Assessment of Sand Encroachment Using Remote Sensing and GIS: Case Study Dongola Area, Sudan

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Desertification is land degradation in arid, and semi-arid and dry sub-humid areas resulting from various factors including climatic variations and human activities (UNCCD, 1994). The major desertification processes are wind erosion, water erosion, denudation of vegetation cover while the other minor ones include salinization, sodicity and compaction of the soil. The Sudanese Desert Encroachment Control and Rehabilitation Programme (DECARP, 1976) concluded that “it appears that no one single factor causes desertification. Obviously, it is a combination of factors, involving fragile ecosystem developed under harsh and fluctuating climate, and man’s activities, some of which are increased in an irreversible magnitude by weather fluctuations, especially periodic drought”.

Sand encroachment is one of the main problems threatening the agricultural production in some parts of the Sudan and in particular the northern State. Wind and water erosion are the major environmental hazards in this State. An understanding of the extent of wind and water erosion on various field surfaces is essential for the selection of appropriate control and preventive measures against land degradation. Furthermore, there is a need to know the appropriate field conditions prior to making any attempts to reduce wind and water erosion to permissible levels. Salih (1996) stated that sand moves from north to south at an alarming rate, and under those conditions 13 Sudanese States out of the 26 are affected by land degradation. He further postulated that sand and sand dunes in the areas between latitudes 10° and 18° N had originated from the weathering products of the Basement complex, Nubian Sandstone together with alluvial deposit. Eltigani (1996) and Awad and Drag (2004) agreed with Salih (1996) findings and concluded that the Northern state is one of these 13 States in the Sudan affected by desertification.

Remote sensing can be defined as the science of collection, processing and interpretation of images and related data, obtained from aircraft and satellites, which record the interaction between matter and electromagnetic radiation (Sabins, 1997). In the Sudan the use of remote sensing technology is a cost- and time-effective way for surveying natural resources. Starting from 1971 remote sensing has been used in natural resources surveys of specific areas chosen by Food and Agricultural Organization (FAO) for testing the possible utilization of remote sensing for surveying, mapping, planning and developing natural resources. Lampery (1975) studied vegetation change in the Sudan and concluded that the desert was then moving southwards with a rate of 5-6 km per year. He attributed this spread of desertification to misuse of land by people. However, Hellden (1978, 1988) showed that there was no systematic desert encroachment and criticized the findings of Lampery (1975) as misinterpretations resulting from his application of the vegetation map of Jackson and Harrison (1958), which depended mainly on the 100mm rainfall isohyets. Hellden (1978, 1988) stated that vegetation recovered during the rainy season.
The flow of the river Nile is affected by the joining flow of the Blue Nile, White Nile and Atbara River (Abdel Salam, 2001). River Nile course is affected by bank erosion especially at the meandering sites and sedimentation of suspended material in form of islands and flood plains. This study aims to assess sand encroachment in Dongla area for the period 1961 to 2000 with emphasis on its effect on productive lands and River Nile course. Satellite imageries and GIS techniques were used.

Dongla area is located in the Northern State, Sudan. It is characterized by a desert climate with very low and irregular rainfall, very hot summers and cool winters. The wind blows most of the year in a north to south direction. The population of area is estimated as 291,630 (Sudan Statistics, 1993). The area is generally a broad peneplain with few scattered mountains along the banks of the River Nile. The Soils in Northern State are categorized into three major types; Entisols which are the dominant soils of the active flood plain that receive annual alluvium deposits, Aridisols which are the soils of the high terrace that had not been flooded for a long time and accordingly have shown limited horizon development and the miscellaneous soil types (Desert soils) which are mainly sandy soils mixed with other miscellaneous land types. Agriculture is practiced mainly on small areas of the Gerf soils (Entisols), but these highly productive soils are currently seriously threatened by sand encroachment.

Landsat images acquired for this area are MSS Landsat (188/47) 1972, TM Landsat (175/47) 1996 and TM Landsat (175/47) 2000. Aerial photos for years 1961 and 2002 were scanned and used in digital forms in the rest of the study. The field work was conducted during the period 29/5/2004 to 11/6/2004 aided by Garmin 12 XL GPS.

Global and linear Enhancement was conducted, in addition to radiometric and geometric corrections for the geo-referenced images using ground control points and first order transformation with an error of < 1.0 pixel. Supervised and unsupervised digital classifications were used based on visual interpretation and the field work. Areas and percentage of the areas affected by sand in each year were determined, and then post classification change detection approach based on map calculation was applied to determine the dynamic of change in sand encroachment.

Visual interpretation showed that sand moved from eastern, western and north western parts of the study area towards the River Nile and Dongola town area. Sand movement is affected by the dominant direction of the prevailing wind in both summer and winter season. In summer the dominant one is the southwesterly wind which steered the sand towards the west bank of the river and away from eastern one. While in winter the dominant wind is the northeasterly one which steered sand toward the eastern bank of the river and away from the western bank.

The area covered by sand dune increased from 51.2 Km2 to 61.2 km2 during the period between 1976 and 1996. However, it decreased to 35.1 km2 in 2000. Moreover, the aerial photos interpretation confirmed the increased pattern of sand dunes for the period between years 1961 to 2002. The apparent decrease of the area covered by sand could be explained by a corresponding increase of the area covered by gravel plus fine and/or coarse sand. This result indicated that the sand dune were active and shifted from one place to an other affected by the direction of the prevailing wind exposing underline gravel plus sand. This suggests that increase in the area covered by gravel plus coarse and/or fine sand could be used as indicator to land degradation in Dongla area. However the outstriking phenomenon was the appearance of sand dunes on the
eastern bank of the River Nile. This sand could have been moved either in suspension from the western part of the River Nile or through sheet or bouncing from the north or the north eastern part of the study area. However, the increase of area covered by sand dune could be attributed to expansion of agricultural activities near to urban areas possibly coupled with climatic variations. These finding agreed with Salih (1996) Eltigani (1996) and Awad and Drag (2004) who found that sand encroachment was a real problem in the Northern Stat of the Sudan.

**River Nile Course**

The Nile River course showed a consistent stable pattern, however the changes in the River Nile course could be due to water erosion along one bank and deposition on the other bank particularly on curvatures due to the meanderings of the Nile. This was confirmed by increase of island areas. However 2000 witnessed an increase in the area covered by River Nile course. This could be attributed to the exceptionally high flood during that year in which either islands and/or active terraces of the Nile were covered by flood water. Figures showed that sand dunes in addition to sandy soil covered a large area along the Nile river course, in addition to islands. This was clearly observed in the satellite images of 1996 and 2000 and aerial photo of 2002.

It is obvious that sand encroachment threatens the River Nile course and the highly productive areas. These findings were supported with the finding of Abdel Salam (2001). This situation will certainly endanger the livelihood of local inhabitants of the area and can lead to more losses of fertile soils of the first terraces of the River Nile (Gerf soils).

**Conclusion and Recommendation**

Sand encroachment threatens the highly productive agricultural land and settlements in Dongola area. This will endanger the livelihood of inhabitants in this area, therefore there is a critical need for adoptions of certain measurements to face this problem such as:

- Adoption of strategies for sand dunes stabilization through plantation of shelter belts to retard sand movement.
- Construction of the proposed canal starting from Marawi dam at the eastern side of the River Nile and up to Dongola province.
- Adoption of optimal land uses that are suitable for these vulnerable areas.
- Improve the awareness of the inhabitants about this problem.
- Conduction of research aiming towards understanding the origin of encroaching sand and creation of new methods to prevent sand encroachments.