Research article

Land Degradation Assessment in El Jicaral Village, Mixteca Region, Mexico

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Abstract Mixteca Region's land resources are being affected by several degradation processes caused by mismanagement of farming systems, deforestation and cattle overgrazing. For assessing the land degradation conditions in a local level, this study was carried out in El Jicaral Village based on the analysis of several variables observed on topographical maps and satellite images. To confirm the reliability and accuracy of the analysis, in the present study a land degradation assessment was carried out through field observation. Along with the assessment, a questionnaire survey was conducted for understanding more the local situation. The questionnaire survey consisted of 24 questions which were divided into three sections: the basic information of local farmers, the application of agricultural chemicals and the current problems in the farming systems. There were 69 households interviewed. Although the results of both assessments were compared, significant difference was not observed between the remote and the field assessments. In addition, it was considered that land degradation information obtained through the remote assessment may be useful for small areas as an alternative method when a field assessment is not possible to be conducted. According to the remote assessment as well as the survey in the research area, it may be concluded that El Jicaral Village is facing a serious land degradation process due to land use conditions in the village, such as crop cultivation under steep slope conditions, deforestation and cattle overgrazing. Furthermore, no soil conservation practices are applied and chemical products are being used without understanding of their negative effects. Due to these conditions, land degradation is a continuing process in El Jicaral Village.

Keywords local farming, land degradation, Mixteca, Mexico, field survey

BACKGROUND AND OBJETIVES

Mixteca Region is one of the poorest regions in Mexico with land degradation and water scarcity situation. The Ministry of Environment and Natural Resources (Secretaría de Medio Ambiente y Recursos Naturales, SEMARNAT) estimated around 500,000 hectares in the region presented high levels of land degradation in 1998 (SEMARNAT-CP, 2003). Mixteca Region is located in Oaxaca State in the southern part of Mexico, with a surface of 15, 600 km^2 (INEGI, 2005) and around 450, 000 habitants (INEGI, 2010).

Land degradation is a natural and socioeconomic cause-effect phenomenon (Hammad, 2012). Demand on the land for economic development from an increasing population is driving unsuitable land use changes; hence land degradation through soil erosion, nutrient depletion, salinity, water scarcity, soil pollution, disruption of biological cycles and loss of biodiversity. The causes are multiple and complex, such as the expansion of cattle raising, the over-exploitation of forest resources, deforestation through slash and burn for agricultural practices and for energy needs (UNEP, 2010). Severity of land degradation has been increasing in many parts of the world, where more than 30% of forests, 20% of all cultivated areas and 10% of grasslands are undergoing

degradation (Bai et al., 2008).

In order to assess the land degradation conditions in a local level, a study was conducted in El Jicaral Village based on the analysis of several variables observed on topographical maps and satellite images (May and Mihara, 2013). The results of this assessment showed that more than 35% of the study area was under severe land degradation. To confirm the reliability and accuracy of the remote assessment, in the present study a land degradation assessment was conducted by means of field observation. At the same time a questionnaire survey was carried out for understanding more the local situation. Accordingly, the objectives of this study are to evaluate the viability of the land degradation assessment based on remote assessment compared with the field assessment and to understand better the causes of land degradation through the results of a questionnaire survey on land degradation assessment.

METHODOLOGY

Land Degradation Assessment

According to Kapalanga (2008) soil erosion represents the most extensive areas of degraded land worldwide, as more than 83% of the areas have been affected. In the classification of the land degradation, the processes of soil erosion dominated for rating the degree and extent of the land degradation. Based on this statement, land degradation assessment was conducted in El Jicaral Village through the field observation in the study area divided into a mesh of 50 meters by 50 meters, the same mesh used in the previous study for the remote assessment (May and Mihara, 2013) covering an area of around 0.5 km^2 (Fig. 1). The results of land degradation assessment through this field observation were compared with that through the remote assessment carried out in the previous study.

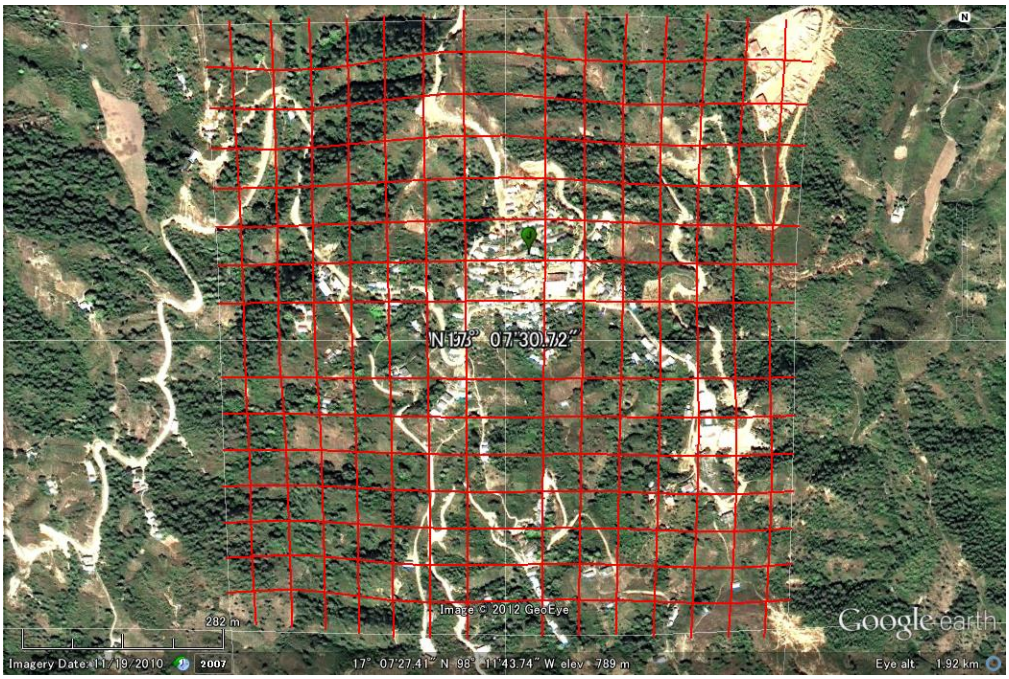


Fig. 1 Land degradation assessment in the study area

In the field assessment, GPS was employed for clarifying the location in every cell. Then detailed observation was conducted based on Morgan Coding System (Morgan, 1995) with rating a value from 0 to 5 at the assigned cell. The Morgan Coding System constituted with several parameters developed for integrated soil erosion appraisal in the field as shown in Table 1. After obtaining a value based on Morgan Coding System for each mesh, a comparison was done between

the field assessment and the remote assessment done in the previous study. For the comparison, statistical method using a correlation analysis was employed.

Table 1 Coding system for soil erosion appraisal in the field

Code	Indicators
0	No exposure of tree roots; no surface crusting; no splash pedestals; over 70% plant cover (ground and canopy)
1	Exposure of tree roots, formation of splash pedestals, soil mounds protected by vegetation, all to depths of 1-10 mm; slight surface crusting; 30-70% plant cover
2	Tree root exposure, splash pedestals and soil mounds to depths of 1-5 cm; crusting of the surface; 30-70% plant cover
3	Tree root exposure, splash pedestals and soil mounds to depths of 5-10 cm; 2-5 mm thickness of surface crust; grass muddied by wash and turned downslope; splays of coarse material due to wash and wind; less than 30% plant cover
4	Tree root exposure, splash pedestals and soil mounds to depths of 5-10 cm; splays of coarse materials; rills up to 1-8 cm deep; bare soil
5	Gullies; rills over 8 cm deep, blow-outs and dunes; bare soil

Questionnaire Survey Conducted in Study Area

Along with the field assessment, the questionnaire survey was conducted in El Jicaral Village, Coicoyán de las Flores Municipality, Mixteca Region, Mexico as additional information for the land degradation assessment. This village was chosen because the degree of poverty is high, as well as it locates in the most land degraded region of the country (PNUD, 2008). El Jicaral Village is an indigenous community with around 1,000 inhabitants, in which people speak in Mixtec, ancient language in the area. The main crops in the village are rain-fed corn, chilly and bean. It locates in the coordinates 17º 07’ 34.6” Latitude North and 98º 11’ 48.9” Longitude West. The questionnaire survey consisted of 24 questions, divided into three sections such as ‘Basic information of local farmers’, ‘Application of agricultural chemicals’ and ‘Current problems in farming systems’ as shown in Table 2.

Table 2 Questionnaire survey for land degradation assessment

Basic information of local farmers	Application of agricultural chemicals	Current problems in farming system
Name, Age, Gender	Application of chemical fertilizers, formula, quantity	Main problems in the farming system
Number of family members working in agricultural sector	Amount of money expend for chemical fertilizers	Soil erosion awareness
Crops, area cultivated, destination of production	Application of pesticides and herbicides	Attendance to soil conservation workshops
Water source, breeding of animals	Application frequency	Concrete information about crops

Fig. 2 Workshop and survey conducted in El Jicaral Village

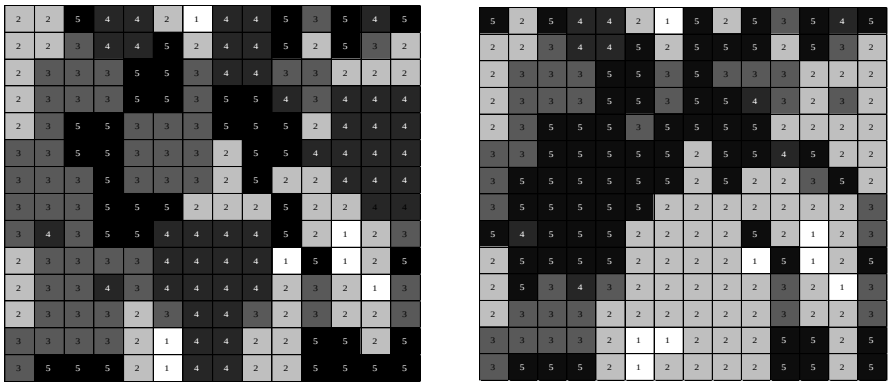
The survey was conducted in July, 2013 in the village with the assistance of a Spanish-Mixtec translator at the workshop on 'Soil conservation for sustainable agriculture' (Fig. 2). The targets were local farmers, being older than 18 years old, who have been conducting agriculture in the village. From one household, only one representative was invited to attend the workshop. There were 69 household interviewees in the workshop and it counted 35% of all 200 households in the village. Due to their local customs, the survey must be divided into several times for each group with around 10 persons.

RESULTS AND DISCUSSION

Land degradation assessment: Field observation, based on the coding system for erosion appraisal, was conducted in the study site. The observation was supported by the use of GPS, in order to make the evaluation inside every cell (Fig. 3)

Fig. 3 Land degradation assessment in the field

The results of the field observation were summarized in the map called "field assessment". On the other hand, there was the map made with "remote assessment" (May and Mihara, 2013), where the identification and classification were carried out based on several variables, such as steepness, slope, vegetation density and land use. In the process to make the map with "remote assessment", these variables were integrated for evaluating land degradation as shown in Fig. 4.



Field assessment **Remote assessment**

Fig. 4 Comparison between land degradation assessments by remote and field methods

After obtaining the land degradation maps with both methods; "field assessment" and "remote assessment", a confidence interval at 99% significant level was selected for evaluating the correlation between both assessments (Fig. 5).

The results of statistical analysis indicated that there was the correlation between both assessments at 99% significant level. It means that the remote assessment based on several variables, such as steepness, slope, vegetation density and land use may be enough for assessing the land degradation in a small scale. This technique is useful when the land degradation assessment is necessary in small areas and not possible to conduct an on-site assessment.

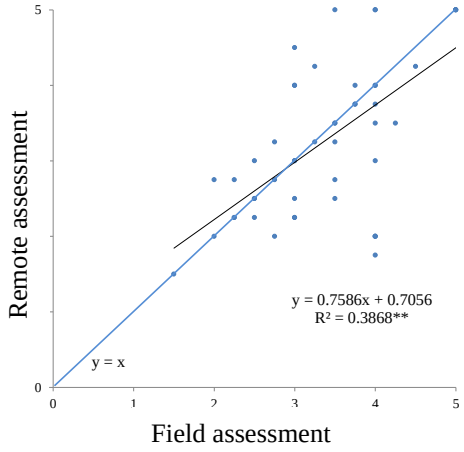


Fig. 5 Correlation between land degradation assessments

Outcomes from questionnaire survey: The results of the questionnaire survey in the village are summarized in the following charts as shown in Fig. 6.

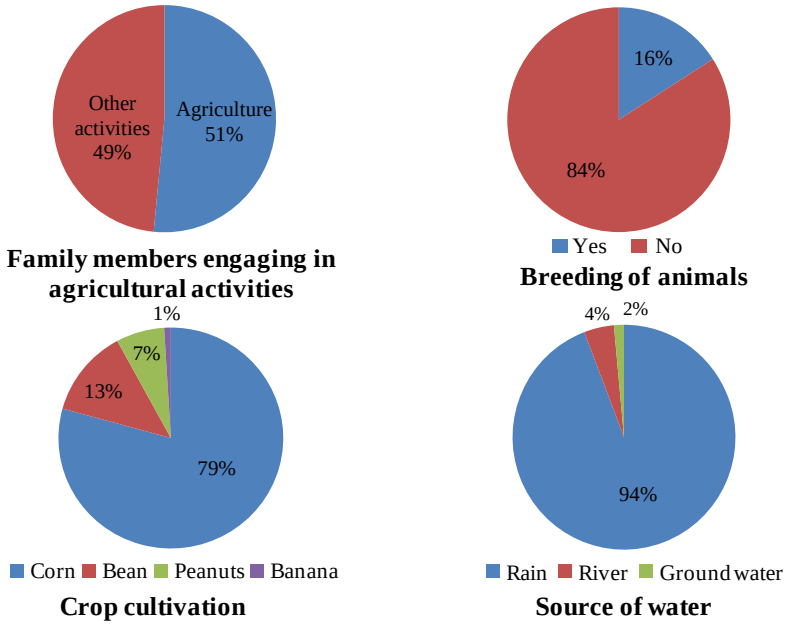


Fig. 6 Basic information of local farmers

It was observed that 35% of the interviewed households dedicated to agricultural activities were between 31 to 40 years old and that 65% was female, this is due to the strong social phenomenon of migration for male. Also, around half of all members at interviewed households were engaged in agricultural activities. The interviewed households at 84% did not breed animals,

and the main crop was corn. It counted at 79% of all cultivated areas hold by interviewed households, followed by beans at 13%. In addition, the main water source for the crop cultivation was rain water at 94%, and followed by river and ground water.

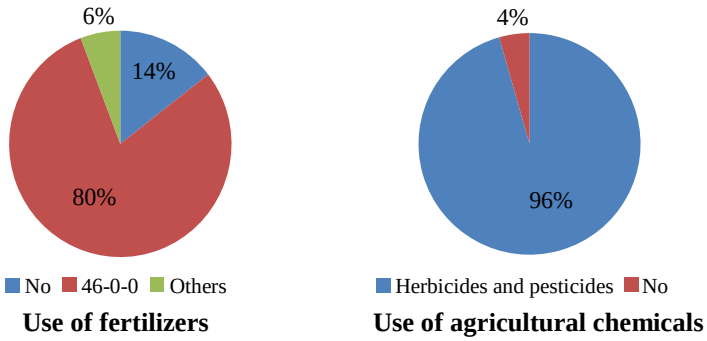


Fig. 7 Application of agricultural chemicals

Concerning the usage of agricultural chemicals, 80% of the interviewed households applied chemical fertilizers and 96% applied herbicides and pesticides to their farmlands as shown in Fig. 7. Some parts of these products are promoted in the Mexican governmental programs.

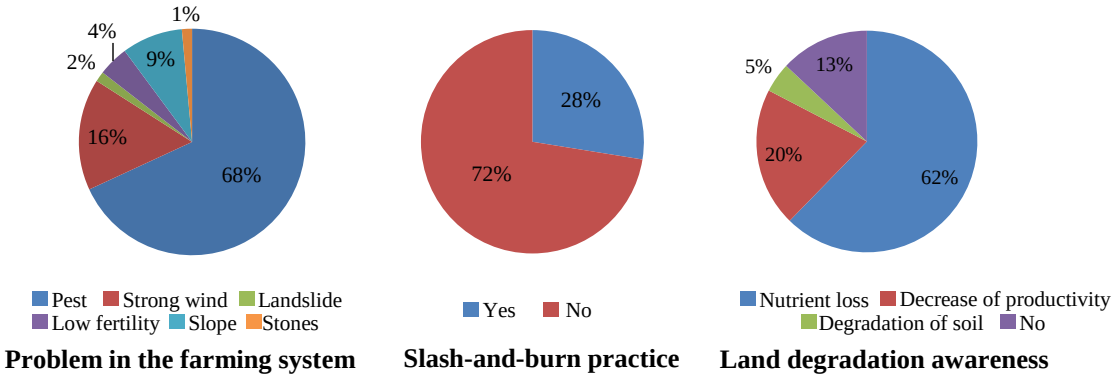


Fig. 8 Current problems in farming systems

Among the problems that farmers face in the village, the main one is pest problem that 68% of the interviewees responded. Especially, the damage by worms like 'gusano cogollero' (*Spodoptera frugiperda*) is severe in the village. The main insecticide applied for the worm is chlorpyrifos. Also, for controlling weeds, the herbicide entitled Paraquat is the most common in the village. However in the village, slash-and-burn farming is not common, as only 28% of the interviewees have been conducting.

Also, the results of questionnaire survey for land degradation assessment indicated that the interviewees had certain awareness on land degradation as well as nutrient loss associated with soil erosion. They also know that the processes of land degradation cause low in land productivity (Fig. 8).

The results of questionnaire survey also indicated that farmers have a perception on land degradation accelerating in the village. Nevertheless, under the current conditions of poverty and less knowledge on sustainable agriculture or land conservation, the farmers have no other alternatives of farming systems. They just continue the same farming even in sloping upland fields for obtaining short-term benefits to survive.

All the interviewed farmers are willing to join land conservation program for sustainable agriculture if there are any opportunities.

CONCLUSION

This study dealt with land degradation assessment through field observation, in addition to remote assessment based on topographical maps and satellite images. Along with the assessment, a questionnaire survey was conducted for understanding more the local situation. According to the remote assessment as well as the field observation through the survey in the research area, it may be concluded that El Jicaral Village is facing a serious land degradation process due to land use conditions in the village, such as crop cultivation under steep slope conditions, deforestation and cattle overgrazing. Furthermore, no soil conservation practices are conducted and chemical products are being used without understanding of their negative effects. Due to these conditions, land degradation is a continuing process in El Jicaral Village.

Although farmers have a perception on land degradation accelerating in the village, they have no other alternatives of farming systems, but just continue the same farming even in sloping upland fields for obtaining short-term benefits to survive. All the interviewed farmers in the village are willing to join land conservation program for sustainable agriculture if there are any opportunities.

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