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A Decision Support Tool to Assess Desertification Condition in Arid and Semi-Arid Regions

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Abstract: Desertification must be monitored on a regular basis so as to implement control measures in good time. There are a range of physical and biological processes involved, but they are seldom integrated into a single index. The "Tashur" decision support tool was developed to bring several indices together to assist in these types of operational decisions. The inputs include the NDVI (Normalized Difference Vegetation Index), the Aridity Index (AI), the long-term rainfall data, the Bare Soil Index (BSI), Moving Standard Deviation index (MSDI) and the Human Activities Impact (HAI). The model starts with an assessment of the NDVI then proceeds to the rainfall trend and changes in the AI. If these all show stable or increasing trends, then the condition of the area has improved or remained stable. If however they show a declining trend then the model also checks the BSI, MSDI and HAI, so as to be able to give an indication of the severity of desertification. This output can then trigger some action from decision makers, landscape planners and the landowner.

Key words: Decision support tool · Desertification · Tashur · Sudan

INTRODUCTION

Desertification encompasses a wide range of processes of a physical and biological nature. Knowing the extent and severity of the land degradation is important as decisions for effective control of the land degradation are made by policy makers and resources managers as well as the local communities and nomads [1]. Therefore, land degradation must be monitored on a regular basis so as to implement control measures in a good time. At present there is no easy way for decision makers to access the information available from the scientific research and so many of the decisions are made with inadequate or incomplete datasets. This should not be the case, as there are many highly sophisticated methods that could be used to analyze the data. The aim here is to make it easier for decision makers at various levels to access the data and integrate it so as to make an informed decision.

The wide range of physical and biological processes involved in land degradation and desertification are seldom integrated into a single index. The challenge is to bring local and scientific knowledge systems together into a single accessible and structured database. This would provide land users and managers as well as scientists with more opportunities to inform and stimulate each other to making improved assessment of the situation and a common basis to work from, for sound decision making. If land users are to be encouraged to become formally involved in the monitoring and adapting management process, they also require access to user friendly tools, which provide them with a view on the current status of the situation [2]. The decision support framework would provide an opportunity for the inclusion of software to support land planners and managers in assessing and interpreting the condition of their land. The most important part of the Decision Support Tool (DST) paradigm is the focus on the end-user [3] and the aim of developing a simple user friendly tool that can address some of the questions facing them.

The purpose of this paper is to describe the development of a decision support tool (DST) for assessment of the desertification severity in arid and semi-arid regions, by integrating biophysical and social parameters (both human and livestock population).

Methodology: The "Tashur" (it is an Arabic word mean desertification) decision support tool was developed as a user friendly tool to assess the severity of desertification in arid and semi-arid regions by integrating biophysical

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and social parameters [4]. It uses macros in a Microsoft Excel 2003 spreadsheet. It is based on the interaction between vegetation and climate factors with human activities, highlighting the role of climate change and climate variability in land degradation. “Tashur” is to be used to raise the awareness of the planners and policy makers working in agriculture, forestry, environment, water affairs and landscaping in arid and semi-arid regions concerning the impact of the desertification. It brings together several indices to assist in this type of operational decision.

The inputs include a long-term rainfall time series data (from either daily or monthly data), the Normalized difference Vegetation Index (NDVI), The Aridity Index (AI) [5] and satellite information which are used to calculate the Bare Soil Index (BSI) and the Moving Standard Deviation Index (MSDI) for at least two time intervals and the Human Activities Impact (HAI). NDVI is the most widely used vegetation index calculated from the visible red and infra-red channels monitored by various satellites and is sensitive to the presence of vegetation on the land surface. AI is important as predictions from global models are that the drylands will become hotter and drier due to an increased evaporation. AI is ratio between precipitation and potential evapotranspiration of the area and so can give an idea of changes in aridity of an area over time. BSI is used to map the bare soil areas and differentiate them from those covered with vegetation using the various bands from the Landsat satellite data. MSDI is standard deviation calculated for a moving window of nine pixels of data so as to be able to monitor the changes in the landscape that would be noticeable if degradation was occurring. HAI is calculated as the residual effect from the NDVI and the rainfall using a residual trend method [6]. The initial step of the model is used to name the site and give the time limits for the calculations.

RESULTS AND DISCUSSION

The model starts with the interface in Figure (1), which requires insert the name of the site and time scale. Then the trends of the NDVI, rainfall and aridity index are computed (Figure 2). If the three parameters show stable or increasing trends it means that there is no sign of degradation, then the condition of the area is considered to have remained stable or could even have improved. However, if any two of those indices show declining trend then it is necessary to do further analysis of the soil and human activities impact. The model can then proceed to check BSI, MSDI and HAI, (Figure 3) so

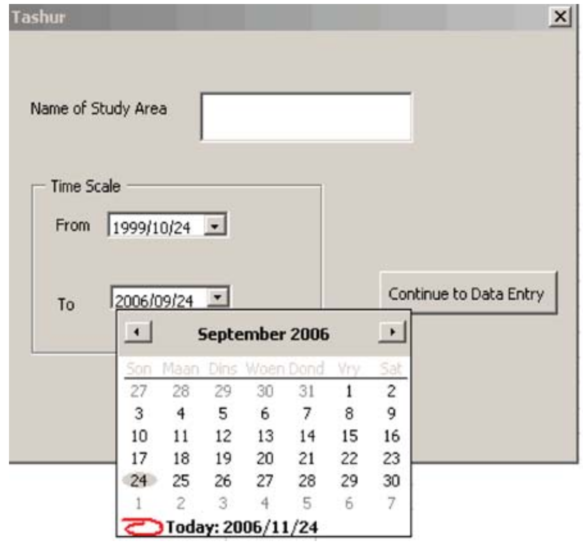

Fig. 1: The first step in which the name of the site and time scale are inserted

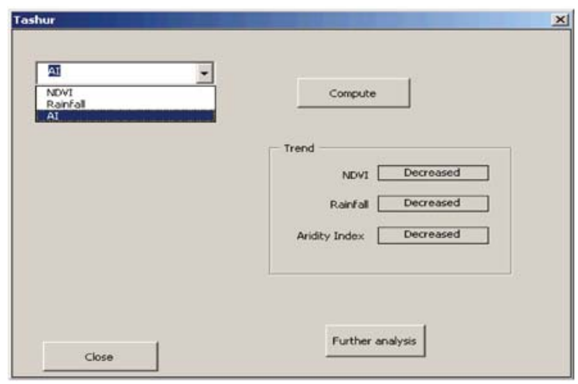

Fig. 2: The second step in which the NDVI, rainfall and Aridity Index trends are computed

as to be able to give an indication of the severity of desertification in the area under consideration. If the bare soil, heterogeneity of the landscape (MSDI) and the human activities impact, increased then the area classified in the “severe desertification” category (Figure 4). If the soil indices increased but the human impact is stable or decreasing there is “moderate desertification”. If the soil indices and the human impact were decreasing or stable then there is “slight desertification”. So all the necessary data needs to be acquired for the selected period and entered into Excel spreadsheet in the required format and then the model can be run. The final display will state the level of desertification in the selected area and then give outcome of the three trends (NDVI, Rainfall and AI) and the direction of the changes of the other three factors (MSDI, BSI and HAI).

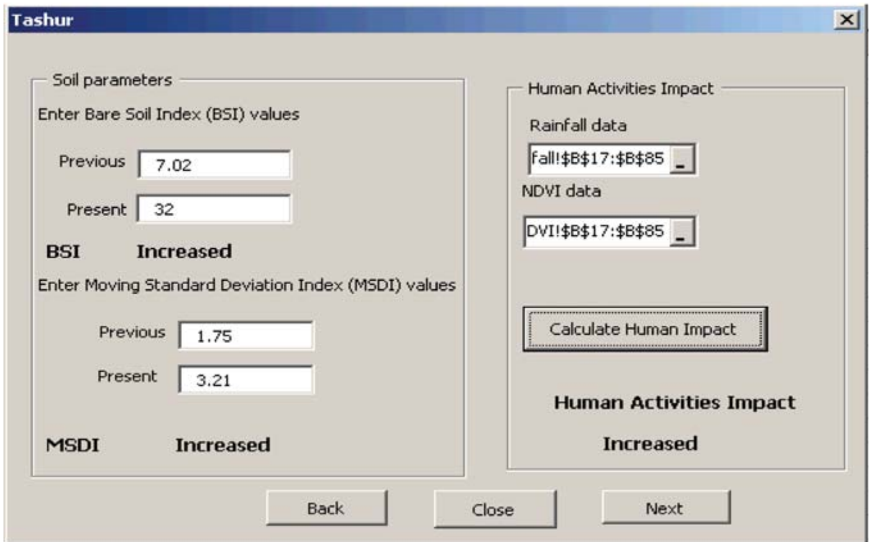

Fig. 3: Computation of the human activities impact and the soil parameters

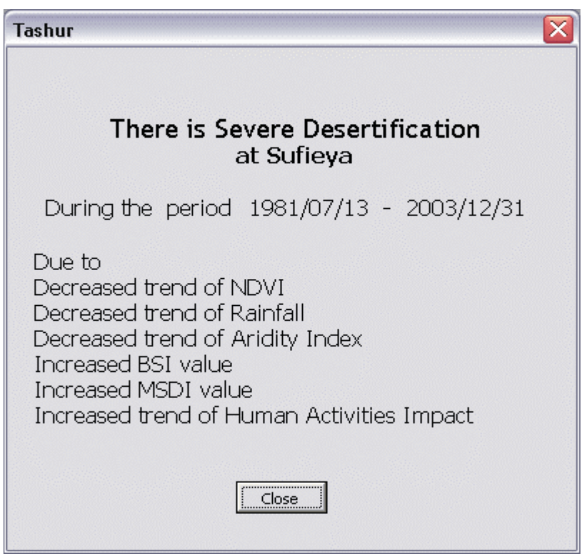

Fig. 4: The decision display by Tashur for the selected site

Three sites were selected to validate "Tashur" which represent two grazing areas and one irrigated site (Rahad irrigated scheme). Maximum monthly NDVI, monthly rainfall and AI covering the period between 13 July 1981 to 31 December 2003, together with the MSDI and BSI for 1987 and 2000 were used as input data. The calculation of NDVI, rainfall and Aridity Index for grazing sites showed decreased trend. In this case the first calculation alone was not sufficient to evaluate the landscape condition and more analysis will be needed for making a decision. Therefore, in order for "Tashur" to declare the decision, MSDI and BSI differences and HAI were computed. The HAI and MSDI and BSI values had increased, then "Tashur" was display "Severe desertification" during the period from 1981 to 2003 for the grazing sites. This result agreed with observations made during the field survey in 2005. The desertification in those areas has led to sand encroachment and accelerate development of dunes. While the evaluation of the landscape condition for the irrigated site showed that there is "Slight desertification". This is also in line with observation made in that area.

CONCLUSIONS

The results from combined decision options showed that the condition of the landscapes can be evaluated by using the climate parameters and vegetation cover index as trigger factors and soil parameters and human activities impact as propagation factors. The output of "Tashur" can then help the planners (agriculturist, foresters and landscape planners) and decision makers in arid and semi-arid regions to assess the landscape conditions and to monitor and map the extent of the land degradation. This will enable them to make better management and planning decisions for the sustainable use of natural resources in these regions.

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