INTERNATIONAL JOURNAL OF ENVIRONMENT

Volume-6, Issue-3, Jun-Aug 2017 ISSN 2091-2854

Received:14 June *Revised:19 August* *Accepted:21 August*

MONITORING LAND USE CHANGE AND VEGETATION DYNAMICS BY REMOTE SENSING IN THE STEPPE REGION OF SIDI BEL ABBES (NORTHWEST, ALGERIA)

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Abstract

The application of remote sensing in land cover changes monitoring is a very efficient tool, for landscape management in arid regions. To assess the spatial-temporal dynamics, of vegetation, in the southern region of Sidi Bel Abbes, for the period (2001- 2014), Landsat and MODIS NDVI data were processed and analysed using remote sensing software. The obtained results, confirm that the steppe region is highly degraded in the south and in the sout h-east, with light progression of vegetation noticed in the north and the north-west of the study area. The increase of vegetation cover is related to the reforestation actions, engaged by the forest services. For decision makers, the use of satellite imagery can improve the strategic conservation and management plans of the steppe ecosystem.

Keywords: Steppe, land use, vegetation dynamics, Landsat, MODIS, Sidi Bel Abbes

Introduction

Algerian steppe is an arid ecosystem, characterized by limited natural resources, poor soil, sparse vegetation, and severe climatic conditions (El Zerey et *al.,* 2009). With pivotal position between the hilly, and humid north, called the *Tell*, and composing 11%, of Algeria's surface, it is the most wide spread rangeland of the North African countries (Hirche et *al.,* 2010). Initially occupied by forests, the gradual deterioration of the steppe, led to the colonisation of xerophytic vegetation, consisting of a mixture of herbaceous, and perennial plants (Skouri, 1993; Quezel and Santa, 1962; 1963). Land use/cover change detection is essential, for a better understanding of landscape dynamics, during a known period, for sustainable management actions. Where landscape patterns, changes, and interactions, between human activities, and natural phenomenon are essential, for proper land management, and decision improvement (Rawat *et al.,* 2015); the need to understand the Earth's ecology, and land cover is becoming increasingly important, and the evaluation of land degradation is a challenging task (Lu et *al.,* 2007). Knowledge of current vegetation trends and the ability to make accurate predictions of ecological changes is essential, to minimise times of food scarcity, in developing countries (Ndayisaba et *al.,* 2016). The comprehension of the soil use modes evolution and the vegetation cover is a major concern for countries, whose ecosystems undergo severe degradations (El Zerey, 2014). Ecological research efforts tend to focus at specific spatial scales ranging. Knowledge of these scaling issues has largely fueled the interest in both top-down and bottom-up approaches to studying ecological processes (Wessman, 1992). With the NASA EOS instruments MODIS and MISR, new capabilities are widely available, in remote sensing, for the observation of terrestrial ecosystems (Asner *et al.,* 1998). Remote sensing techniques provide important tools, for generating information, on land degradation status, and its geographical extent (Wessels et *al.,* 2004). Remote sensing, and techniques used for observation help, to gather knowledge, for analysis, interpretation, and management of the environment, starting from measurements, and images obtained, using airborne, space, and terrestrial platforms. These tools of processing and multidisciplinary data exploitation constitute a mean allowing, having a good idea, updated regularly, of the landscape units on immense territory, and reducing the cost of the field investigations (Bachir Bouidjra and El Zerey, 2014).

Spatial modelling is also used to predict distributions of invasive species, deforestation, urbanization, and vegetation type (Franklin 1995, Guisan and Zimmermann 2000). Remote sensing techniques enable researchers, to have a better choice of the sites, to be observed, to reduce the number of survey visits on the ground, and to save time and means.

Material and methods

The study area

The study is based on a representative region of the Algerian steppe. The study area, located to the south of the region of Sidi Bel Abbes at an altitude of 1000 to 1400 m, extends over an area of 3660.82 Km^2 about 40 % of the territory (Figure 1). The region is characterized by a Mediterranean climate and belongs to the arid bioclimatic stage (Emberger, 1942). The meteorological data records a climate fluctuation concerning rainfall and temperature, an average rainfall regression and temperature increase. In fact, the average annual precipitation ranges from 149 to 174 mm during (1970-2005) (ONM, 2008) versus 301 to 319 mm during the periods1913-1938 (Seltzer).

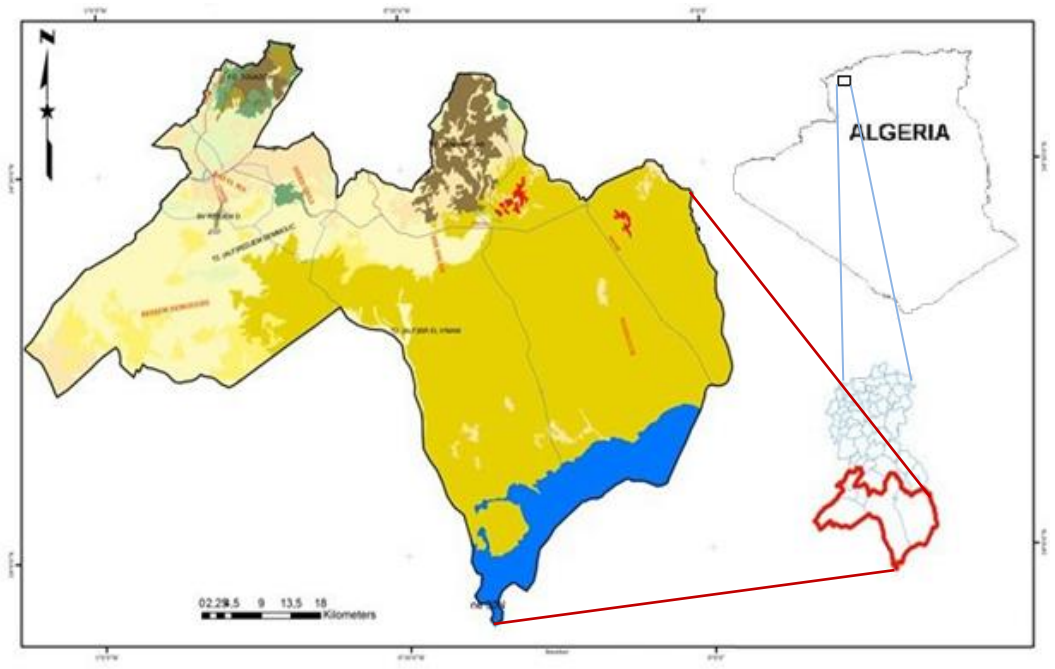

Figure 1. Localisation of the study area: natural limits of steppe ecosystem (Sidi Bel Abbes, Algeria)

Data processing

In the current study, four satellite images were used:

- Landsat ETM+ and OLI satellite images for the two years, 2001 and 2014.
- MODIS satellite images (NDVI) for the two years 2001-2014.

The satellite data covering study area were, obtained from Global Land Cover Facility (GLCF) and USGS. For the processing of satellite data, we used the software ENVI 4.7 (Environment for Visualizing image). It allows the analysis of large data of most formats, and to manipulate multiple multi-spectral images.

Methods

The processing of satellite images is based on:

1. Geometric rectification, image registration, and atmospheric correction;
2. Combination of three bands (4,3,2) for Landsat ETM+ and (5,4,3) for Landsat OLI;
3. The processing of the MODIS images, using Normalized Difference Vegetation Index (NDVI), to monitor the vegetation chlorophyll activity. Where, the values of NDVI, used in ecological observation range from 0.0 to 1.0.
4. Mapping landscape changes, using MODIS data, for the period (2001-2014).

Field investigation and phyto-ecological survey were carried out; in order to valid results.

Results

According to the analysis and visual interpretation of the satellite images (Landsat ETM+ 2001 and Landsat OLI 2014), the following observations can be pointed out: the study area is characterized, by sparse vegetation cover. Where, the degraded steppe zone is observed, mostly covered by sand (Figures 2, 3).

The comparison of chlorophyll activity, in the study area, using two MODIS images, for the period (2001-2014), give more details, about vegetation dynamics. The values of Normalized Difference

Vegetation Index (NDVI), in 2001 were generally between 0 and 0.4; we notice values between 0 and 0.2 from the centre to the south of the region. In the north (NDVI) was between 0.2 and 0.4, in the centre, the values of (NDVI) were between 0.1 and 0.3. While, in the south, the zone was characterized by a major absence of chlorophyll activity, confirmed by (NDVI) values between 0 and 0.2 (Figure 4).

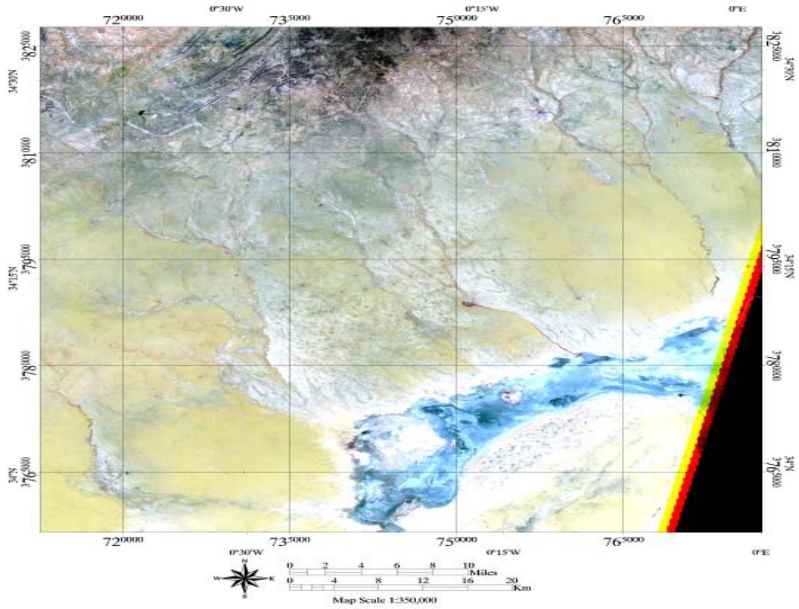

Figure 2. Landsat TM, false colour composite (2001)

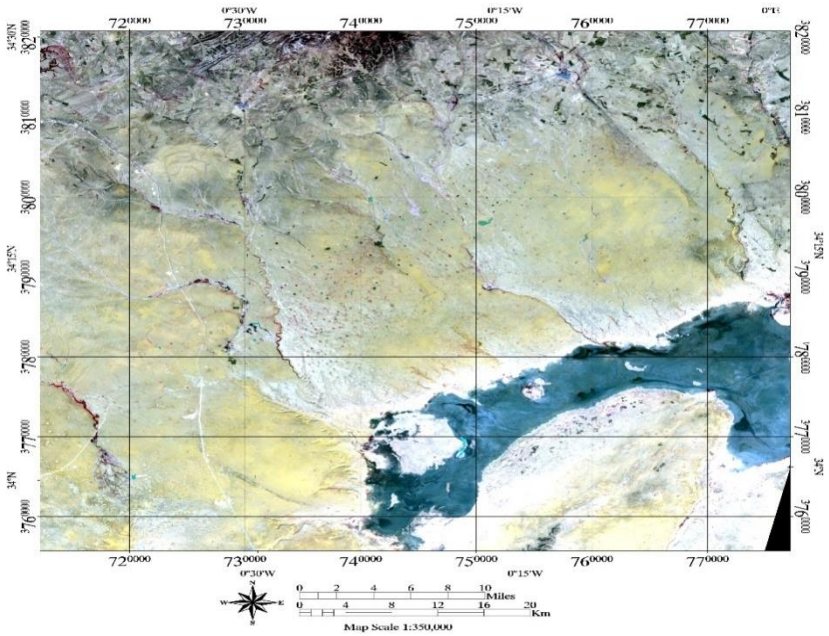

Figure 3. Landsat OLI, false colour composite (2014)

By 2014, there is a pronounced chlorophyll activity, in the northern extremities of the study area, with NDVI values, between 0.2 and 0.5, whereas a low chlorophyll activity was recorded in the centre, where NDVI is between 0.2 and 03. In the south-east, there is a presence of chlorophyll activity, confirmed by, NDVI values between 0.2 and 0.3 (Figure 5).

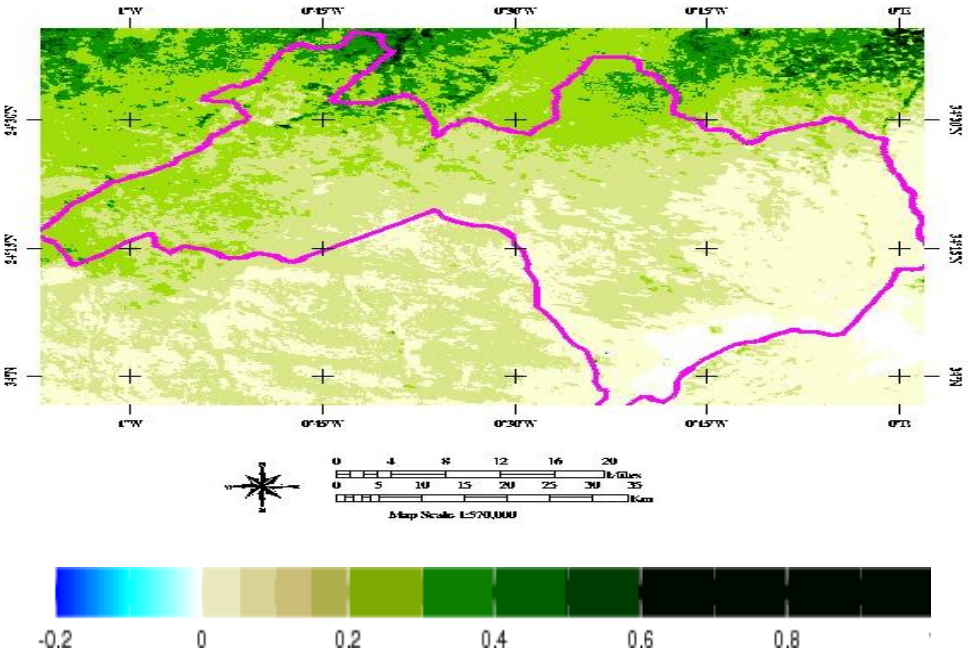

Figure 4. NDVI of the study area (2001)

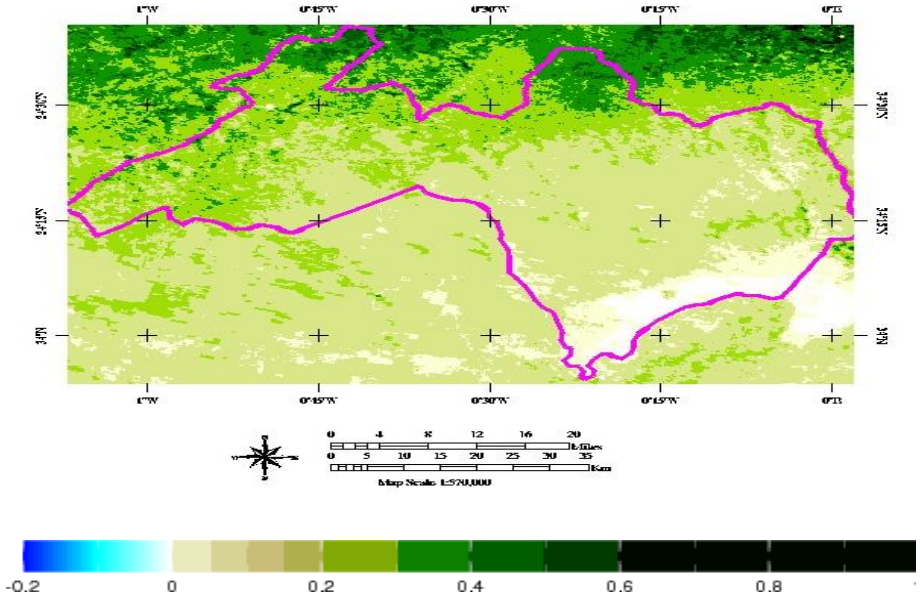

Figure 5. NDVI of the study area (2014)

According to the map of changes, as the product of the comparison of the chlorophyll activity in the study area, from year 2001 to 2014, the region is characterized generally in the north and north-west by the increase of chlorophyll activities, compared to; the south-east characterized by the decrease of vegetation cover (Figure 6).

According to field investigation, the study area constitutes natural habitat, for more shrubby elements of the steppe, such as *Macrochloa tenacissima, Lygeum spartum,* and *Artemisia herba-alba*) (Figure 7,C,D,E), psammophilous species such as *Stipa parviflora*, *Noaea mucronata*, *Peganum harmala*, and halophilic species as *Atriplex halimus* and *Salsola verniculata*, which occur in the area of Chott Chergui, presenting low NDVI values in 2001, because of overgrazing and climatic variability. The increase of NDVI values, in 2014 is related to reforestation operations of open areas and abandoned land, and natural regeneration in enclosed grazing areas conducted by the forest services, (Figure 7, C, E, F).

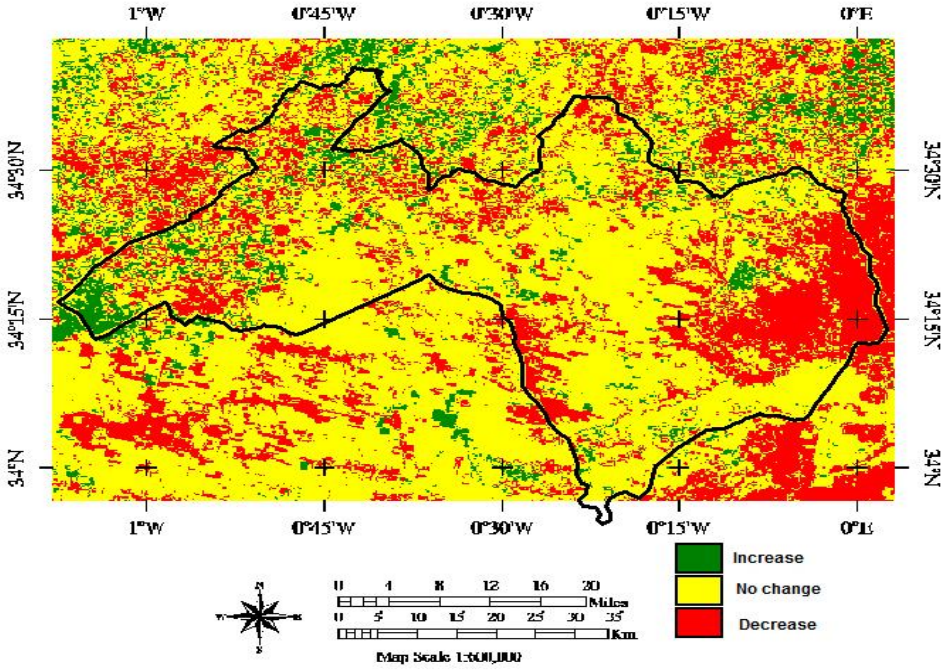

Figure 6. Map of changes between (2001-2014)

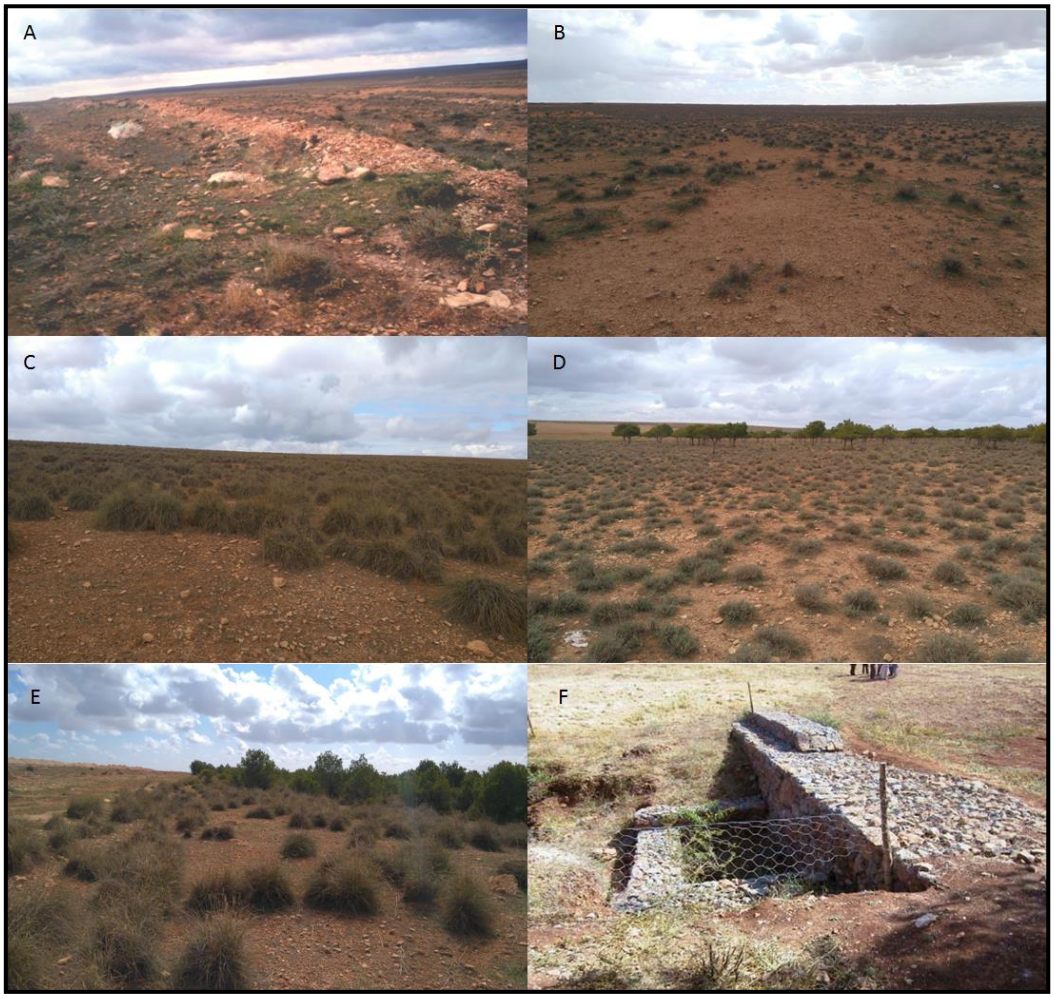

Figure 7: Various steppe landscapes: a degraded land on a calcareous clay soil (A, B); natural land for *Macrochloa tenacissima* (C) and *Artemisia herba-alba* (D), reforestation work, enclosed grazing areas (C, E) and soil improvement (F).

Discussion

the steppe region of Sidi Bel Abbes is a perfect illustration of the mutation of the spaces exploited by nomads becoming sedentary. In this area, the soil resources are continuously and permanently used. They are ploughed for the grain production; then extensively used as range or grazing land. These factors increase the pressure on the steppe soil. Thus, the bare soil comes mainly from clearing, cultivation, and overgrazing. These factors conducive to heavy erosion which does not allow profile development. This explains the difference of NDVI values. The current study area is characterized by carbonate soils which

are originally poor in humus and organic matter and recognized by their grey colour (Benabdeli, 2000; Meterfi *et al*., 2011).

Moreover, one of the main edaphic features in the region is the predominate of calcareous brown soils with clayey texture on the surface and argillaceous in depth, resting on a calcareous hard crust at a depth varying from 30 to 40 cm (Meterfi *et al*., 2011).

According to Benabdeli (2000) grazing is the main socio-economic activity, in this region. This activity is based on natural steppe vegetation; the availability of grass is dependent on the rainfall, especially, between January and May. Climatic variability drives herds to exploit all the available green resources. This obvious imbalance, between, the natural potentialities, of the steppe ecosystem, and the needs of local population, explains, the change of vegetation dynamics and land use. Two types of factors are causing, or leading to the degradation of this fragile ecosystem. Direct causes related to human activities, such as deforestation, overgrazing, and clearing, and Indirect causes linked to socio-economic needs, like population growth, poverty, and distribution of resources (El Zerey, 2014; El Zerey et *al.*, 2016). The demographic pressure subjects the environment to excessive exploitation, which works to weaken the steppe ecosystem. This observation was raised by Le Houreou, (1983), where he noted that in most arid world zones, the population growth rate is between 2.5% to 3.5% per year, and sometimes more. Areas, where population pressure is most intense, are also areas where the risk of desertification is more serious.

Conclusion

The diachronic study, carried out in the southern region of Sidi Bel Abbes between 2001 and 2014, reveals a slight progression of vegetation cover in an extremely degraded steppe ecosystem. The progression of vegetation cover is primarily related to management actions carried out by the forest conservation services. The region is always at an advanced stage of degradation and is predominately threatened by sand encroachment. According to the climatic and socio-economic data of the area, we can conclude that the main factor for this degradation is the anarchic and abusive use of natural resources by the local population. Valuable efforts such as reforestation, enclosed grazing areas and soil improvement

are managed to counter the erosion effects leading to re-vegetation and natural regeneration. The modest development programs conducted in the region are encouraging but still insufficient. More operations and programs need to be established and carried out based on multidisciplinary studies integrating socio-economic approaches. Remote sensing by the macroscopic vision of the region and the repetitiveness of the data is a very powerful and very important analysis tool, for decision-makers in the region, to establish strategic conservation and management plans of the steppe ecosystem.

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