view was also expressed by about 77% of the respondents of the sampled survey (Fig.1). The loss of mangroves has implication for sustainability in the region. Studies show that mangrove loss in the Niger Delta has reduced the uses to which the wood is put and the cost prohibitive (Wilcox and Powell, 1985; Bassey, 1999; Raji *et al,* 2000).

Also, the mangrove ecosystem is the basic nursery for aquatic species, especially fish (Rutzler and Feller, 1987). The Niger Delta mangroves provide breeding grounds for numerous species of fin fish, prawns, and as habitat for crabs and molluscs (IPIECA, 1993). It would seem that huge loss of mangroves coupled with the poor water quality has led to reduction in fish stocks. This has correspondingly reduced fish catches significantly in the region. This is shown in the result of the sample survey (Fig.2) where about 75% of the respondents opined that fish catches have reduced in the Niger Delta. In addition, this has resulted in the virtual extinction of some fauna in the region. Omoweh (1998) reported the virtual extinction of cat fish, manatee or sea cow, electric fish, hippopotamus and shark in the Niger Delta. Emuedo (2010) reported that iguana (Ogborigbo), edible frog (Okhere), and small red cray fish (Iku-ewhewhe) have also become virtual extinct in the region. Furthermore, poor water quality has also led to the bio-accumulation of heavy metals by common fish species found in the region; Tympanotonus fuscatus var radula (periwinkle) (Davies *et al.,* 2006), Bonga Shad (Ethmalosa fimbriata) (Etesin and Nsikak, 2007), Synodontis clarias (catfish) Agbozu, *et al.,* 2007), Shrimp (Macrobrachium felicinum) (Opuene, and Agbozu, 2008), Tilapia (Tilapia nicolitica) (Godwin *et al.,* 2011).

VI. Conclusion

The quality of water in an aquatic environment is very important for the survival of its flora and fauna. Water quality also has a role to play in the overall health of an environment. This study showed very low pH levels as well as levels of heavy metal much higher than the WHO prescribed limits; indicating the unhealthy state of the Niger Delta environment. The incessant oil spills in the region have led to chronic pollution of the environment with much negative impacts on the mangrove ecosystem. As shown by the study, this has resulted in mangrove forests depletion, with severe consequences; scarcity of mangrove wood, reduction in fish stocks. As Sullivan *et al.* (2008) has asserted "for 75% of rural poor (as in the Niger Delta), across the world, access to good water makes the difference between life and death". The study has thus shown that oil activities have adversely affected water quality in the mangrove ecosystem with overall negative effects on the sustainability in the Niger Delta environment. The government and the multinational oil corporations are therefore advised to carry out proper cleanup of all subsequent oil spills and embark on a remediation of the water bodies in the region.

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Assessment of Land use and Land Cover Change in Kwale, Ndokwa-East Local Government Area, Delta State, Nigeria

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Abstract- The study examines land use and land cover change in Kwale Ndokwa-East Local Government area Delta State, Nigeria between 1975 and 2008 using GIS and remote sensing technique. The satellite data that were employed included LandSat (MSS) 1975, LandSat (TM) 1987, LandSat (ETM+) 2001, downloaded from Global Landcover Resources Website (http:www.glcf.com), while images from NigSat1 2008 were obtained from the National Centre for Remote Sensing, Jos, Plateau state, Nigeria. The software used for the processing and analysis for this study includes ARCGIS 9, ERDAS 8.1 and ILWIS 3.2a. Results of the study revealed that on the average, between 1975 and 2008, bare surfaces decreased to by 93.51%: forest vegetation by 30.98%: settlement by 25.61% and woodlands by 37.19. Marshlands, cultivated lands;, shrublands and water bodies increased respectively by 54.45%, 24.42%;, 3.21% and 319.91%. This showed that bare surfaces, forest vegetation, settlements and woodlands were gradually being replaced by marshlands, cultivated lands, shrublands as well as water bodies. Settlements were found to be aggregating within specific geographic regions, over time. It is therefore recommended that concerted efforts be made to reclaim the areas occupied by bare surface and marshlands into arable agricultural lands. And finally, further efforts should be devoted towards reducing gas flaring, increasing afforestation strategies while discouraging lumbering, oil spillage as well as gas flaring within the region.

Keywords: *land use, change, remote sensing, GIS, kwale, nigeria.*

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Assessment of Land use and Land Cover Change in Kwale, Ndokwa-East Local Government Area, Delta State, Nigeria

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Abstract- The study examines land use and land cover change in Kwale Ndokwa-East Local Government area Delta State, Nigeria between 1975 and 2008 using GIS and remote sensing technique. The satellite data that were employed included LandSat (MSS) 1975, LandSat (TM) 1987, LandSat (ETM+) 2001, downloaded from Global Landcover Resources Website (http:www.glcf.com), while images from NigSat1 2008 were obtained from the National Centre for Remote Sensing, Jos, Plateau state, Nigeria. The software used for the processing and analysis for this study includes ARCGIS 9, ERDAS 8.1 and ILWIS 3.2a. Results of the study revealed that on the average, between 1975 and 2008, bare surfaces decreased to by 93.51%: forest vegetation by 30.98%: settlement by 25.61% and woodlands by 37.19. Marshlands, cultivated lands;, shrublands and water bodies increased respectively by 54.45%, 24.42%;, 3.21% and 319.91%. This showed that bare surfaces, forest vegetation, settlements and woodlands were gradually being replaced by marshlands, cultivated lands, shrublands as well as water bodies. Settlements were found to be aggregating within specific geographic regions, over time. It is therefore recommended that concerted efforts be made to reclaim the areas occupied by bare surface and marshlands into arable agricultural lands. And finally, further efforts should be devoted towards reducing gas flaring, increasing afforestation strategies while discouraging lumbering, oil spillage as well as gas flaring within the region.

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I. Introduction

Kwale falls within the Niger Delta region of Nigeria. The area is located within latitudes $5^{o}40^{1}$N and $5^{o}50^{1}$N and longitudes $6^{o}15^{1}$E and $6^{o}30^{1}$E (Figure 1a, b) (Anonymous, 2011 and Avbovbo and Ogbe, 1978). 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 is within Ndokwa East Local Government Area and is situated within the Sombriero Warri deltaic plain deposit invaded by mangroves. 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 (Keddy, 2010; Ibe, 1988; Merki, 1972 and Murat, 1972). Okpai/Aboh region is a low-lying area with elevation of not more than 3.0 metres 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 is about 2,500mm. The mean monthly temperature range from 24-25°C during the rainy season in August to 27-29°C during the 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 moderated by cloud cover and damp air. It experiences a humid tropical equatorial 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 distributaries and creeks. This area has been classified geomorphologically as tidal flat and large flood plains lying between mean, low and high tides. Three different highs exist within the Kwale, in Ndokwa-East Local Government 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.

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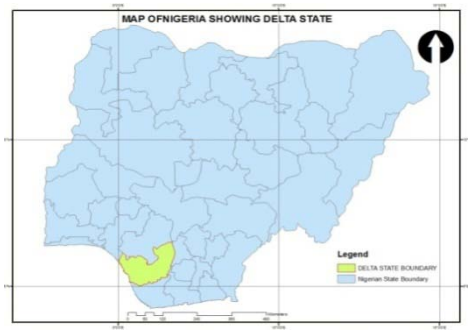


Figure 1a : Nigeria showing Delta State



Source: Delta State Ministry of Lands and Survey (2009)

Figure 1b : Delta State showing Ndokwa East LGA

The coastal areas of the Niger Delta are the home to oil exploration and exploitations in Nigeria (Nwilo and Badejo, 1995). 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. The report also rated, Nigeria as the fifth largest supplier of crude oil to the United States (EIA, 2003). Nigeria's proven oil reserves drives the economy because it is almost exclusively dependent on earnings from the oil sector, which generates about 20% of GDP, 95% of foreign exchange and about 65% of budgeting revenues (CIA World fact Book, 2008). No doubt, human activities like oil exploration and production have impacted negatively on the delicate balance of nature and the fragile ecosystems of the study area.

Land use and land cover have become very important parameters in highlighting such environmental changes that have taken place over time within the earth's surface (Matiko *et al,* 2012). It has become one of the major parameters for environmental change monitoring and natural resource management (Zhang *et al*, 2008). Thus, Fuchs (1996) aptly stated that land use and land cover and impacts on terrestrial ecosystems including forestry, agriculture, and biodiversity have been identified as high priority issues at global, national, and regional levels. The indirect impact of land-use and land cover is altering climate on the waters (Weng, 2001) while the direct effect could be compromising water quality (Rogers, 1994). Kwale region is not alone with respect to deterioration of its landscape. Woodgate and Black (1988) reported that an estimated 66% of Victoria's native vegetation has been cleared as a result of the growth and economic development of the State.

According to Dami *et al* (2011) the environmental impacts of land use change are usually distinguished according to their spatial level i.e. global, regional and local. As regards global environmental impacts of land use and cover change, land use and cover are relatively new additions to the core concerns of global environmental change research (Meyer and Turner, 1996 Yemefack, 2005). Land use/cover change impacts are basic to environmental changes as the local changes cumulatively affect the whole globe. Large-scale environmental phenomena like land degradation, desertification, biodiversity loss, habitat destruction and species transfer happen at local scales but they cumulatively manifest as regional and global changes. Landuse changes cause a multitude of environmental impacts at the lower spatial levels of urban, suburban, rural and open space areas, which have been extensively documented (Salami and Balogun, 2006, Odeyemi, 1999; Yuliang et al, 2004, Turner and Meyer 1994, Turner et al 1995, LUC 1988, 1999). The impacts include changes in the hydrological balance of the area, increase in the risk of floods and landslides, air and water pollution.

Geographic Information Systems (GIS) Global Positioning System (GPS) and Remote Sensing (RS) have become indispensable tools in almost all environmental endeavors (UN, 1986). These concepts have been employed in various studies including atmospheric studies (Fagbeja, 2008), lithospheric (Maruo *et al,* 2002), hydrologic (Nwilo and Badejo, 1995) biodiversity (Salami and Balogun, 2006), assessment of developmental change over time (Twumasi and Merem, 2006), land use and land cover categories (Ehlers *et al.,* 1990; Treitz *et al.,* 1992) as well as ground water (Maruo *et al*, 2002). Kwale region's landscape had undergone environmental changes over a long period of time as a result of oil exploitation in the area. This environmental change, therefore, has necessitated the need to carry out a holistic approach to land use and land cover inventory of the area with a focus of establishing the geospatial infrastructure for policy makers as well as for proper planning and management of the environmental conditions of the region.

II. Methodology

The types of data acquired for this study are shown in Table 1. They were sourced from ***global Land cover resources website (http:www.glcf.com),*** while the image from the Nigsat1 2008 was obtained from the National Centre for Remote Sensing, Jos, Plateau State, Nigeria.

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Table 1 : Satellite imageries and its characteristics

S/No	Satellite imagery	Year	Resolution
1	Landsat MSS	1975	60m
2	Landsat TM	1987	28.5m
3	Landsat_ETM	2001	28.5m
4	Nigsat 1	2008	28.5m

III. Data Extraction Process

Following the acquisition of the required satellite images from their respective sources for the aforementioned years, the extraction of the study area portion from the entire image covering the entire South Western /South Southern corner of the country was done using ArcGIS. The georeferencing of the satellite data as well as the subset operation using ILWIS 3.3 Academy software was performed.

IV. Digital Image Processing and Analysis

The stage of analysis include a reconnaissance field survey (ground truthing) with GPS to obtain coordinates of each location; the 1975 topographic sheet (1: 25,000) covering the entire region was used to aid in identifying notable spatial features of the area. This process proved very useful in unraveling, demystifying and harmonizing the disparity between what was observed on ground and their respective spectral signatures displayed in the images. In this regard however, it was observed that both bare surfaces and settlements exhibited somewhat similar spectral characteristics as both randomly did have a mix of cyan and white color, which are the standard color representations for both settlements and bare surfaces.

The procedure developed for the sample dataset of the submap was carried out based on the supervised classification techniques using the eight (8) land use/cover classes (features) of the area as indicated in Table 2.

Table 2 : Codes and Class of Land uses Recognized in the Study Area

Code	Class
1.	Bare Surface
2.	Forest Vegetation
3.	Marshland
4.	Cultivated land
5.	Settlement
6.	Shrubland
7.	Water Body
8.	Woodland

Sources : Adapted from Dami (2003)

Furthermore, the maximum likelihood method of classification (MLC) in the ILWIS 3.3 Academic software was adopted for the classification. The maximum likelihood method is a statistical decision rule that examines the probability function of a pixel for each of the classes, and assigns the pixel to the class with the highest probability. The classifier assumes that the training statistics (sample sets) for each class have a normal or 'Gaussian' distribution. The classifier then uses the training statistics to compute a probability of whether of a pixel belonging a particular land cover. This allows for within-class spectral variance. MLC usually provides the highest classification accuracies. Accordingly, it has a high computational requirement because of the large number of calculations needed to classify each pixel (Natural Resources Canada, 2005).

Three softwares were used to analyse the spatial data. ARCGIS was used for curve fitting processing while ERDAS Imagine was used for land use land cover classification, evaluating the quality of input data and ensuring that thematic maps were accurately classified. Finally, ILWIS (Integrated Land and Water Information System) was very useful in combining raster (image analysis), vectors and thematic data operations in one comprehensive phase.

V. Results and Discussion

Table 3 shows that bare surfaces rose astronomically from 35,395 km^2 in 1975 to 154,630 km^2 in 1987 representing an area change of 119,235 km^2 (336.87%). This could be due to the establishment of the Agip Gas Plant. which started operation within the area in 1975 (NAOC, 2007). Oil exploration and production activities abound in the region (Oboli, 1978). From 1975 to 1987 oil exploration and exploitation activities were at their peak. Close observation reveals that areas covered by thick oil sleeks after oil spillage, do become bare with time (Fabiyi, 2008). This could be responsible for huge leap of bare surfaces from the 1975 and 1987. In 2001, there was a significant decrease in land area to 61,374 km^2, accounting for 25,979 km^2 (73.40%) area change. By 2008, there was a further significant decrease to 2,296 km representing -33,099 km^2 (-93.51%) area change. This gross reduction from the 1987 estimates to those of the 2001 and 2008 could be as a result of the frantic efforts of prospecting oil and gas companies at carrying out environmental remediation and mitigation mainly through phytoremediation within the study area. This showed that bare surfaces are losing their space to marshlands, cultivated lands shrub lands and water bodies (Figure 2).

The area had a forest reserve that was recognized by the Federal Government of Nigeria as far back as 1975 (Mensah and Amukali, 2000; Ekine and Iyabe, 2009). Also, the Green Revolution of 1978 and restrictions to entrance to the forested area of the region

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must have encouraged the growth of plants, thus the high areal coverage of forest vegetation (45,363 km^2). While the bare surface increased significantly, forest vegetation decreased from 45, 363 km2 to 10,910 km^2 in 1987 accounting for -34,453 km^2 (-75.95%) area change. The gross reduction could be due to the massive oil exploration and exploitation activities which went on without much regard to environmental consideration in the region. By 2001, forest cover increased to 46,873 km^2 representing an area change of 1,510 km^2 (3.33%) increase. Unfortunately, forest cover decreased to 31,309 km^2 representing an area change of -14,054 km^2 (-30.98) in 2008.

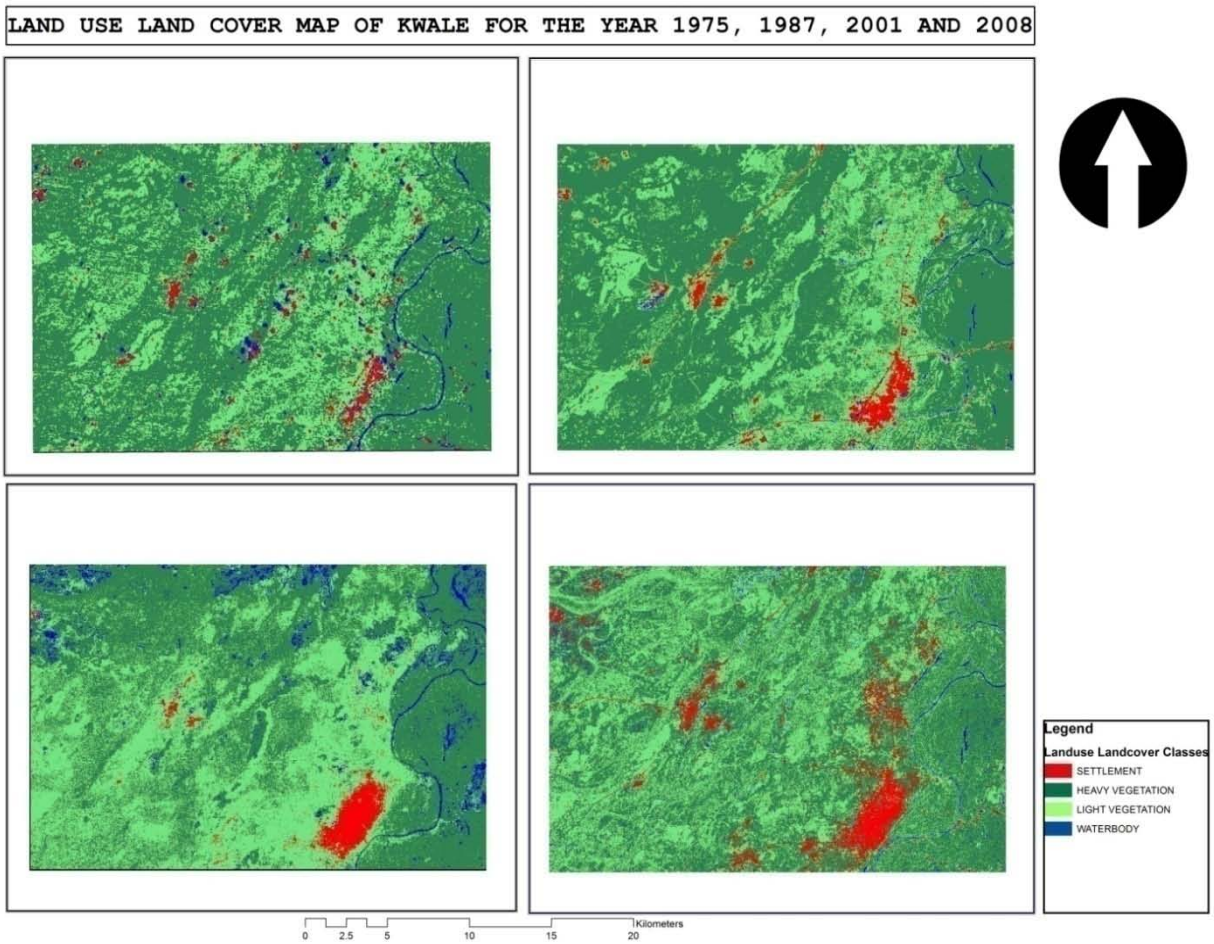


Figure 2 : Land Use Land Cover Map for 1975, 1987, 2001 and 2008

This trend depicts a scenario where there is inconsistency in the nature and type of human activities going on in this part of the region. Thus, the 1987 estimate could be attributed to increased human and economic activities within the area partly owing to a general relaxation of the restrictions on the Forest Reserve which lost its status and the huge presence and activities of prospecting and production oil companies in the area. The global agitation for more environmentally-friendly practices and subsequently the various mitigative tendencies of oil companies must have influenced the trend in 2001 while the further reduction in forest vegetation in 2008 could be due to increased exploration and exploitation activities of the area.

Marshlands increased from 125,431 km^2 in 1975 to 197,752 km^2 representing an area change of 72,321 km^2 (57.66%) in 1987 but decreased to 154,105 km^2 in 2001 representing an area change of 28,674 km^2 (22.86%) and increased to 193,725 km^2 representing area change of 68,294 km^2 (54.45%) in 2008. Field observations revealed that the study area is exposed to massive deposition of organic agents like silt, clay, debris and a host of other decomposable materials as supported by (GGFRI, 2009 and Allen, 1972). Thus, the increase in marshlands area prior to 1987, but when oil related activities increased within this area, after the 1980's, easy formation, transportation and deposition of marshlands became affected and this could be

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Table 3 : Main Land Use/Land Cover in Kwale 1975, 1987, 2001 and 2008

Main Landuse/ Cover Class	1975	1987	2001	2008
Bare Surface (km²)	35,395	154,630	61,374	2,296
Forest Vegetation (km²)	45,363	10,910	46,873	31,309
Marshland (km²)	125,431	197,752	154,105	193,725
Scattered Cultivation(km²)	62,374	61,916	88,156	139,977
Settlement (km²)	22,074	17,437	13,375	16,420
Shrubland (km²)	196,724	79,998	267,613	203,046
Water Body (km²)	9,776	13,215	4,556	41,050
Woodland (km²)	355,979	317,258	217,064	225,293

responsible for the decrease in marshlands noticed in 2001 while the further increase in the 2008 value could be attributed to factors like lumbering and farming as well as those factors that earlier favored increases. Mensah and Amukali (2000) described the rural communities in the area as rural subsistence farmers. In 1975, scattered cultivated areas were estimated at 62,374 km² which slightly decreased to 61,916 km² representing area change of -458 km² (-0.73%) in 1987. In 2001, there was a massive increase to 88,156 km² representing area change of 25,782 km² (41.34%) and this continued till 2008 where an increase of 139,977 km² representing area change of 77,603 km² (124.42%) occurred.. The slight decline of scattered cultivated areas from 1975 to 1987 must have been influenced by farmers giving up farming to taken in juicy jobs in the oil industry. Settlement areas decreased from 22,074 km² in 1975 to 17,437 km² representing area change of -4,637 km² (-21.01%) in 1987 and later to 13,375 km² representing area change of -8,699 km² (-39.41%) in 2001. However, by 2008 the areas covered by settlements were shown to be 16,420 km² representing area change of -5,654 km² (25.61%), respectively. As shown from the interpreted satellite images (Figure 2), settlements were initially seen to be scattered but in 2008, the settlements became more concentrated within specific geographical regions. This trend could be explained by the recent resettlement of some communities within the study area to pave way for more oil exploration and exploitation. Shrub lands decreased from 196,724 km² in 1975 to 79,998 km² representing area change of -116,726 km² (-59.34%) in 1987. This later increased to 267,613 km² representing area change of 70,889 km² (36.04%) in 2001 but decreased 203,046 km² in 2008 representing area change of 6,322 km² (3.21%). Afforestation efforts or seasonal regeneration of plants during the 1990's as at the time the images were captured must have been responsible for the increase noticed from 1987 to 2001. It could also be due to decreased activities of oil prospecting and production companies within the area owing to the activities of militants, increased agricultural cultivation and spread of settlement areas must have contributed to the initial increase in shrub lands but later unavoidable reduction in shrub lands in the area. This scenario depicts high amount of human and economic activities within the area after 1975. But, since most shrubs are seasonal plants that grow massively during rainy seasons, it could be deduced that the time the images were taken could have influenced the results, hence the huge jump from the 1975 to that of 1987 and later from 2001 to 2008 respectively. Water bodies area were calculated to be 9,776 km² in 1975 and increased to 13,215 km² representing area change of 3,439 km² (35.18%) in 1987 but dwindled to 4,556 km² representing area change of -5,220 km² (-53.40%) in 2001. In 2008, water bodies increased to an estimated area of 41,050 km² representing area change of 31,274 km² (319.91%). Seasonality must have influenced the trend as observed in the study.

Massive accumulation of marshlands, drastic reduction in the number of forest vegetation, shrub lands and woodlands all expose surface water bodies to the direct influences of the vagaries of weather, thereby contributing to increased evaporation. Thus, water-holding capacities of soils decrease, making them lose same to ground, surface and atmospheric sources. Woodlands reduced from 355,979 km² in 1975 to 317,258 km²m in 1987 representing area change of -38,721 km² (-10.88%) and to 217,064 km² representing area change of -138,915 km² (-39.02) in 2001. Finally, in 2008, the area covered by woodlands as shown in Table 3 was 225,293 km² representing area change of -130,686 km² (-36.71). Increased lumbering activities in this part of the country, must have contributed to decreased woodland from 1975 to 1987 and 2001 while afforestation efforts as part of environmental remediation must have contributed to the increase in 2008.

VI. Conclusion

The delicate balance of nature and fragile ecosystem of the Kwale in Ndokwa-East Local Government area has been altered by natural and human factors over time. This study was able to model

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the long term land use and land cover changes between 1975 when the area was still free of exploration and exploitation activities to 2008 when oil-related activities reached their peak and provide analysis of LUCC information in the area which helped in showing significant trends. The results of this study showed that between 1975 and 2008, bare surfaces decreased by 33,099 km^2 representing 93.51%, forest vegetation to 14,054 km^2 amounting to 30.98%, settlement to 5,654 km^2 which is equivalent to 25.61% and woodlands 133,377 km^2 representing 37.19%. Furthermore, scattered cultivation, scrublands and water bodies correspondingly increased by 68,294 km^2 (54.45%), 77,603 km^2 (124.42%), 6,322 km^2 (3.21) and 31,274 km^2 (319.91%), respectively. This indicate that bare surfaces, forest vegetation, settlements and woodlands were gradually being replaced by marshlands, scattered cultivation, shrublands as well as water bodies. This study therefore, recommends the reclaiming of the areas occupied by bare surfaces and marshlands to agricultural activities to reduce poverty and improved food security in the region.

VII. Acknowledgement

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Shoreline Change Detection in the Niger Delta: A Case Study of Ibeno Shoreline in Akwa Ibom State, Nigeria

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Abstract- This research presents remote sensing and Geographic Information System (GIS) based application in the analysis of Shoreline change in Ibeno L. G. Area, Akwa Ibom State. Satellite imageries of 1986, 2006 and 2008 were used to extract the shoreline through heads-up digitization. The rate of shoreline change was assessed using Linear Regression (LRR) and End Point Rate (EPR) methods. The shoreline change detection was conducted using the Digital Shoreline Analysis System (DSAS). The result however indicated that the rate of erosion is found out to be very high with maximum value of -7.8m/yr recorded at Itak Abasi community. On the other hand, some portions of the shoreline are accreting at an average rate of 2m/yr. Based on this result however, it is concluded that Ibeno shoreline is eroding at an average rate of -3.9m/yr. Areas mostly affected by accretion processes are identified near Qua Iboe River Estuary and ExxonMobil Jetty where sand filling is usually done for settlement purposes. This best explains the reason for the submersion of school buildings, residential buildings and the persistent inundation of large portions of land in the area. However, acquisition of high resolution satellite images which is believed will facilitate regular assessment, monitoring and modeling of the Nigerian shorelines has been recommended. This will help to model the scenario and proffer proactive measures towards curbing the menace by ensuring effective environmental management practices, timely emergency responses, and salvage the immediate physical environment.

Keywords: *shoreline, geographic information system, environmental management, change detection, erosion and accretion.*

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I. Introduction

Michalis, et al (2008) described shoreline as the line of contact between the land and a body of water. Shoreline is always very uncertain due to the fact that water level is always in a state of flux, constantly changing and very unstable. Changes in the shoreline occur due to actions of natural forces like wind, tides, waves, and the ocean currents etc thus, giving way to backward movement of sand towards the ocean and loss of land mass. These forces act everyday on the shorelines in the same and opposite directions which to some extent cause great changes in their shapes and leading to erosion or accretion (Fletcher et al, 2003). Erosion is the wearing down of the top surface, while accretion has to do with the building up of the loose materials at a place.

Owing to the persistent land use activities – intensive farming, uncontrolled construction and housing development in these areas, the resulting erosion or accretion is consequently accelerated. The rate at which erosion or accretion occurs depends solely on the interplay of the physical and the anthropogenic factors. The physical factors in this case include but not limited to the geological factors like the rock types, amount of sediment supply, changes in the earth's crust within the coastal region under consideration, amount and rate of coastal region sediment transport from lakes and rivers, water table position in coastal slopes, structural protection in rocks or sediments, onshore and offshore coastal topography. More so, depending on the geographical location of the affected area, some climatic factors, including winds, waves, changes in water level, and intensity/frequency of storms and tides, frequency and amount of rainfall play significant roles in the process. On the other hand, the anthropogenic factors equally contribute to erosion or accretion processes in the coastal regions. These are manifested in man-made structures like drainage control networks and other modifications intended to protect the coastal areas.

Occasionally, coastal erosion processes could be very expansive and devastating to invaluable properties, human lives and even the natural environment. Globally, this has generated much concern; interests with regard to the scourge are also on the increase in academic discourse. However, the coastline of Akwa Ibom State with particular reference to Ibeno Local Government Area is not an exemption. The natural action of winds and waves, together with the anthropogenic forces resulting from the continued desire for natural resources exploitation are constantly at work in this region. Although human actions may sometimes yield positive results, they cannot be completely exempted from facilitating and accelerating the extent of damage to the natural landscape. Upon the resulting effect/changes on the natural landscape of the Area however, there is a complete knowledge lag on the shoreline dynamics in Ibeno L. G. Area. The situation

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can therefore not facilitate any management practices in the event of an emergency or encourage any form of predictions. In the best circumstances, there is need for effective coastal management with a view to ensuring a safer environment for growth and development of the human society.

Since coastal areas are regions of high economic value, the prediction of shoreline positions depends solely on having a clear understanding of the shoreline parameters. Based on this argument therefore, an appreciable knowledge of the shoreline characteristics is of utmost importance and timely. This has become very essential and necessary to make informed decisions towards effective coastal management. If such parameters are put in place, it is believed that any information relative to shoreline characteristics will be readily accessible at any point in time. In the light of the foregoing, taking into consideration the high economic potentials of the area, this study seeks to extract Ibeno shoreline from the satellite imagery, determine the rate of shoreline change as well as the net shoreline movement in the area.

With the possibilities offered in the advent of Geographic Information Systems (GIS), image processing techniques, and quantitative analysis, to a reasonable degree of accuracy, any change(s) in shoreline due to erosion and/or accretion become(s) practically possible. In the context of this study, GIS mapping and change detection techniques prove quite useful (Srivastava, 2005). With regard to the methods of extracting shorelines, a number of methods are available for use. For instance Efe and Tagil (2001) made use of the on-screen digitization method due to its accuracy over the digitizing tablet. On the other hand, Scott et al (2003) proposed a semi-automated method for extracting the land-water interface. They successfully applied these methods to generate multiple shoreline data for the States of Louisiana and Delaware. Another approach of extraction is by automation. Many scholars have successfully applied this. Thus, Liu and Jezek (2004), Karantzalos and Argialas (2007) automated the extraction of coastline from satellite imagery by canny edge detection using Digital Number (DN) threshold while Li, et al (2001) compared shorelines of the same area that were extracted using different techniques, evaluated their differences and discussed the causes of possible shoreline changes. However, other methods of change detection in shorelines have been in use in recent times. Such methods include the End Point Rate (EPR) method (Liu, 1998); (Galano & Gouglas, 2000); the Average of Rate (AOR) (Thieler, et al, 2001) and (Dolan, et al, 1991); the Minimum Description Length (MDL) method, (Fenster, et al, 1993) and Crowell, et al, 1997); Ordinary Least Squares (OLS) method , (Seber and Lee, 2003) and (Kleinbaum, et al, 1998); Reweighted Least Squares (RLS) method, (Rousseeuw and Leroy, 1987) and the Average of Era (AOA) (Dolan, et al, 1991), etc. In shoreline change prediction modeling, the major challenge has always been to create models with robust spatio-temporal numerical analysis, which can generate testable predictions about the functioning of a coastal erosion system (Fletcher, et al 2003). Since the coastal erosion causing forces also vary according to geographical location and seasons, it becomes difficult to develop more generalized models with high level of applicability from one coastal area to another. In this context however, this study adopts a multi spatio-temporal technique to analyze Ibeno shoreline characteristics.

However, the result of the study revealed remarkable changes in Ibeno shoreline. On the average, the rate of change of -3.9m/year and 2m/year for erosion and accretion has been respectively recorded. The paper concludes that the severity and intensity of erosion and/or accretion process at the coastal region of Ibeno Local Government Area in Akwa Ibom State and other parts of the Niger Delta region of Nigeria is quite outstanding and alarming. Based on this revelations therefore, acquisition of high resolution satellite facilities, such that will support regular assessment and monitoring of the region is hereby recommended so as to model the scenario and proffer proactive measures towards curbing the menace by ensuring effective environmental management practices, timely emergency responses, and salvage the immediate physical environment.

II. Study Area

Ibeno shoreline is located on the south eastern part of Nigeria, it is sandy, a stretch of the coast along the Bight of Bonny spanning from a point at Atabrikang village, latitude 40 31 and 22.6198 N and longitude 70 49' 16.0114'' E to a point at Okposo village, latitude 40 34' 09.7667'' N and longitude 80 17' 52.6643'' E in Ibeno L. G. Area of Akwa Ibom State. Like other parts of southern Nigeria, the area is contingent on the movement of the Tropical Discontinuity (ITD). It is characterized by very high rainfall (annual total > 4,000mm, high temperature values of about 270C, high values of relative humidity with mean value of 80.3 percent. Apart from the shoreline and tidal mudflats which are in most areas covered by the invasion of Nypa friutcans, all other areas depict highly disturbed vegetation following persistent and increasing anthropogenic pressure. The common vegetation types are bush fallowing and small farmlands, secondary and riparian forests as well as grasslands. The area is gentle undulating sandy plains heavily incised by numerous creeks, shallow streams, and rivers. Generally, the relief or the area ranges from less than three meters above the sea levels on the beach, to about 45m inland. The area is drained by a number of rivers including the Cross River, and the Qua Iboe River. Underlain by one

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main geological formation, Ibeno L. G. Area is made up of coastal plain sands comprising largely of poorly consolidated sands. Mineral deposits comprise coarse –silt and fine sand fraction of the coastal plains indicating the dominance of quartz, iron oxide(FE203) and aluminum oxide(AL203) all constituting less than 10 percent in fraction . The advent of oil exploration and production by Exxonmobil at Qua Iboe Terminal brought about the densely populated settlements which have in turn resulted in the removal of the vegetative cover, thus exposing the soil to erosion and/or accretion.

III. Materials and Methods

In the process of carrying out this study, the use of satellite images and GIS tools to extract the shorelines for three different years of 1986, 2006 and 2008 became very necessary. In this case, Landsat Thematic Mapper (LTM) of 1986 and Enhanced Thematic Mapper (ETM) of 2006 both of 28.5 X 28.5 metres ground resolution were acquired from the United States Geological Surveys (USGS) and actually used for various analysis carried out. A high resolution Ikonos image of 2008 with about 1m ground resolution was obtained and used. These imageries cover a period of 22yrs. The range of time and years chosen was due to data availability.

The images were processed to delineate the shorelines for 1986, 2006 and 2008 with a view to determining their rate of changes over the study period. Large-scale aerial photographs of 2006 were also acquired and used in the accuracy assessment of the 2006 landsat imagery. The map of Akwa Ibom State obtained from the State's Ministry of Lands and Housing in an analogue format at a scale of 1:100,000 became useful as the study area map and the settlements therein were captured in the GIS. The Global Positioning System (GPS) was also used to acquire ancillary data during field work.

Different analogue maps collected were captured through scanning, geo-referencing, heads-up digitizing and database creation in ArcGIS 9.2 software. The captured data were eventually set to WGS 84, UTM Zone 32 north. The sites visited in the field were captured using GPS and the data were used to identify locations on the imagery during the ground truthing exercise.

a) Processes of Shoreline Extraction

To extract the shorelines from the satellite images, shapefiles were created in Arc catalog for each of the images. For easy data handling, the three images were spatially re-projected to Universal Transverse Mercator (UTM 1984). This was followed by the determination of shoreline reference feature where measurements were based. The high-water line (HWL) was therefore adopted since it was relatively easy to distinguish it on all the images as a wet/dry line especially on the Ikonos imagery. According to Parker (2003), the HWL is the legal shoreline of the United States, represented in NOAA nautical charts and considered as the most consistent reference feature. The extraction was then carried out using the heads-up digitizing method. This manual method was adopted in an attempt to avoid the difficulties associated with the use of automated methods of extraction. However, features from the landsat satellite imageries of 1986, 2006 and the 2008 Ikonos image were digitized along the dry-wet sand boundaries which could be recognized from different tones in the sand beach. Usually, the tonal differences are caused by the variation in moisture in the sands as a result of being previously immersed or washed by high water level.

b) Determination of Rate of Shoreline Change

After the shorelines were extracted, a base-line was created parallel to these extracted shorelines in order to cast perpendicular lines to the shorelines and also to serve as the origin for measuring distances of the shorelines in relation to the established base-line. The base-line was created through buffering method in ArcGIS 9.2 and this served as the starting point for generating transects. In this case, a 600 meter buffer was created just above the lines, resulting in a single buffer of 600 meters around the outermost line. This buffer was converted to a polyline and split on top left and top right directly above the end of the shorelines. The upper and side sections of the buffer were deleted resulting in a single line 600 meters from the shoreline. This line served as the base-line and was smoothened to remove the rough side of the line in order to cast perpendicular transects on the shorelines under consideration.

The base-line and shoreline data were imported into a geo-database in order for DSAS to recognize the data. Before running the DSAS program, spatial reference and feature type requirements of the shoreline files were reconciled. The multiple shapefiles of the shorelines were appended into a single feature class by using the Append tool from the ArcToolbox. The various attribute tables for the baseline and the appended shoreline file were created as shown in Tables 1 and 2 below. If no accuracy field value exist for a specific shoreline or Zero is used in the accuracy field, a default value specified in the Set data Accuracy section by the user could be used. The ID field was populated to control the order of transect casting along the baseline.

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Table 1 : Shoreline Attribute Table

OBJECT ID*	SHAPE_LENGTH(m)	ID	DATE	ACCURACY
1	36127.98444	5	1/1/2008	0
2	392.953503	6	1/1/2008	0
3	9421.45049	7	1/1/2008	0
4	45782.27499	4	1/1/2006	0
5	3306.248434	1	1/1/1986	0
6	13003.19507	2	1/1/1986	0
7	29853.12538	3	1/1/1986	0

Table 2 : Base-line Attribute Table

BASE-LINE ATTRIBUTE TABLE, 3/8/2011				
OBJECT ID	SHAPE	ID	SHAPE_LENGTH(m)	CASTDIR
13	Polyline	1	44634.56799	1

The Digital Shoreline Analysis System (DSAS) was thereafter launched in ArcMap environment. The DSAS is an extension of the ArcGIS. According to Thieler, et al (2003) the purpose of this program was to measure historic shoreline changes by creating perpendicular transect to be used as measurement locations across multiple shorelines. The spacing between the transects along the base-line and the length of the transects was specified as shown in Figure 2. The DSAS generated transects lines that were created at each 100m segment perpendicular to the base-line and drawn to intersect all the three extracted shorelines as shown in Figure 1. Although the transect spacing had affected the accuracy of the result, smaller values gave more detailed and accurate analysis of the shoreline, while larger ones omitted some information thereby giving inaccurate analysis of the shoreline. Consequent upon this however, the nature of the shoreline needed to be considered before choosing a transect line spacing value. The intersected points were spatially joined to the base-line to create a field that calculated the shortest perpendicular distance from each point to the base-line. The transect-shoreline intersections were therefore used to calculate the rate-of-change statistics. To compute the shoreline rate of change, the End Point Rate (EPR) method and Linear Regression Analysis were used in DSAS. This was chosen over other methods due to the fact that it best proffers solution to shoreline change detection.

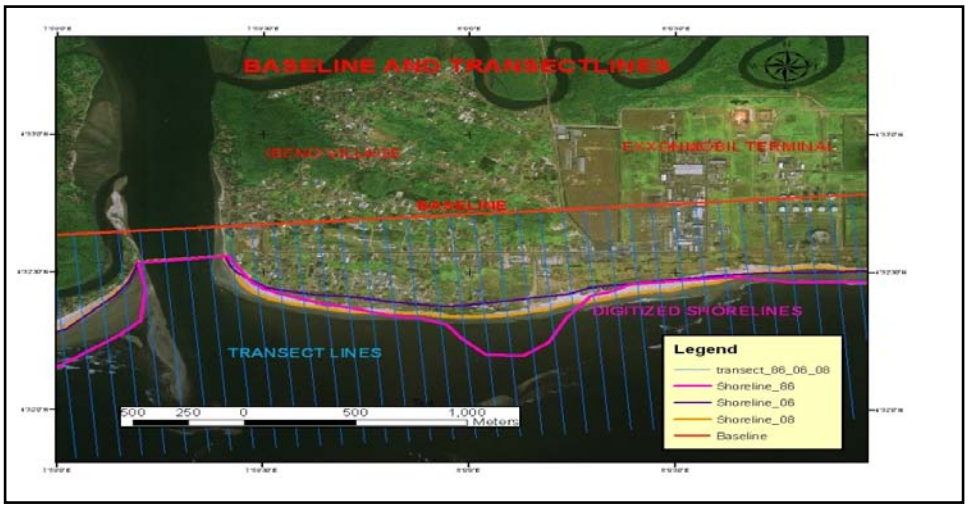


Figure 1 : Transect lines, Base-line and Extracted Shorelines

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c) Determination of Net Shoreline Movement (NSM)

After the computation of the rate of change in shoreline, the End Point Rate method was used to calculate the distance of shoreline movement by subtracting between the earliest and latest measurements (i.e., the oldest and the most recent shoreline). The major advantage of the EPR is that, it is easy to compute with minimal requirements of shoreline data (two shorelines). One disadvantage of this method is that in cases where more than two shorelines are available, the information about shoreline behavior provided by additional shorelines is neglected. In the best circumstances, the EPR should be limited to Net shoreline movement. The linear regression rate-of-change statistic (LRR) was the second rate of change method used. This was done by fitting a least squares regression line to all shoreline points for a particular transects. The rate is the slope of the line. The linear regression method has the advantage that all the data are used, regardless of changes in the trend or accuracy in addition to the method being purely computational.

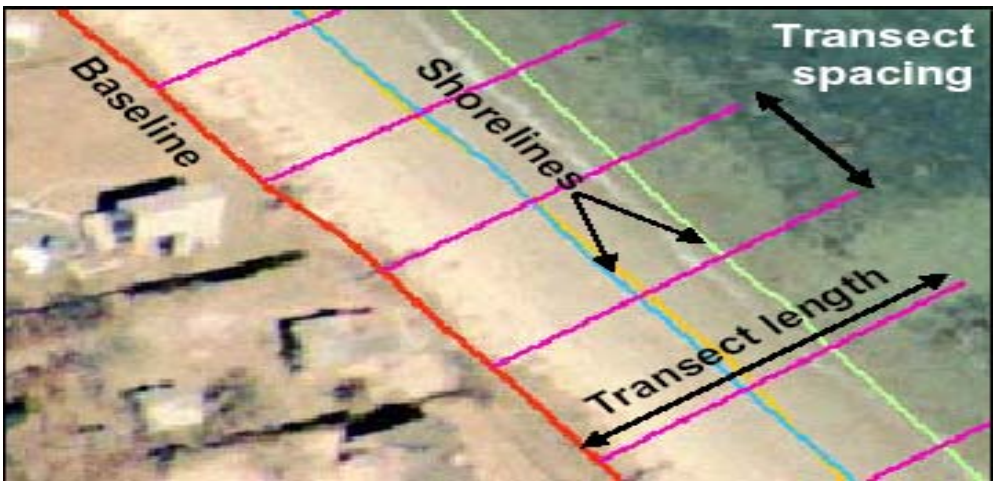


Figure 2 : Base-line, Shorelines, Transect length and Transect Spacing

IV. Results

a) The Extracted Shoreline

The total length of the extracted shoreline from 1986 landsat image is 46.162km and 45.811km for 2006 while that of 2008 Ikonos imagery is 45.942km. The shorelines are represented with different colors. A closer look at the digitized shorelines shows that there is a remarkable change in the shape of the shoreline over time as shown in Figure 3.

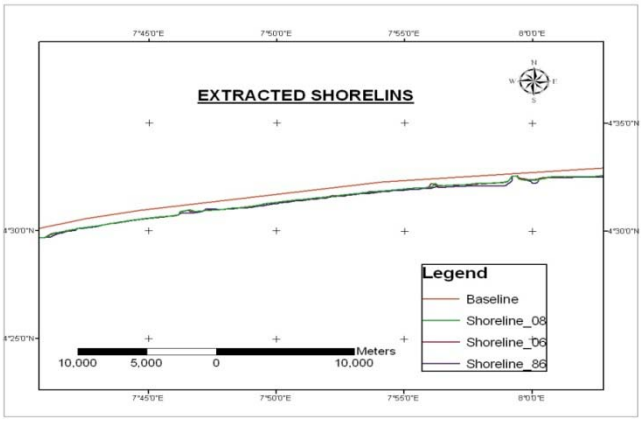


Figure 3 : Base-line and Shorelines Extracted

b) Changes in Shoreline over Time

The result of the analysis revealed remarkable changes in Ibeno Shoreline, the net change measured as the distance between the most recent and earliest shorelines, in this case the 1986, 2006 and the 2008 shorelines. The change that occurred between the timing of each available image is presented in Figures 4, 5, and 6. Table 3 below shows the sum total of the magnitude of Net Erosion and Accretion that occurred over the different periods under investigation.

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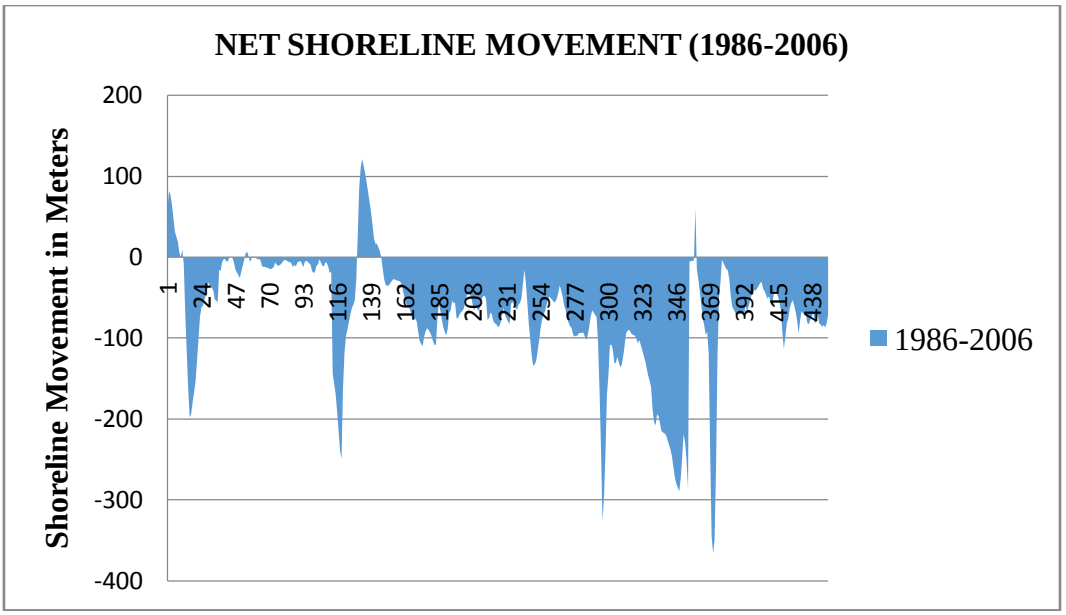


Figure 4 : Net Shoreline Movement (1986-2006)

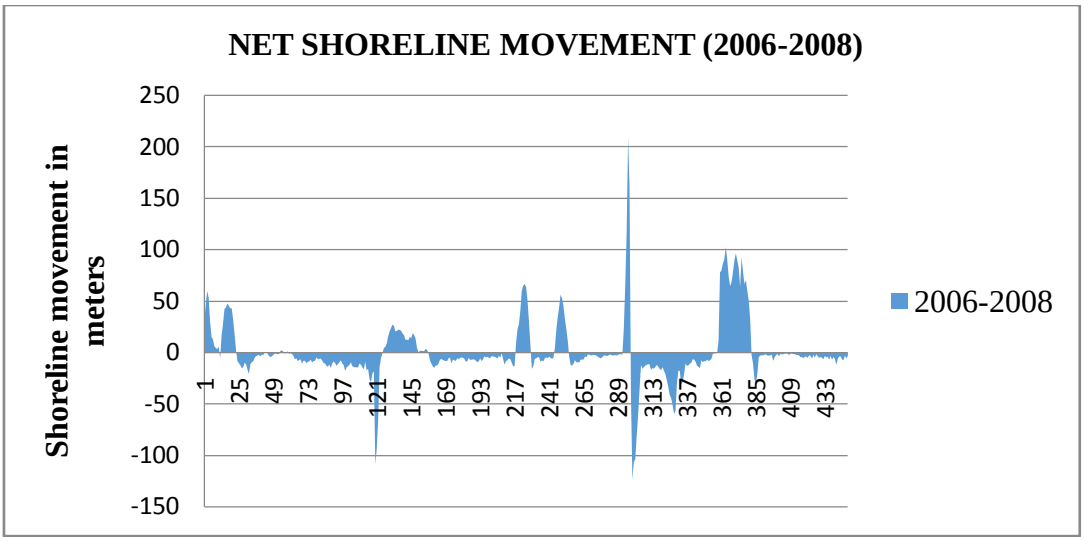


Figure 5 : Net Shoreline Movement (2006-2008)

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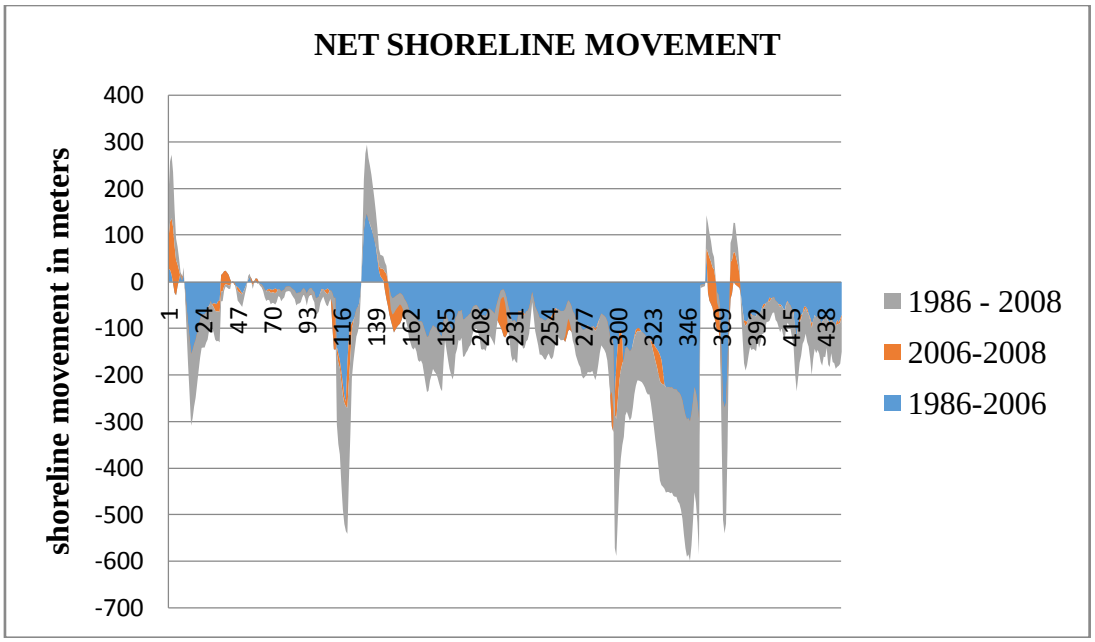


Figure 6 : Net Shoreline Movement (1986-2008)

Table 3 : Shoreline Erosion, Accretion and Net Change in Meters

PERIODS	ACCRETION (m)	EROSION (m)	NET CHANGE (m)
1986 - 2006	1472.42	-32905.2	-31432.78
2006 - 2008	4074.28	-3714.1	360.18
1986 - 2008	2618.38	-33691.2	-31072.82

In the rate of change analysis result, the zones were generated by identifying and selecting transects that show similar characteristics. Places with slightly the same rate of change are zoned together. (Please See Figure 7).

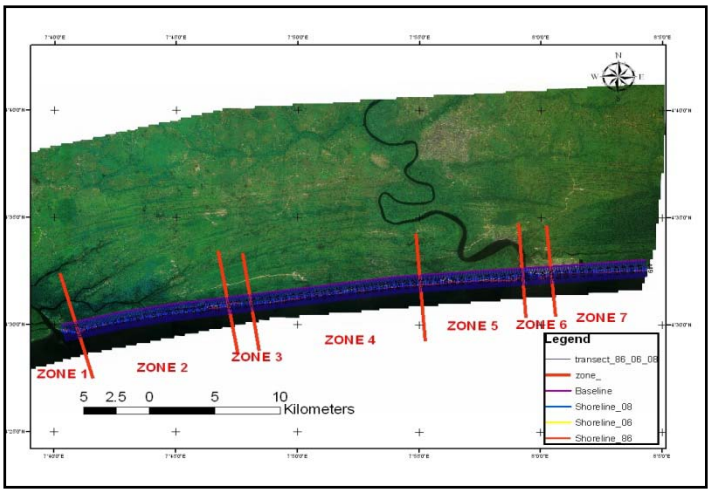


Figure 7 : Zoning of Shoreline in Ibeno L. G. Area

The rate of erosion and accretion in each zone is the average rate of the entire transects in that particular zone. The accretion process in **Zone 1** is very significant. This is largely due to human activities at the Imo River Estuary and the shoreline. This area is also characterized by thick vegetation and high sandy beach. On the average, the rate of accretion is 2.2m/yr in this zone. **Zone 2** is the region with the least rate of change and is characterized by narrow sandy beach with thick vegetation. The rate of change here is insignificant when

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compared to other places. The reason is that human activity around the region is relatively reduced. The average rate of change of erosion is -2.1m/yr. Zone3 on the other hand is covered with high vegetation. The high variation in transect is due to shoreline accretion which is caused by human activities at the river estuary in the region. Average rate of accretion is 3m/yr in this zone.

Zone 4 displays minimal net change in erosion. The area is limited to perched sandy beach with continuous thick vegetation. Human activities here are low and the average rate of erosion is -3.2m/yr. Zone 5 encompasses the main erosion. Sediments are completely stripped from the beach leaving an extensive land exposed, trees are destroyed and buildings damaged. Itak Abasi community in Ibeno Local Government Area is located in this region. Erosion is very severe such that a greater portion of the area is completely eroded (See plates 1, 2 and 3). The average rate of erosion in this region is -7.8m/yr.



Plate 1 : Destroyed Trees along the Shoreline



Plate 2 : Vacated School Near the Shore, Destroyed by Erosion

In Zone 6, variable change with high accretion is more apparent than erosion. This is caused by human activities going on at Qua Iboe River Estuary and sand filling from built up areas near the shore. This area is accreting at the average rate of 1.1m/yr. Zone 7 records minimal erosion with relatively wide, homogenous stretch of sandy beach. A large amount of deposited sediment is observed to move to and from the sea. Storm and high wave are some of the contributions of this erosion. The location of ExxonMobil terminal, built up places near the shore and other engineering activities going on in this area are the main cause of this slight erosion. On the average, erosion rate is -2.9m/yr.

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Plate 3 : Engineering Activities (Pipe-laying) on the Shore

V. Discussions

In view of the result of this study, there are remarkable changes in the shape and length of Ibeno shoreline under consideration. The length of the shoreline captured from different images is 46.162km in 1986, 45.811km in 2006, and 45.94 in 2008. This result is in line with the findings of Liu and Jezek (2004); Scott et al (2003) and Efe and Tagil (2001) for their respective areas of study. It is however worthy to note that this finding has set the pace for data management and timely information delivery with regard to Ibeno shoreline activities which is very significant in terms of data requirement for assessment and monitoring of the coastal environment.

In consideration of the 1986, 2006 and 2008 shorelines parameters, the 1986 case was selected as the earliest date for comparison. Meanwhile, within the period of ten years considered for this study (1986-2006), accretion was calculated as 1472.42m, erosion as-32905.2m thus giving the change as -31432.78m (See Table 1). Within the period of two years (2006-2008), accretion was calculated to be 4074.28m, erosion -3714.1m while the net change was 360.18m. On the whole, between 1986 and 2008, accretion, erosion, and net shoreline values in Ibeno shoreline were 2618.38m, -33691.2m and -31072.82m respectively. However, within the period of this assessment, the highest accretion value was 147.07m while the lowest accretion value was 0.5m. On the other hand, the highest erosion value in the area was -299.19m while the lowest erosion value was -1.28m. Meanwhile and from the outcome of this analysis, it is worthy to note that there are more eroding portions than accreting portions across the entire shoreline in Ibeno Local Government Area. This implies that sediments are continually stripped from the beach leaving an extensive land exposed. Trees are completely destroyed and buildings damaged as shown in Plates 1, 2 and 3. However, Itak Abasi village in Ibeno Local Government Area is known to be adversely affected by this environmental challenge. This condition persistently subjects the socio- economic activities of the people in the affected area into jeopardy.

Interestingly, it is worthy of note that most places affected by minimal erosion are as a result of engineering activities going on in the area while some are caused by intensive human activities at the river estuary along the shoreline. The accretion near ExxonMobil jetty is as a result of sand fills done in the past for settlement purposes. On the average, the rate of change of shoreline in Ibeno L. G. Area is -3.9m/yr and 2m/yr for erosion and accretion respectively. The negative (-) sign represents erosion while the positive (+) sign represents accretion in the area. This revelation involving the rate of change in erosion and accretion processes in Ibeno L. G. Area known to be very useful in cases of future predictions to determine shoreline positions as in the case of U.S. Army Corps of Engineers (1992). Consequently, the implication is that areas affected by accretion will hinder free movement of people, support capsizing of fishing boats and the soften nature of the shifting sand bars will pose a threat when jetties are sited close to them. Furthermore, areas affected by erosion will experience flooding and the resultant effect from there.

VI. Conclusion and Recommendation

Based on the outcome of this study, it is concluded that there is a remarkable change in the shoreline under consideration. This trend is similar to other parts of the Niger Delta region of Nigeria. Erosion and accretion processes have been ongoing, outstanding, and very severe in the area. Specifically, it is worthy to note that these occurrences are very much peculiar to the coastal region of Ibeno Local Government Area in Akwa Ibom State. Based on this revelation however, acquisition of high resolution

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satellite facilities such that will support regular assessment and monitoring of the region is hereby recommended so as to model the scenario and proffer proactive measures towards curbing the menace by ensuring effective environmental management practices, timely emergency responses, and salvage the immediate physical environment.

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Spectral Characteristics and Mapping of Rice Fields using Multi-Temporal Landsat and MODIS Data: A Case of District Narowal

By Farooq Ahmad, Qurat-ul-ain Fatima, Hira Jannat Butt, Shahid Ghazi, Sajid Rashid Ahmad, Ijaz Ahmad, Shafeeq-Ur-Rehman, Rao Mansor Ali Khan, Abdul Raoof, Samiullah Khan, Farkhanda Akmal, Muhammad Luqman, Ahmad Raza & Kashif Shafique

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Abstract- Availability of remote sensed data provides powerful access to the spatial and temporal information of the earth surface. Real-time earth observation data acquired during a cropping season can assist in assessing crop growth and development performance. As remote sensed data is generally available at large scale, rather than at field-plot level, use of this information would help to improve crop management at broad-scale. Utilizing the Landsat TM/ETM+ ISODATA clustering algorithm and MODIS (Terra) the normalized difference vegetation index (NDVI), and enhanced vegetation index (EVI) datasets allowed the capturing of relevant rice cropping differences. In this study, we tried to analyze the MODIS (Terra) EVI/NDVI (February, 2000 to February, 2013) datasets for rice fractional yield estimation in Narowal, Punjab province of Pakistan. For large scale applications, time integrated series of EVI/NDVI, 250-m spatial resolution offer a practical approach to measure crop production as they relate to the overall plant vigor and photosynthetic activity during the growing season. The required data preparation for the integration of MODIS data into GIS is described with a focus on the projection from the MODIS/Sinusoidal to the national coordinate systems. However, its low spatial resolution has been an impediment to researchers pursuing more accurate classification results and will support environmental planning to develop sustainable land-use practices. These results have important implications for parameterization of land surface process models using biophysical variables estimated from remotely sensed data and assist for forthcoming rice fractional yield assessment.

Keywords: EVI, Landsat TM/ETM+, land-use, multi-temporal, multi-spectral, NDVI, Pakistan.

GJHSS-B Classification : FOR Code: 300899



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Spectral Characteristics and Mapping of Rice Fields using Multi-Temporal Landsat and MODIS Data: A Case of District Narowal

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Abstract- **Availability of remote sensed data provides powerful access to the spatial and temporal information of the earth surface. Real-time earth observation data acquired during a cropping season can assist in assessing crop growth and development performance. As remote sensed data is generally available at large scale, rather than at field-plot level, use of this information would help to improve crop management at broad-scale. Utilizing the Landsat TM/ETM+ ISODATA clustering algorithm and MODIS (Terra) the normalized difference vegetation index (NDVI), and enhanced vegetation index (EVI) datasets allowed the capturing of relevant rice cropping differences. In this study, we tried to analyze the MODIS (Terra) EVI/NDVI (February, 2000 to February, 2013) datasets for rice fractional yield estimation in Narowal, Punjab province of Pakistan. For large scale applications, time integrated series of EVI/NDVI, 250-m spatial resolution offer a practical approach to measure crop production as they relate to the overall plant vigor and photosynthetic activity during the growing season. The required data preparation for the integration of MODIS data into GIS is described with a focus on the projection from the MODIS/Sinusoidal to the national coordinate systems. However, its low spatial resolution has been an impediment to researchers pursuing more accurate classification results and will support environmental planning to develop sustainable land-use practices. These results have important implications for parameterization of land surface process models using biophysical variables estimated from remotely sensed data and assist for forthcoming rice fractional yield assessment.**

Keywords: EVI, Landsat TM/ETM+, land-use, multi-temporal, multi-spectral, NDVI, Pakistan.

I. Introduction

Remote sensing dataset offers unique possibilities for spatial and temporal characterization of the changes. The fundamental requirement is the availability of different dates of satellite imagery which permits continuous monitoring of change and environmental developments over time (Lu et al., 2004; Nasr and Helmy, 2009; Ahmad, 2012b; Ahmad et al., 2013). RS sensor is a key device that captures data about an object or scene remotely. Since objects have their unique spectral features, they can be identified from RS imagery according to their unique spectral characteristics (Xie, 2008; Ahmad and Shafique, 2013; Ahmad et al., 2013). A good case in vegetation mapping by using RS technology is the spectral radiances in the red and near-infrared (NIR) regions, in addition to others (Ahmad et al., 2013). The radiances in these regions could be incorporated into the spectral vegetation indices (VI) that are directly related to the intercepted fraction of photosynthetically active radiation (Asrar et al., 1984; Galio et al., 1985; Xie, 2008; Ahmad and Shafique, 2013; Ahmad et al., 2013). The spectral signatures of photosynthetically and non-photosynthetically active vegetation showed obvious difference and could be utilized to estimate forage quantity and quality of grass prairie (Beeri et al., 2007; Xie, 2008; Ahmad and Shafique, 2013).

RS is the technology that can give an unbiased view of large areas, with spatially explicit information distribution and time repetition, and has thus been widely used to estimate crop yield and offers great potential for monitoring production, yet the uncertainties associated with large-scale crop yield (Quarmby et al., 1993; Báez-González et al., 2002; Doraiswamy et al., 2003; Ruecker et al., 2007; Ahmad and Shafique, 2013a) estimates are rarely addressed (Ahmad et al., 2013).

RS dataset of better resolution at different time interval helps in analyzing the rate of changes as well as the causal factors or drivers of changes (Dai and Khorram, 1999; Ramachandra and Kumar, 2004; Ahmad, 2012b). Hence, it has a significant role in planning at different spatial and temporal scales. Change detection in agricultural planning helped in enhancing the capacity of local governments to implement sound environmental management (Prenzel and Treitz, 2004; Ramachandra and Kumar, 2004; Ahmad, 2012b). This involves development of spatial and temporal database and analysis techniques. Efficiency of the techniques depends on several factors such as classification schemes, modelling, spatial and

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spectral resolution of RS data, ground reference data and also an effective implementation of the result (Ramachandra and Kumar, 2004; Ahmad, 2012b). Natural resources in the arid environment are declining in productivity and require special attention, and if the ecological condition persists, a further decline in resources may result in land degradation (Babu et al., 2011).

Preprocessing of satellite datasets prior to vegetation extraction is essential to remove noise (Schowengerdt, 1983; Ahmad and Shafique, 2013) and increase the interpretability of image data (Campbell, 1987; Schowengerdt, 2006; Ahmad and Shafique, 2013). The ideal result of image preprocessing is that all images after image preprocessing should appear as if they were acquired from the same sensor (Hall et al., 1991; Xie, 2008; Ahmad and Shafique, 2013). Image preprocessing commonly comprises a series of operations, including but not limited to bad lines replacement, radiometric correction, geometric correction, image enhancement and masking although variations may exist for images acquired by different sensors (Schowengerdt, 1983; Campbell, 1987; Xie, 2008; Ahmad and Shafique, 2013). 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; Ahmad, 2012a).

The development of long-term data records from multi-satellites/multi-sensors is a key requirement to improve our understanding of natural and human-induced changes on the Earth and their implications (NRC, 2007; Miura et al., 2008; Ahmad, 2012c). A major limitation of such studies is the limited availability of sufficiently consistent data derived from long-term RS (Ouyang et al., 2012; Ahmad, 2012a; Ahmad et al., 2013). The benefit obtained from a RS sensor, largely depends on its spectral resolution (Jensen, 2005; Ahmad, 2012a; Ahmad et al., 2013), which determines the sensor's capability to resolve spectral features of land surfaces (Fontana, 2009; Ahmad, 2012a; Ahmad et al., 2013). 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; Ahmad, 2012a; Ahmad et al., 2013).

Landsat ETM+ has shown great potential in agricultural mapping and monitoring due to its advantages over traditional procedures in terms of cost effectiveness and timeliness in availability of information over larger areas (Murthy et al., 1998; Rahman et al., 2004; Adia and Rabiu, 2008; Ahmad, 2012d) 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 the accuracy of results (Adia and Rabiu, 2008; Ahmad, 2012d).

The MODIS (Terra) NDVI (Rouse et al., 1973) and EVI (Liu and Huete, 1995; Justice et al., 1998; Huete et al., 1999) datasets provide unique opportunities for monitoring terrestrial vegetation conditions at regional and global scales (Yang et al., 1997; Piao et al., 2006; Ahmad, 2012a; Ahmad et al., 2013), and has widely been used in research areas of net primary production (Potter et al., 1993; Paruelo et al., 1997; Piao et al., 2006; Ahmad, 2012a; Ahmad et al., 2013), 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; Ahmad, 2012a; Ahmad et al., 2013), biomass (Myneni et al., 2001; Dong et al., 2003; Piao et al., 2006; Ahmad, 2012a; Ahmad et al., 2013), and phenology (Reed et al., 1994; Moulin et al., 1997; Piao et al., 2006; Ahmad, 2012a; Ahmad et al., 2013).

Multi-year time series of EVI/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; Ahmad, 2012a). 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; Ahmad, 2012a). The NDVI has the potential ability to signal the vegetation features of different eco-regions and provides valuable information as a RS tool in studying vegetation phenology cycles at a regional scale (Guo, 2003; Ahmad, 2012a).

The NDVI is established to be highly correlated to green-leaf density and can be viewed as a proxy for above-ground biomass (Tucker and Sellers, 1986; Ahmad, 2012e). The NDVI is the most commonly used index of greenness derived from multispectral RS data (USGS, 2010; Ahmad, 2012e), and is used in several studies on vegetation, since it has been proven to be positively correlated with density of green matter (Townshend et al., 1991; Huete et al., 1997; Huete et al., 2002; Debien et al., 2010; Ahmad, 2012e). The NDVI provides useful information for detecting and interpreting vegetation land cover it has been widely used in RS studies (Dorman and Sellers, 1989; Myneni and Asrar, 1994; Gao, 1996; Sesnie et al., 2008; Karaburun, 2010; Ahmad, 2012f; Ahmad and Shafique, 2013a; Ahmad et al., 2013).

The NDVI is chlorophyll sensitive; the EVI (Liu and Huete, 1995; Justice et al., 1998; Huete et al., 1999; Ahmad et al., 2013) is more responsive to canopy structural variations, including canopy type, plant physiognomy and canopy architecture (Gao et al., 2000; Huete et al., 2002; Ahmad et al., 2013). The two VIs complement each other in global vegetation studies and improve upon the detection of vegetation changes and

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extraction of canopy biophysical parameters (Huete et al., 1999; 2002; Ahmad et al., 2013).

a) Study Area:

The District Narowal (Figure 1; 2) lies in the Punjab province of Pakistan from 31° 55' to 32° 30' North latitude and 74° 35' to 75° 21' East longitude. The district is bounded on the north-west by Sialkot district, on the north by Jammu State, on the east by Gurdaspur district (India) and on the south by Amritsar district (India) and Sheikhupura district (GOP, 2000).

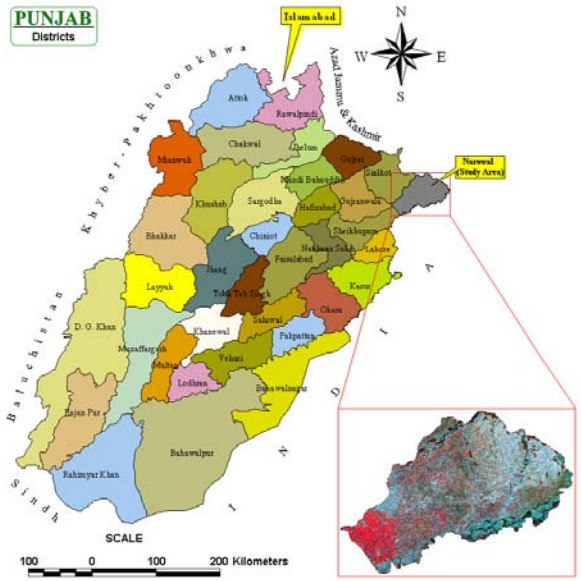


Figure 1 : Location Map of the Study Area

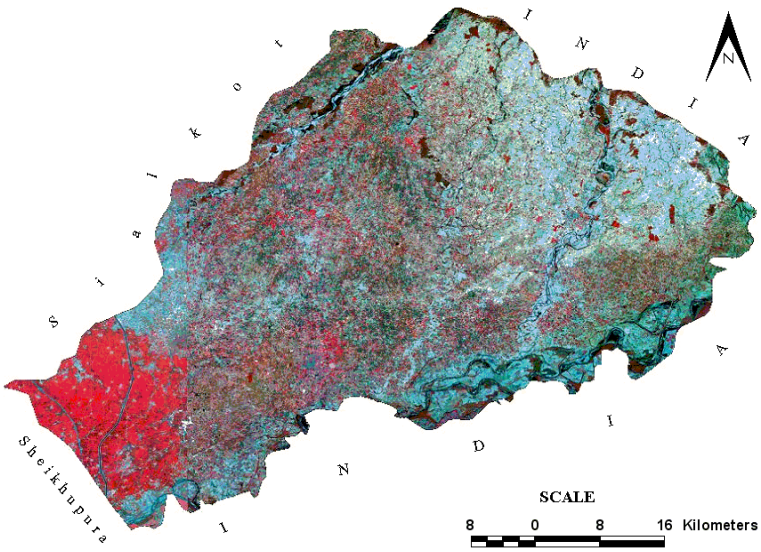


Figure 2 : Narowal - Landsat ETM+ 30th September, 2001 image *Source: http://glovis.usgs.gov/*

b) Physical Features:

The general aspect of the district is a plain slopping down from the uplands at the base of the Himalayas to the level country to the south-west (Figure 3), and the general altitude is 266 meters above sea level (GOP, 2000; Shah, 2007).

Bounded on the south-east by the river Ravi, the district is fringed on the either side by a line of fresh alluvial soil, about which rise the low banks that form the limits of the river bed. At about a distance of 24 km from Ravi, another stream, the Dake which rises in the Jammu hills traverses the district. The district is practically a level plain. Its north-eastern boundary is at a distance of about 32 km from the outer line of the Himalayas, but the foot-hills stop short of the district and its surface is level plain broken only by the river Ravi, by the Aik and Dake streams and a few *nullahs* that are little more than drainage channels. The general slope as indicated by the lines of drainage is from north-east to south-west (GOP, 2000).

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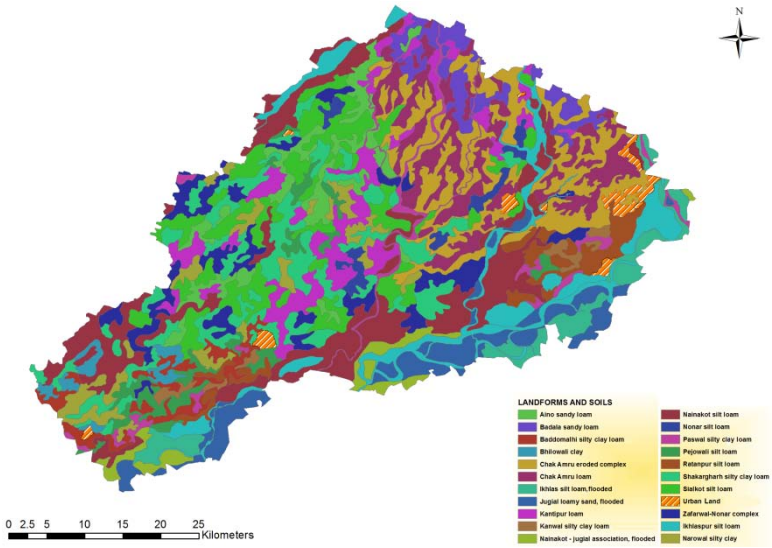


Figure 3 : Landforms and Soils, Narowal District *Source: After Shah, 2007*

II. Research Design and Methods

In this research, Landsat TM/ETM+ (path 148, row 38; path 149, row 38) scenes of 30th September, 2001 and 2nd November, 2010 was used to detect and identify the rice-pixels and paddy cropped areas in Narowal. The fundamental steps are: image registration and image enhancement (Macleod and Congalton, 1998; Mahmoodzadeh, 2007; Al-Awadhi et al., 2011). The scene was corrected and geo-referenced using projection UTM, zone 43 and datum WGS 84.

To monitor the cultivated land under different environmental conditions, RS has been approved the best technology (Heller and Johnson, 1979; Eckhardt et al., 1990; Pax-Lenney et al., 1996; DeFries et al., 1998; Lobell et al., 2003; Thenkabail et al., 2005; Alexandridis et al., 2008; Ozdogan and Gutman, 2008; Thenkabail et al., 2009; Ozdogan et al., 2010). RS provides synoptic coverage of paddy/rice fields with temporal frequencies sufficient to assess growth, maturity, and ripening (Ozdogan and Gutman, 2008; Ozdogan et al., 2010). Satellite dataset is time-consuming and less costly than traditional statistical surveys. This makes particularly valuable for inventories of crop land/crop growth for monitoring, evaluation and assessment (Ozdogan et al., 2010) in developing countries like Pakistan.

Image amplification of satellite dataset also include latest computerized methodologies (Keene and Conley, 1980; Thiruvengadachari, 1981; Kolm and Case, 1984; Haack et al., 1998; Ozdogan et al., 2010). The studies benefit from the strong spectral separation of paddy/rice fields from other crops and fallow land in the visible and NIR portions of the EMS (Ozdogan et al., 2010). Image classification of satellite dataset is useful because the analysis time is shorter and cost associated with mapping is lower. Familiar methods include multi-stage classification (Thelin and Heimes, 1987; El-Magd and Tanton, 2003; Ozdogan et al., 2010), supervised clustering (Kauth and Thomas, 1976; Thelin and Heimes, 1987; Eckhardt et al., 1990; Ozdogan et al., 2010), and density slicing with thresholds (Manavalan et al., 1995; Starbuck and Tamayo, 2007; Ozdogan et al., 2006; Ozdogan et al., 2010). The multi-stage procedure involves classification of land cover at increasingly refined categorical levels following the concept that paddy/rice fields are subclass of cultivated lands, which themselves belong to vegetated landscapes (Ozdogan et al., 2010). As in image augmentation, digital image classification benefits from spectral transformations (Kauth and Thomas, 1976; Eckhardt et al., 1990; Pax-Lenney et al., 1996; Ozdogan et al., 2006; Starbuck and Tamayo, 2007; Ozdogan et al., 2010). In particular, the NDVI proves to be indispensible for identifying crop lands in local scale studies.

The use of the NDVI would comprise direct inclusion into a categorization algorithm as an input feature (Ozdogan et al., 2010). Using dataset from multiple time periods, the prejudice procedure is based on the different spectral responses of crops according to their phenological evolution (Abuzar et al., 2001; Ozdogan et al., 2010). A number of studies have established that using spectral information from two successive seasons in a crop-year is sufficient to identify the paddy/rice fields. However, for each season, the estimates require multiple datasets (Abuzar et al., 2001; Ozdogan et al., 2006; Ozdogan et al., 2010). This is because single-date analysis in visible cropping intensity often does not take into account planting dates that vary from year to year. Therefore, multi-temporal analysis has greater potential to define paddy/rice fields (Akbari et al., 2006; Ozdogan et al., 2010). Eventually, the results of classification are restricted upon the temporal and spatial variability of the spectral signature of the land cover type in question, so suitable datasets

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must be available for the temporal approach to provide a complete inventory of all crops (Ozdogan et al., 2010).

RS studies of vegetation normally use specific wavelengths selected to provide information about the vegetation present in the area from which the radiance data emanated. These wavelength regions are selected because they provide a strong signal from the vegetation and also have a spectral contrast from most background resources (Tucker and Sellers, 1986). The wavelength region located in the VIS–NIR transition has been shown to have high information content for vegetation spectra (Collins, 1978; Horler et al., 1983; Broge and Leblanc, 2000). The spectral reflectance of vegetation in this region is characterized by very low reflectance in the red part of the spectrum followed by an abrupt increase in reflectance at 700–740 nm wavelengths (Broge and Leblanc, 2000). This spectral reflectance pattern of vegetation is generally referred to as the 'red edge'. The red edge position is likewise well correlated with biophysical parameters at the canopy level, but less sensitive to spectral noise caused by the soil background and by atmospheric effects (Baret et al., 1992; Demetriades-Shah et al., 1990; Guyot et al., 1992; Mauser and Bach, 1994; Broge and Leblanc, 2000).

Leaf water content governs the reflectance properties beyond 1000 nm, but has practically no effect on the spectral properties in the VIS and NIR regions (Broge and Leblanc, 2000). In fact, chlorophyll concentration was sufficient to absorb nearly all of the blue and red radiation. Reflectance in the green (550 nm) and red-edge (715 nm) bands increase significantly as chlorophyll concentration decrease (Daughtry et al., 2000). Variations of leaf dry matter content affects canopy reflectance by increasing or decreasing the multiple intercellular scattering of the NIR rays. However, for practical RS applications, this effect can be assumed to be negligible, because within-crop variations of leaf dry matter content is very stable (Broge and Leblanc, 2000). Soil compaction negatively affects crop growth characteristics (Lowery and Schuler, 1991; Kulkarni and Bajwa, 2005; Ahmad et al., 2013), yield (Johnson et al., 1990; Kulkarni and Bajwa, 2005; Ahmad et al., 2013), and root distribution and development (Taylor and Gardner, 1963; Unger and Kaspar, 1994; Kulkarni and Bajwa, 2005; Ahmad et al., 2013). However, bare soil reflectance may be affected by the impact of tillage practices and moisture content (Barnes et al., 1996; Kulkarni and Bajwa, 2005; Ahmad et al., 2013). The wavelengths detected as responsive to soil compaction were close to each other, they might had similar information about the vegetation vigor. In the red portion of spectrum, the wavelengths ranged from 620 to 700 nm (Thenkabail et al., 2000; Kulkarni and Bajwa, 2005; Ahmad et al., 2013).

The NDVI assumed the most common vegetation index used throughout the history of satellite data applications. The NDVI represents the absorption of photosynthetic active radiation and hence is a measurement of the photosynthetic capacity of the canopy (Rouse et al., 1973; Woomer et al., 2004). The NDVI is computed following the equation:

$$NDVI = \frac{\rho_{NIR} - \rho_{Red}}{\rho_{NIR} + \rho_{Red}}$$

Where, ρ_{NIR} and ρ_{Red} are the surface bidirectional reflectance factors for their respective MODIS bands. The NDVI is referred to as the 'continuity index' to the existing 20+ year NOAA-AVHRR derived NDVI (Rouse et al., 1973; Ahmad, 2012c) 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, 2012c), which could be extended by MODIS data to provide a longer term data record for use in operational monitoring studies (Chen et al., 2003; Ahmad, 2012c). The NDVI has been established to be highly correlated to green-leaf density, absorbed fraction of photosynthetically active radiation and above-ground biomass and can be viewed as a surrogate for photosynthetic capability (Asrar et al., 1984; Tucker and Sellers, 1986; Propastin and Kappas, 2009).

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; Ahmad, 2012a; Ahmad et al., 2013). On the contrary, 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; Ahmad, 2012a; Ahmad et al., 2013).

The EVI is an 'optimized index' designed to enhance the vegetation signal with improved sensitivity in high biomass regions and improved vegetation monitoring through a de-coupling of the canopy background signal and a reduction in atmosphere influences (Liu and Huete, 1995; Justice et al., 1998; Huete et al., 1999; Ahmad, 2012c). The EVI is computed following the equation:

$$EVI = G \times \frac{(NIR - RED)}{(NIR + C1 \times RED - C2 \times Blue + L)}$$

Where NIR/RED/Blue are atmospherically-corrected or partially atmosphere corrected (Rayleigh and ozone absorption) surface reflectances, L is the canopy background adjustment that addresses non-linear, differential NIR and red radiant transfer through a canopy, and C1, C2 are the coefficients of the aerosol resistance term, which uses the blue band to correct for aerosol influences in the red band. The coefficients adopted in the EVI algorithm are; L=1, C1 = 6, C2 =

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7.5, and G (gain factor) = 2.5 (Liu and Huete, 1995; Justice et al., 1998; Huete et al., 1999; Huete et al., 2002; Karnieli and Dall'Olmo, 2003; Huete, 2005; Gao and Mas, 2008; Ahmad, 2012c).

The MODIS has been supplying a continuous data stream since 2000, lending to comprehensive time series analysis of the global terrestrial environment (Grogan and Fensholt, 2013). Of the available POES datasets, the MODIS reflectance products are favored among many in the research community with a focus on monitoring regional to global vegetation dynamics. The MODIS has a number of advantages when compared to other moderate-to-course resolution sensors, including superior spatial resolution, a broad spectral range (visible to mid-infrared), and superior geolocational accuracy (Wolfe et al., 2002; Grogan and Fensholt, 2013). One additional attraction to the MODIS dataset is the detailed description of data quality accompanying the products in the form of quality flags, including indicators of cloud cover, cloud shadow, aerosol loading and sensor-solar geometry for both the surface reflectance products (Vermote et al., 2011; Grogan and Fensholt, 2013) and the derived Vegetation Index (VI) composites (Solano et al., 2010; Grogan and Fensholt, 2013).

The MODIS (Terra) EVI/NDVI (MOD13Q1) data products for research area were acquired, in this case 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; 2012b; Ahmad et al., 2013). A gapless time series of MODIS (Terra) EVI/NDVI composite raster data from February, 2000 to February, 2013 with a spatial resolution of 250 m (Table 1) was utilized for calculation of the rice fractional yield. The datasets provide 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; Ahmad, 2012a; Ahmad et al., 2013). MODIS products are designed to provide consistent spatial and temporal comparisons between different global vegetation conditions that can be used to monitor photosynthetic activity and forecast crop yields (Vazifedoust et al., 2009; Cheng and Wu, 2011; Ahmad et al., 2013). Details documenting the MODIS (Terra) EVI/NDVI compositing process and Quality Assessment Science Data Sets can be found at NASA's MODIS web site (MODIS, 1999; USGS, 2008; Ahmad et al., 2013). This study explored the suitability of the MODIS (Terra) EVI/NDVI (MOD13Q1) pixels obtained from a paddy/rice cultivated area, Naina Kot over thirteen years (February, 2000 to February, 2013), to explore rice fractional yield (Mulianga et al., 2013).

Table 1 : MODIS (Terra) bands used in this research study

Bandwidth specifications (nm)	Band 1: 620–670
	Band 2: 841–876
Spatial resolution (m)	250
Radiometric resolution (bits)	12
Time window	16-days

ERDAS imagine 2014 and ArcGIS 10.1 software were used for the application of the NDVI model to detect the paddy/rice cropped area and calculation for Landsat TM/ETM+ (path 148, row 38; path 149, row 38) images of 30th September, 2001 and 2nd November, 2010 respectively. The supervised classification was applied upon the image for the estimation of the paddy cropped area. Calculation of paddy crop growth stages (transplanting to maturity and further ripening) using MODIS (Terra) EVI/NDVI pixel values of the selected 11 villages; Bara Manga, Becochak, Boora Dala, Budha Dhola, Fattu Chak, Gumtala, Lalian, Naina Kot, Nathoo Kot, Pherowal, and Talwandi Bhindran were carried out and linear forecast trendline was plotted to identify the variations in the rice fractional yield dataset of Naina Kot from February, 2000 to February, 2013. Standard multispectral image processing techniques were generally developed to classify multispectral images into broad categories of surface condition (Shippert, 2004; Ahmad, 2012; Ahmad et al., 2013).

The importance of the NDVI index may vary according to habitat nature (Pettorelli et al., 2005; Hamel et al., 2009; Ahmad and Shafique, 2013a; Ahmad et al., 2013). 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; 2012c). The strength of the NDVI is in its ratio concept (Moran et al., 1992; Ahmad, 2012a), which reduces many forms of multiplicative noise present in multiple bands (Chen et al., 2002; Nicandrou, 2010; Ahmad, 2012a; 2012b). RS provides a viable source of data from which updated land-cover information can be extracted efficiently and cheaply in order to invent and monitor these changes effectively (Mas, 1999; Ahmad and Shafique, 2013a; Ahmad et al., 2013).

Supervised classification which is a part of post classification comparison technique or direct classification method. This approach is based on the natural groupings of the spectral properties of the pixels which are usually selected by the RS software without any influence from the users (Al-Awadhi et al., 2011; Ahmad et al., 2013). Satellite dataset offers unique possibilities for spatial and temporal characterization of the changes. The basic requirement is the availability of different dates of imagery which permits continuous monitoring of change and environmental developments

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over time (Ayman and Ashraf, 2009; Ahmad and Shafique, 2013).

The EVI/NDVI pixel values were used to calculate fractional yield (Shinners and Binversie, 2007; Ahmad et al., 2013) from February, 2000 to February, 2013. The NDVI pixel values showed theoretical yield and EVI pixel values showed actual yield. The fractional yield is computed following the equation:

$$\text{Fractional Yield} = \frac{\text{Actual Yield}}{\text{Theoretical Yield}} \text{ x } 100$$

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 NDVI or EVI. 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; 2012b; Ahmad and Shafique, 2013).

Vegetation phenology derived from RS is important for a variety of applications (Hufkens et al., 2010; Ahmad, 2012b). Vegetation phenology can provide a useful signal for classifying vegetated land cover (Dennison and Roberts, 2003; Ahmad, 2012b). Changes in vegetation spectral response caused by phenology can conceal longer term changes in the landscape (Hobbs, 1989; Lambin, 1996; Dennison and Roberts, 2003; Ahmad, 2012b). Multi-temporal data that captures these spectral differences can improve reparability of vegetation types over classifications based on single date imagery (DeFries et al., 1995; Ahmad, 2012b).

III. Results

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; Ahmad, 2012a), 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; Ahmad, 2012a).

The application of the NDVI (Rouse et al., 1973; Tucker, 1979; Ahmad, 2012a) 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; Ahmad, 2012a).

The NDVI has been widely used for vegetation monitoring primarily for its simplicity. It is conceived as the normalized difference between the minimum peak of reflectance in the red wavelength and the maximum reflectance in the NIR domain: the higher the index value the better the vegetation conditions in terms of both biomass amount and vegetation health (Daughtry et al., 2000; Haboudane et al., 2002; Stroppiana et al., 2006).

Vegetation extraction from satellite imagery is the process of extracting vegetation information by interpreting satellite images based on the interpretation elements and association information (Xie, 2008; Ahmad and Shafique, 2013). Hyperspectral vegetation research is still based on multi-spectral indices used as reference or contemporary data. These indices are readily adaptable to hyperspectral data but remain problematic in arid and semi-arid areas (Broge and Leblanc, 2000; McGwire et al., 2000; Frank and Menz, 2003; Ahmad and Shafique, 2013). Hyperspectral data could provide much more possibilities compared with multi-spectral data in detecting and quantifying sparse vegetation because it provides a continuous spectrum across a range in wavelengths (Kumar et al., 2001; Frank and Menz, 2003; Ahmad and Shafique, 2013).

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; Ahmad, 2012a), direct human drivers such as land uses and land covers changes (Grau et al., 2005; Fearnside, 2005; Huang et al., 2007; Baldi and Paruelo, 2008; Baldi et al., 2008; Ahmad, 2012a), infrastructure enterprises (Canziani et al., 2006; Baldi et al., 2008; Ahmad, 2012a), and urban expansion (Romero and Ordenes, 2004; Pauchard et al., 2006; Baldi et al., 2008; Ahmad, 2012a; Ahmad, 2012f) took place.

Figure 4 shows classified NDVI 2001, Narowal. After rectification, the NDVI model was applied upon Landsat ETM+ image acquired on 30th September, 2001. ArcGIS symbology tool was used to develop NDVI classes and recognize the paddy cropped areas in Narowal. Maximum NDVI, minimum NDVI, mean NDVI and standard deviation is given in Table 2.

Figure 5 shows classified NDVI 2010, Narowal. After rectification, the NDVI model was applied upon Landsat TM image acquired on 2nd November, 2010. ArcGIS symbology tool was used to develop NDVI classes and recognize the paddy cropped areas in Narowal. Maximum NDVI, minimum NDVI, mean NDVI and standard deviation is given in Table 2.

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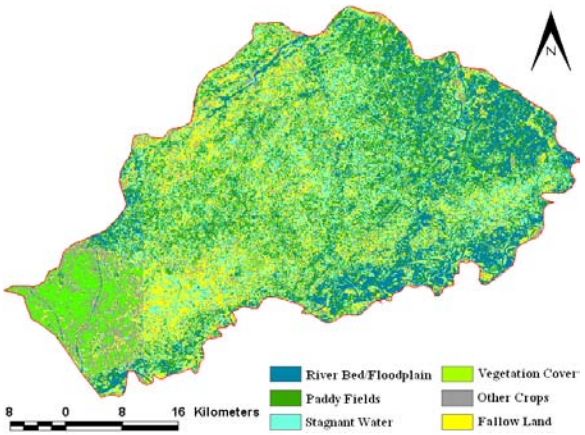


Figure 4 : Classified NDVI 2001, Narowal

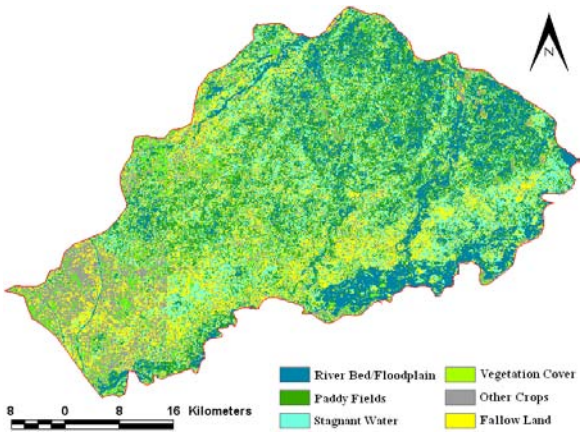


Figure 5 : Classified NDVI 2010, Narowal

Table 2 : NDVI values of Landsat TM/ETM+ image

Image Acquisition Date	Maximum NDVI	Minimum NDVI	Mean NDVI	Standard Deviation
30th September, 2001 (Landsat ETM+)	0.56	-0.42	0.05	0.11
2nd November, 2010 (Landsat TM)	0.65	-0.40	0.13	0.11

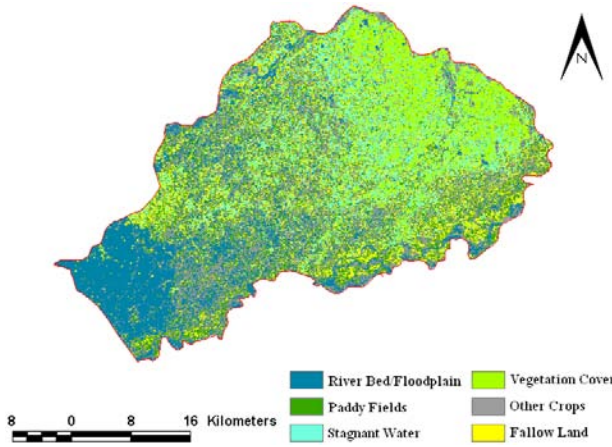


Figure 6 : Supervised Classification 2001

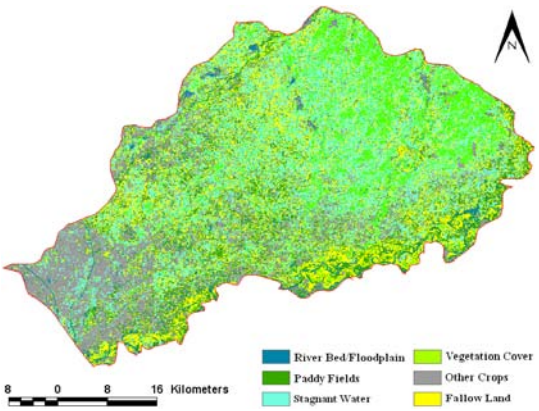


Figure 7 : Supervised Classification 2010

Table 3 : Supervised Classification of Landsat ETM+ image

Image Acquisition Date	Classes	Area (km^2)	Area (%)	Accuracy Assessment (%)
30th September, 2001 (Landsat ETM+)	River Bed/Floodplain	498.69	19.37	87.42
	Paddy Fields	430.88	16.73	85.44
	Stagnant Water	382.97	14.87	87.08
	Vegetation Cover	294.12	11.42	88.45
	Other Crops	565.24	21.95	92.20
	Fallow Land	403.10	15.66	87.29
	SUM	2575	100	-

Figure 6 shows supervised classification 2001, Narowal. The classification was applied upon Landsat ETM+ image acquired on 30th September, 2001. The findings showed that the river bed/floodplain covered the area of 498.69 km^2 (19.37%), paddy fields 430.88 km^2 (16.73%), stagnant water 382.97 km^2 (14.87%), vegetation cover 294.12 km^2 (11.42%), fallow land 403.10 km^2 (15.66%) while other crops covered the area of 565.24 km^2 (21.95%). Accuracy assessment is given in the Table 3.

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Table 4 : Supervised Classification of Landsat TM image

Image Acquisition Date	Classes	Area (km^2)	Area (%)	Accuracy Assessment (%)
2nd November, 2010 (Landsat TM)	River Bed/Floodplain	481.90	18.71	87.02
	Paddy Fields	400.14	15.53	88.04
	Stagnant Water	359.31	13.95	92.04
	Vegetation Cover	320.48	12.45	85.42
	Other Crops	467.01	18.14	90.20
	Fallow Land	546.16	21.22	87.09
	SUM	2575	100	-

Figure 7 shows supervised classification 2010, Narowal. The classification was applied upon Landsat TM image acquired on 2nd November, 2010. The findings showed that the river bed/floodplain covered the area of 481.90 km^2 (18.71%), paddy fields 400.14 km^2 (15.53%), stagnant water 359.31 km^2 (13.95%), vegetation cover 320.48 km^2 (12.45%), fallow land 546.16 km^2 (21.22%) while other crops covered the area of 467.01 km^2 (18.14%). Accuracy assessment is given in the Table 4.

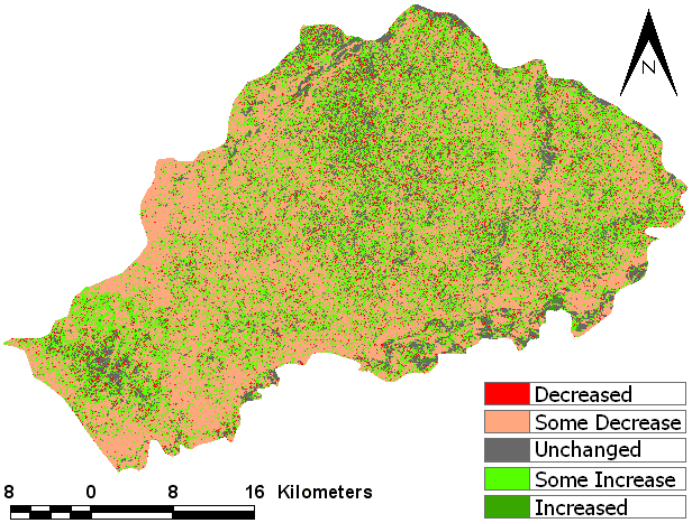


Figure 8 : Image Difference (2001-2010) at Narowal

Table 5 : Image Difference (2001-2010) at Narowal

Classes	During 2001 to 2010		
	Area (km^2)	Area (%)	Accuracy Assessment (%)
Decreased	1254.83	48.73	87.31
Some Decrease	840.27	32.64	90.19
Unchanged	133.95	5.20	87.22
Some Increase	336.37	13.06	85.79
Increased	9.58	0.37	92.14
SUM	2575	100	-

Figure 8 shows image difference or change detection (2001-2010) at Narowal. The findings showed that decreased was 1254.83 km^2 (48.73%), some decrease 840.27 km^2 (32.64%), unchanged was 133.95 km^2 (5.20%), some increase 336.37 km^2 (13.06%) while increased was 9.58 km^2 (0.37%). Decreased and some decrease in vegetation cover was much higher as compared to some increase and increased. Accuracy assessment is given in the Table 5.

Detection of change is the measure of the distinct data framework and thematic change information that can direct to more tangible insights into underlying process involving land cover and land-use changes (Singh et al., 2013; Ahmad and Shafique, 2013). Monitoring the locations and distributions of land cover changes is important for establishing links between policy decisions, regulatory actions and subsequent land-use activities (Lunetta et al., 2006;

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Ahmad and Shafique, 2013). Change detection as defined by Hoffer (1978) is temporal effects as variation in spectral response involves situations where the spectral characteristics of the vegetation or other cover type in a given location change over time. Singh (1989) described change detection as a process that observes the differences of an object or phenomenon at different times (Adia and Rabiu, 2008; Ahmad and Shafique, 2013).

Accurate assessment of vegetation response across multiple-year time scales is crucial for analyses of global change (Running and Nemani, 1991; Sellers et al., 1994; Stow, 1995; Justice et al., 1998; Fensholt, 2004; Baugh and Groeneveld, 2006; Ahmad, 2012c), effects of human activities (Moran et al., 1997; Milich and Weiss 2000; Thiam, 2003; Baugh and Groeneveld, 2006; Ahmad, 2012c) and ecological relationships (Baret and Guyot, 1991; Asrar et al., 1992; Begue, 1993; Epiphanio and Huete, 1995; Gillies et al., 1997; Baugh and Groeneveld, 2006; Ahmad, 2012c).

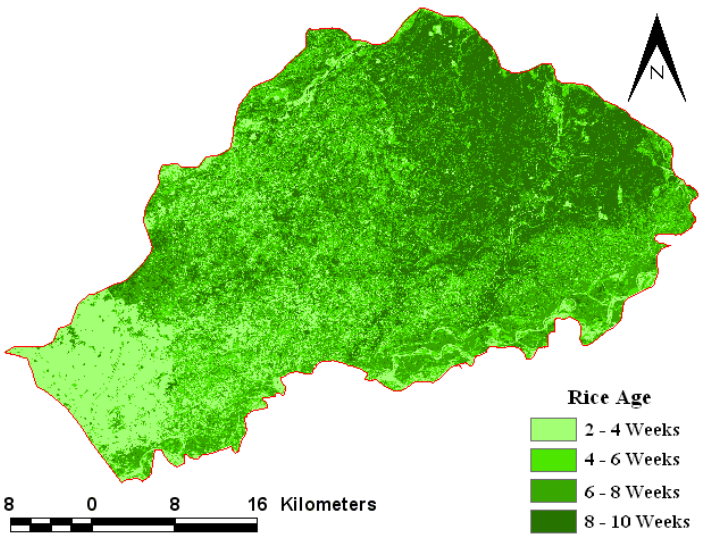


Figure 9 : Paddy/rice fields distribution map of Narowal from the analysis of Landsat ETM+ image

Figure 9 shows paddy/rice fields distribution map of Narowal from the analysis of Landsat ETM+ image using the following Rice Growth Vegetation Index (RGVI) model. In Narowal, especially in early transplanting periods, water environment plays an important role in rice spectral (Nuarsa et al., 2011; Nuarsa et al., 2012). The blue band of Landsat ETM+ has good sensitivity to the existence of water; therefore, the development of RGVI used the B1, B3, B4, and B5 of Landsat ETM+ with the following equation (Nuarsa et al., 2011):

$$RGVI = \frac{(B4+B5+B7) - (B1+B3)}{(B4+B5+B7)}$$

Simplified equation is as follow:

$$RGVI = 1 - \frac{(B1+B3)}{(B4+B5+B7)}$$

Where RGVI is the rice growth vegetation index, and B1, B3, B4, B5, and B7 refer to the band of Landsat ETM+. Theoretically, rice fields in normal conditions are the same, like vegetation in general (Nuarsa et al., 2011). Chlorophyll pigments, present in leaves absorb red light. In the near-infrared portion, radiation is scattered by the internal spongy mesophyll leaf structure, which leads to higher values in near-infrared channels. This interaction between leaves and the light that strikes them is often determined by their different responses in the red and near-infrared portions of reflective light (Niel and McVicar, 2001; Nuarsa et al., 2005; Nuarsa et al., 2011; Nuarsa et al., 2012). In contrast, absorption properties of the middle infrared band cause a low reflectance of rice fields in this channel (Lillesand and Kiefer, 1994; Nuarsa et al., 2011).

RS has been widely applied and recognized as a powerful/effective tool in detecting land use and land cover changes (Nuarsa et al., 2011). Landsat satellite images have 8 bands, including a thermal and a panchromatic band. In visible, near-infrared and middle infrared regions, Landsat ETM+ has 30-m spatial resolution. However, in thermal and panchromatic regions, spatial resolutions are 60 m and 15 m, respectively (Nuarsa et al., 2005; Nuarsa et al., 2011). This study used both visible and reflectance infrareds (Band-1 - 5 and band-7) of Landsat ETM+ (Nuarsa et al., 2011). Although the Landsat ETM+ used in this study had the SLC off, considerations of better spatial, spectral, and temporal resolution of these images made it relevant to use. With 16 days of temporal resolution,

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Landsat ETM+ was the ideal satellite image for rice monitoring (Nuarsa et al., 2011; Nuarsa et al., 2012).

The visible band of Landsat ETM+ (Band 1, Band 2, and Band 3) showed a weak exponential relationship to rice age; however, the reflective infrared band of Landsat ETM+ (Band 4 and B5) and the Rice Growth Vegetation Index (RGVI) showed a strong exponential relationship to rice age (Nuarsa et al., 2005; Nuarsa et al., 2011; Nuarsa et al., 2012). Use of vegetation indexes to monitor and map rice field gives better results than use of a single band of Landsat ETM+. RGVI is a better vegetation index to describe rice age than existing vegetation indexes (Nuarsa et al., 2011) like EVI. Paddy/rice fields have specific land cover properties. Rice land coverage changes during the rice life circle. In irrigated rice fields of Narowal, almost all land coverage is dominated by water during the plantation period. As the rice ages, rice vegetation coverage grows and reaches a maximum (rice age = 2½ months) and then gradually decreases until harvest time (Shao et al., 2001; Nuarsa et al., 2005; Nuarsa et al., 2011).

Figure 10 shows time-series phenology metrics for Bara Manga district Narowal. In this profile MODIS (Terra) EVI/NDVI 250 m data products for the period February 2000 to February 2013 at 16-days interval was evaluated. The NDVI value in February 2000 (start) was 0.79 and the NDVI value in February 2013 (end) was 0.66 while EVI pixel value in February 2000 (start) was 5835 and in February 2013 (end) was 3786. The maximum NDVI value (0.87) was recorded in February 2007 while minimum NDVI value (0.05) was in January 2003. The trend analysis (NDVI) showed no change during the entire period. The phenological profile showed the paddy crop growth stages (transplanting to maturity and further ripening) at Bara Manga. The fluctuations in the phenological profile were due to variation in the temperature-precipitation. 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; Ahmad, 2012a).

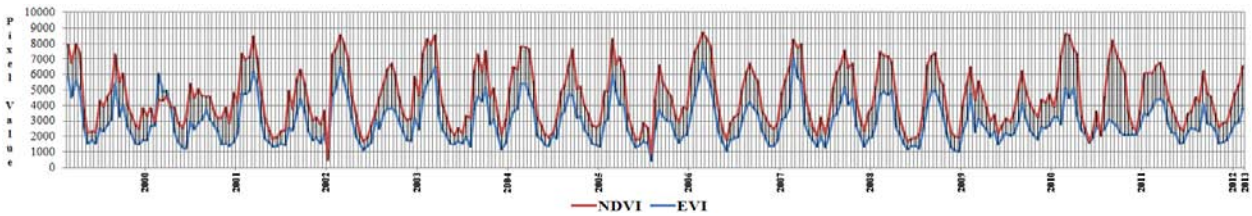


Figure 10 : Time series phenology metrics for Bara Manga *Processed by the author*

Figure 11 shows time-series phenology metrics for Becochak district Narowal. The NDVI value in February 2000 (start) was 0.57 and NDVI value in February 2013 (end) was 0.62; EVI pixel value in February 2000 (start) was 3287 and in February 2013 (end) was 3306. The maximum NDVI value (0.85) was recorded in July 2011 while the minimum NDVI value (0.05) was in January 2003. Liu and Huete (1995) integrated atmospheric resistance and background effects in NDVI to enhance vegetation signals in high biomass regions and proposed EVI (Ahmad, 2012c).

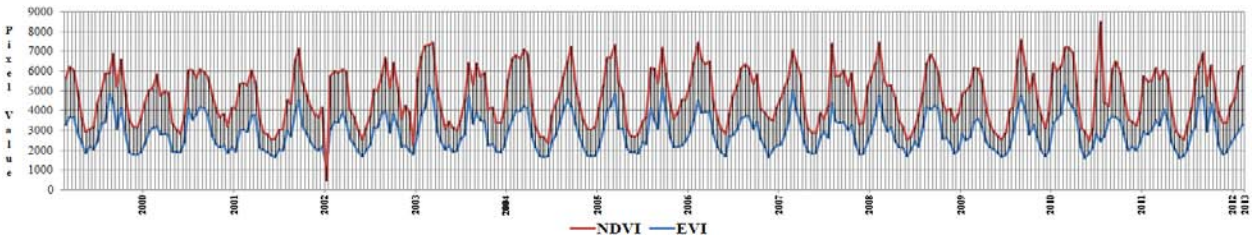


Figure 11 : Time series phenology metrics for Becochak *Processed by the author*

Figure 12 shows time-series phenology metrics for Boora Dala district Narowal. The NDVI value in February 2000 (start) was 0.53 and the NDVI value in February 2013 (end) was 0.63 while EVI pixel value in February 2000 (start) was 3375 and in February 2013 (end) was 3441. The maximum NDVI value (0.79) was recorded in March 2011 while minimum NDVI value (0.04) was in January 2003. The EVI differs from NDVI because of endeavor to differentiate atmospheric and background effects (Ahmad, 2012b). The EVI is better to categorize little differences in dense vegetative areas, where NDVI showed saturation (Ahmad and Shafique, 2013).

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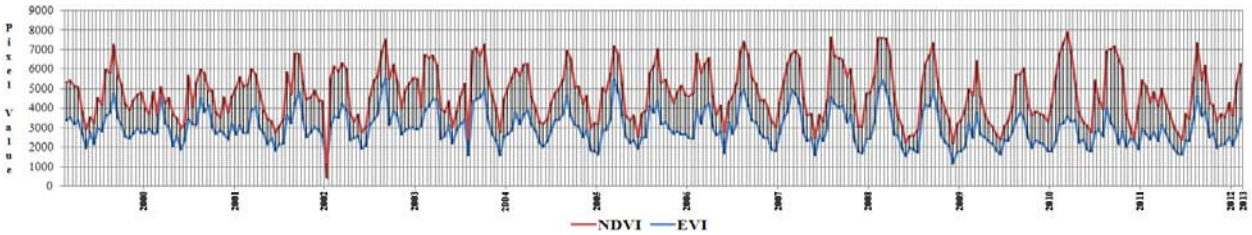


Figure 12 : Time series phenology metrics for Boora Dala *Processed by the author*

Figure 13 shows time-series phenology metrics for Budha Dhola district Narowal. The NDVI value in February 2000 (start) was 0.60 and the NDVI value in February 2013 (end) was 0.73 while EVI pixel value in February 2000 (start) was 3873 and in February 2013 (end) was 2998. The maximum NDVI value (0.83) was recorded in January 2013 while minimum NDVI value (0.04) was in January 2003. The green cover fraction and 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 2012b; Ahmad and Shafique, 2013). The EVI values are generally lower in order to avoid saturation in high biomass areas (Huete et al., 2002).

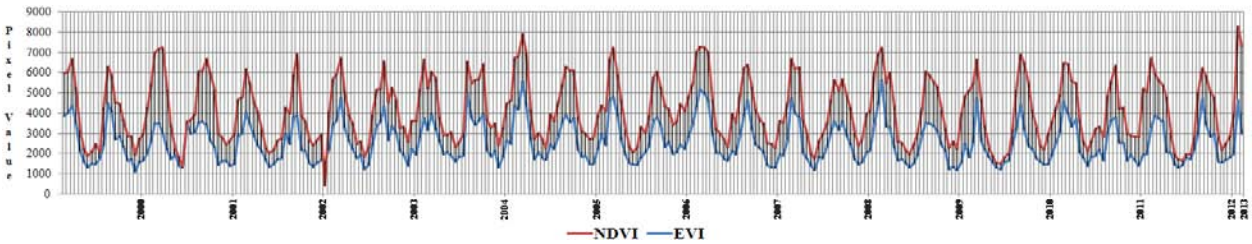


Figure 13 : Time series phenology metrics for Budha Dhola *Processed by the author*

Figure 14 shows time-series phenology metrics for Fattu Chak district Narowal. The NDVI value in February 2000 (start) was 0.46 and the NDVI value in February 2013 (end) was 0.66 while EVI pixel value in February 2000 (start) was 3433 and in February 2013 (end) was 4140. The maximum NDVI value (0.81) was recorded in March 2007 while minimum NDVI value (0.04) was in January 2003. The evolution of vegetation index exhibits a strong correlation with the typical green vegetation growth stages (Zhao et al., 2005; Ahmad, 2012d). The results (temporal curves) can be analyzed to obtain useful information such as the start/end of vegetation growing season. However, RS 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 RS, 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; Ahmad, 2012d).

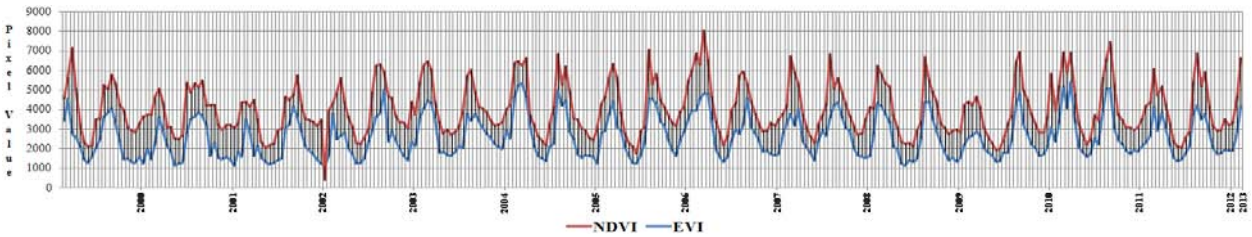


Figure 14 : Time series phenology metrics for Fattu Chak *Processed by the author*

Figure 15 shows time-series phenology metrics for Gumtala district Narowal. The NDVI value in February 2000 (start) was 0.38 and the NDVI value in February 2013 (end) was 0.58 while EVI pixel value in February 2000 (start) was 2453 and in February 2013 (end) was 3450. The maximum NDVI value (0.70) was recorded in August 2011 while minimum NDVI value (0.04) was in January 2003. 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, 2012a) but also effective for monitoring rainfall and drought, estimating net primary production of vegetation, crop growth conditions and crop yield, detecting weather impacts and other events important for agriculture and ecology (Glenn, 2008).

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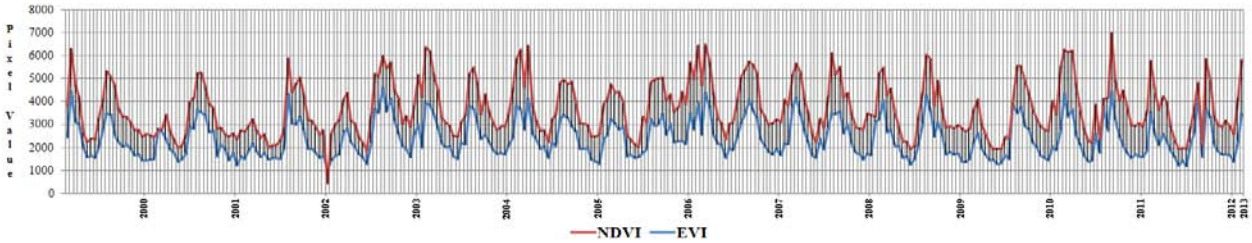


Figure 15 : Time series phenology metrics for Gumtala *Processed by the author*

Figure 16 shows time-series phenology metrics for Lalian district Narowal. The NDVI value in February 2000 (start) was 0.49 and the NDVI value in February 2013 (end) was 0.50 while EVI pixel value in February 2000 (start) was 3291 and in February 2013 (end) was 3001. The maximum NDVI value (0.85) was recorded in August 2010 while minimum NDVI value (0.04) was in January 2003. The application of the NDVI (Rouse et al., 1973; Tucker, 1979; Ahmad, 2012a) 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; Ahmad, 2012a).

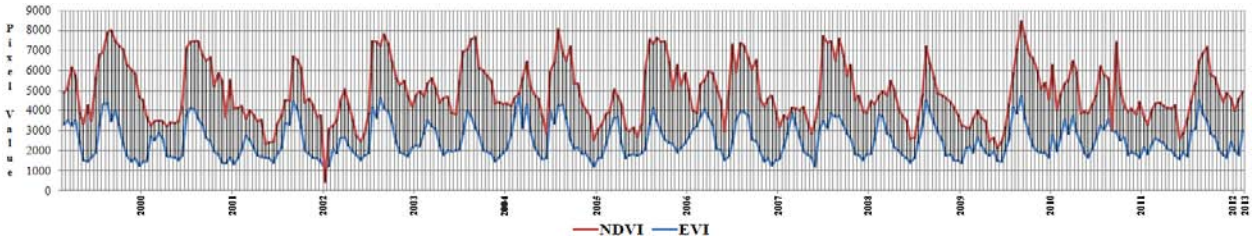


Figure 16 : Time series phenology metrics for Lalian *Processed by the author*

Figure 17 shows time-series phenology metrics for Naina Kot district Narowal. The NDVI value in February 2000 (start) was 0.80 and the NDVI value in February 2013 (end) was 0.66 while EVI pixel value in February 2000 (start) was 3524 and in February 2013 (end) was 3576. The maximum NDVI value (0.83) was recorded in September 2005 while minimum NDVI value (0.05) was in January 2003. The NDVI suppresses differential solar illumination effects of slope and aspect orientation (Lillesand and Kiefer, 1994; Sader et al., 2001; Ahmad and Shafique, 2013a) and helps to normalize differences in brightness values when processing multiple dates of imagery (Singh, 1986; Lyon et al., 1998; Sader et al., 2001; Ahmad and Shafique, 2013a).

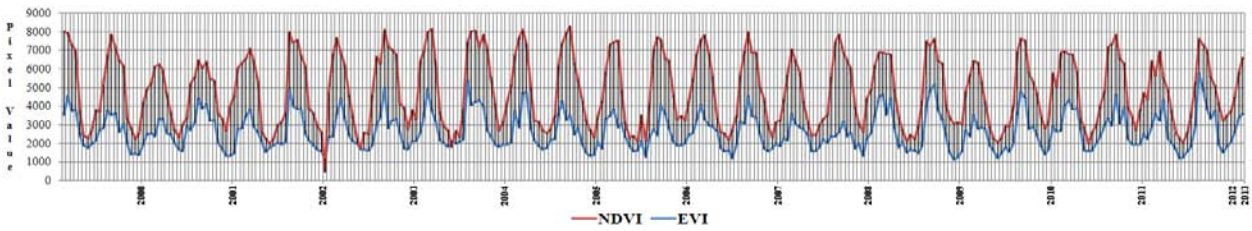


Figure 17 : Time series phenology metrics for Naina Kot *Processed by the author*

Figure 18 shows time-series phenology metrics for Nathoo Kot district Narowal. The NDVI value in February 2000 (start) was 0.60 and the NDVI value in February 2013 (end) was 0.77 while EVI pixel value in February 2000 (start) was 3944 and in February 2013 (end) was 5073. The maximum NDVI value (0.78) was recorded in March 2012 while minimum NDVI value (0.05) was in January 2003. RS 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, 2012e; Ahmad, 2012f). Changes in the phenological events may therefore signal important year-to-year climatic variations or even global environmental change (Botta et al., 2000; Jolly et al., 2005; Hashemi, 2010; Ahmad, 2012e; Ahmad, 2012f).

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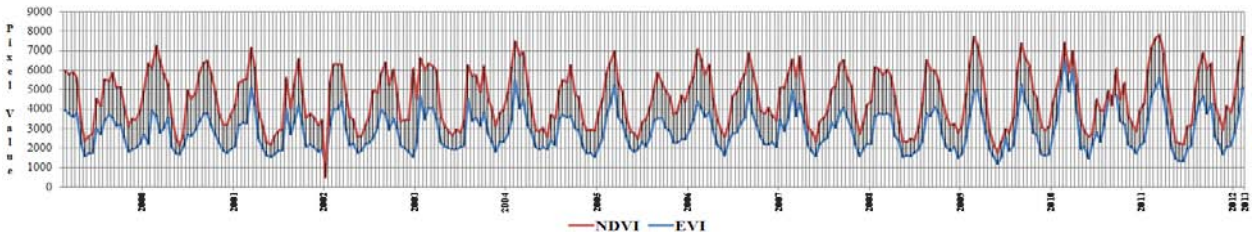


Figure 18 : Time series phenology metrics for Nathoo Kot *Processed by the author*

Figure 19 shows time-series phenology metrics for Pherowal district Narowal. The NDVI value in February 2000 (start) was 0.69 and the NDVI value in February 2013 (end) was 0.74 while EVI pixel value in February 2000 (start) was 4758 and in February 2013 (end) was 4289. The maximum NDVI value (0.80) was recorded in March 2012 while minimum NDVI value (0.04) was in January 2003. RS change detection techniques can be broadly classified as either pre or post classification change methods. Pre-classification methods can further be characterized as being spectral or phenology based (Lunetta et al., 2006; Ahmad and Shafique, 2013). 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 (Ahmad, 2012c). The use of vegetation indices, in general, takes into account mostly the green living vegetation (Cyr et al., 1995; Ahmad, 2012c).

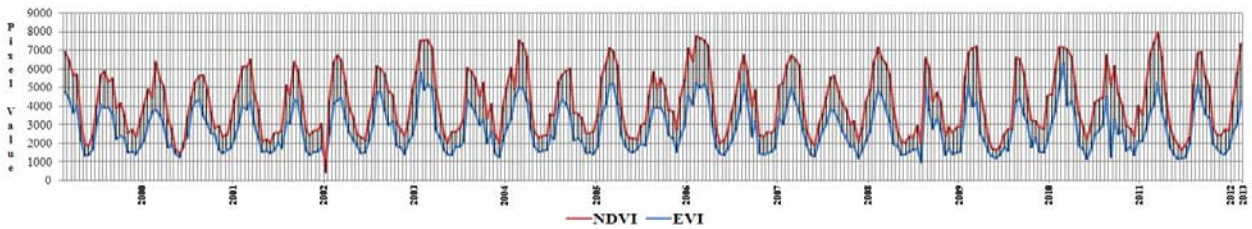


Figure 19 : Time series phenology metrics for Pherowal *Processed by the author*

Figure 20 shows time-series phenology metrics for Talwandi Bhindran district Narowal. The NDVI value in February 2000 (start) was 0.65 and the NDVI value in February 2013 (end) was 0.37 while EVI pixel value in February 2000 (start) was 4620 and in February 2013 (end) was 1722. The maximum NDVI value (0.79) was recorded in March 2005 while minimum NDVI value (0.04) was in January 2003. The NDVI is the most commonly used of all the VIs tested and its performance, due to non-systematic variation as described by Huete and Liu (1994) and Liu and Huete (1995). The soil background is a major surface component controlling the spectral behaviour of vegetation (Ahmad and Shafique, 2013). Although vegetation indices, such as the soil-adjusted (Huete, 1988) vegetation indices, considerably reduce these soils effects, estimation of the vegetation characteristics from the indices still suffers from some imprecision, especially at relatively low cover, if no information about the target is known (Rondeaux et al., 1996; Ahmad and Shafique, 2013).

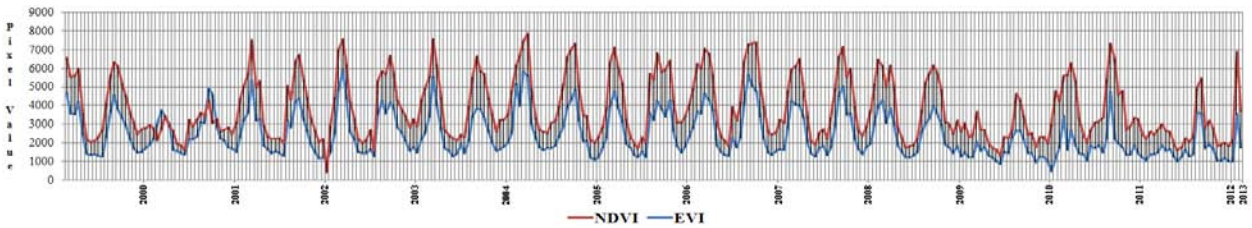


Figure 20 : Time series phenology metrics for Talwandi Bhindran *Processed by the author*

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Table 6 : MODIS (Terra) EVI/NDVI and Fractional Yield dataset of Naina Kot

Image Acquisition (Month/Year)	EVI Pixel Value	NDVI Pixel Value	Fractional Yield (%)	Image Acquisition (Month/Year)	EVI Pixel Value	NDVI Pixel Value	Fractional Yield (%)
Feb. 2000	3524	8008	44.01	Feb. 2007	4061	7586	53.53
May 2000	1775	2289	77.54	May 2007	1590	2557	62.18
Aug. 2000	3516	7839	44.85	Aug. 2007	4531	7971	56.84
Nov. 2000	1411	2874	49.10	Nov. 2007	1585	3025	52.40
Feb. 2001	2363	6118	38.62	Feb. 2008	3564	7055	50.52
May 2001	1677	2332	71.91	May 2008	1602	2447	65.47
Aug. 2001	3847	6021	63.89	Aug. 2008	2607	7832	33.29
Nov. 2001	1687	3317	50.86	Nov. 2008	1984	3079	64.44
Feb. 2002	3415	6524	52.35	Feb. 2009	4595	6857	67.01
May 2002	1782	1957	91.06	May 2009	1491	2121	70.30
Aug. 2002	3988	7373	54.09	Aug. 2009	4786	7202	66.45
Nov. 2002	1904	3596	52.95	Nov. 2009	1485	3416	43.47
Feb. 2003	3506	7671	45.70	Feb. 2010	3510	6422	54.66
May 2003	1669	1707	98.12	May 2010	1205	2068	58.27
Aug. 2003	4981	8101	61.49	Aug. 2010	4740	7610	62.29
Nov. 2003	1699	3922	43.32	Nov. 2010	1816	3405	53.33
Feb. 2004	4858	7968	60.97	Feb. 2011	3994	6968	57.32
May 2004	2133	1792	119.03	May 2011	1602	1961	81.70
Aug. 2004	4214	8057	52.30	Aug. 2011	2929	7303	40.08
Nov. 2004	1937	4090	47.36	Nov. 2011	1951	3409	57.23
Feb. 2005	2863	7701	37.18	Feb. 2012	3559	5639	63.11
May 2005	1684	2324	61.82	May 2012	1206	2283	52.83
Aug. 2005	3252	7920	41.06	Aug. 2012	4804	7263	66.14
Nov. 2005	1497	3240	46.20	Nov. 2012	1500	3205	46.80
Feb. 2006	3481	7309	47.63	Feb. 2013	3576	6584	54.31
May 2006	1578	2434	64.83				
Aug. 2006	2441	7710	31.66				
Nov. 2006	1907	3292	57.93				

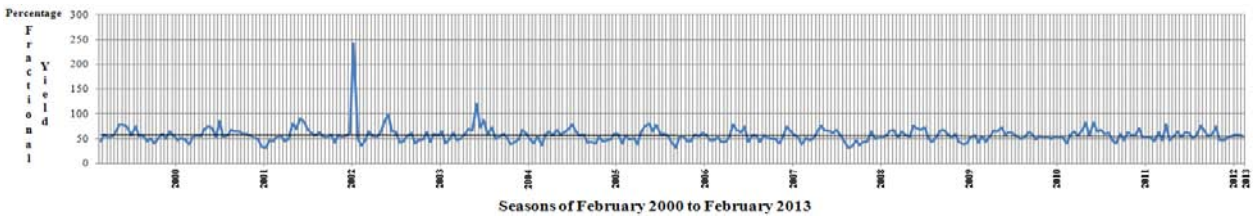


Figure 21 : Linear forecast trendline for the dataset of Naina Kot

Linear forecast trendline was plotted upon the fractional yield dataset of Naina Kot (Table 6; Figure 21) to investigate the general trend. Linear forecast trendline showed that fractional yield at Naina Kot was smooth during the entire period. The findings showed that January 2003 was the driest month during the entire period; February 2000 to February 2013. Heavy amount of fertilizer was used for crop growth and soil productivity.

IV. Discussion and Conclusions

RS datasets and techniques have already proven to be relevant to many requirements of crop inventory and monitoring (Haboudane et al., 2002). At the present, there is an increased interest in precision farming and the development of smart systems for agricultural resource management; these relatively new approaches aim to increase the productivity, optimize the profitability, and protect the environment. In this context, image-based RS technology is seen as a key tool to provide valuable information that is still lacking or inappropriate to the achievement of sustainable and efficient agricultural practices (Moran et al., 1997; Daughtry et al., 2000; Haboudane et al., 2002).

RS 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, 2012a; 2012f). The study also identified several data acquisition and processing issues that warrant further investigation. Studies are under way to assess the importance of coordinating and

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timing field data collection and image acquisition dates as a means of improving the strength of the relationships between image and land condition trend analysis (Senseman et al., 1996; Ahmad, 2012c) ground-truth data. Recent literature has shown that the narrow bands may be crucial for providing additional information with significant improvements over broad bands in quantifying biophysical characteristics of paddy/rice crop (Thenkabail et al., 2000).

RS of agricultural resources is based on the measurement of the electromagnetic energy reflected or emitted from the Earth surface as a result of the energy matter interaction. RS data interpretation and processing aim to derive vegetation biophysical properties from its spectral properties (Stroppiana et al., 2006).

Spectral-based change detection techniques have tended to be performance limited in biologically complex ecosystems due, in larger part, to phenology-induced errors (Lunetta et al., 2002; Lunetta et al., 2002a; Lunetta et al., 2006; Ahmad and Shafique, 2013). An important consideration for land cover change detection is the nominal temporal frequency of remote sensor data acquisitions required to adequately characterize change events (Lunetta et al., 2004; Lunetta et al., 2006; Ahmad and Shafique, 2013). Ecosystem-specific regeneration rates are important considerations for determining the required frequency of data collections to minimize errors. As part of the natural processes associated with vegetation dynamics, plants undergo intra-annual cycles. During different stages of vegetation growth, plants' structure and associated pigment assemblages can vary significantly (Lunetta et al., 2006; Ahmad and Shafique, 2013).

Validation is a key issue in RS based studies of phenology over large areas (Huete, 1999; Schwartz and Reed, 1999; Zhang et al., 2003; 2004; Ahmad, 2012d). While a variety of field programs for monitoring phenology have been initiated (Schwartz, 1999; Zhang et al., 2003; 2004; Ahmad, 2012d), these programs provide data that is typically specie-specific and which is collected at scales that are not compatible with coarse resolution RS observations.

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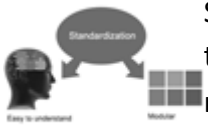


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References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

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