A STUDY OF LANDSCAPE DYNAMICS USING RASTER GIS: CASE OF TONALA, METROPOLITAN ZONE OF GUADALAJARA.

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Abstract

Metropolitan Zone of Guadalajara had suffered a great demographic pressure during last years, that had caused an unbalanced structures. Consecuently, the cultural space had shown a growing trend as presure upon land became greater. In order to manage appropriately the natural resources of the metropolitan zone, a precise knowledge of the territory is necessary, for that it is important to assess the potential change sensitivity of natural environment into cultural areas. This would allow us to preserve determined natural zones. Our purpose is to study the land cover dynamics using GIS techniques, that offer many advantages in relying different source data, to obtaining cartographic products, as well as accurate statistical analysis.

1. Introduction.

Farming sector had played a relevant roll in the development of Mexico, because for many years supported industrial and urban activities. This have started an economical transformation during 1940s, and a heterogenous growth was propitiated in whole Mexican country.

In 1990, near to 38% of population was concentrated in three most important metropolitan zones: Mexico, Guadalajara and Monterrey. In same year, there were 154,000 localities with less than 2,500 inhabitants, where resided 29% of total population. Thus Mexico presents an excessively concentrated population distribution scheme in urban areas, while it is disperse in rural zones. In these zones grave disturbances were generated between existent, available and actual use of natural resources. This recent process had caused great spatial changes, and also social problems and physical environment decay. This phenomena needs to be evaluated and corrected.

This study would be located at Jalisco State, in one of the municipalities of Guadalajara Metropolitan Area (GMZ). GMZ includes four of 124 municipalities of the State; Guadalajara, Tlaquepaque, Tonalá and Zapopan. From 1970 to 1990, these last three municipalities had experienced high annual mean growth rates, with a maximum of 10.09% for Tonalá, followed by Zapopan with 7.90%, and Tlaquepaque with 6.25%, meanwhile Guadalajara, had only 1.60%. This means that GMZ had grown up due to peripheral municipalities.

Our aim is to determine natural areas sensitivity to be converted into culture lands, by mean of spatial change analysis between two significative dates (1971 and 1989), in Tonalá municipality.

The raster GIS would be an essential tool for this work. Aerial photographs and satellite imagery would be also used for to generate land cover maps. Further, changes would be detected and would be related to a DEM for changed areas statistical measurements.

2. Study area.

Tonalá municipality is located in central-eastern part of Jalisco State. It has an extent of 162,508 km^2, which represents 0,20% of total State area and 10,7% of GMZ. Its entire territory belongs to physiographic region of Transversal Volcanic Axis, which is the very center of the State. Generally, its lithology is constituted by igneous Tertiary rock, while Cuaternary materials includes sandstones, conglomerates and flood depositions, hence the municipality is characterized by notable explosive volcanic events.

Its topography offers mainly roughed hills, which extends from the center of the municipality to northern direction, till it reaches to Grande de Santiago river canyons. There are also isolated volcanic shells that conforms a little mountain chains situated in the south of municipality. Tonalá belongs to a large hydrologic basin which flows to the Pacific Ocean. Its relief, combined to its climate and vegetation, determines a mosaic (according to FAO/UNESCO classification) of soils with a diversity of vegetation types: tropical rainforest, sub-tropical shrubland and grassland.

In 1990 Tonalá had 168,555 inhabitants, ranking the fourth position among Jalisco's most populated municipalities, and it is the third most densely populated, with a mean value of 1,037 inhabitants by km^2. Agricultural activities is mainly extensive exploitation, because of 99% of culture surface is devoted to dry farming, and only 1% represents irrigated farming. Tonalá has an artisan industry, that has an important participation in Jalisco state industry. Pottery articles and other typical products, as well as food elaboration are main municipal activities.

In any aspects, GMZ had influenced in order to prevent a more dynamic development, nevertheless industrial tradition had favored little family companies settlement, distinguishing for giving job for most part of municipal families.

3. Methodology.

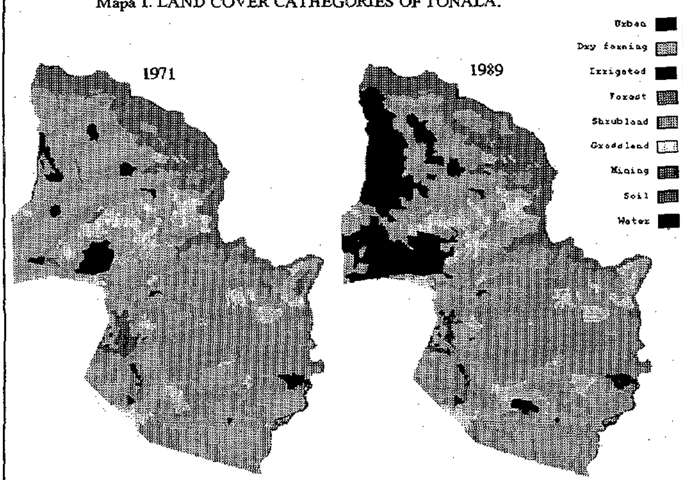
We have used a land use map at 1:50,000 scale, elaborated by INEGI (National Institute for Statistics, Geography, and Data Processing), from 1971 information, for generating the first map; and a Landsat-TM data of 1989 was acquired in order to generate the second land cover map. For supporting the satellite image, aerial photographs (from 1985 and 1986) at 1:30.000 scale have been consulted. Thus, land cover maps for both dates were generated by visual analysis and photo-interpretation.

Contour lines were digitized from 1:50,000 scale topographic map by using ARC/INFO vector GIS (ESRI, 1990). This layer was projected to UTM System using TRANSFORM algorithm, resulting a input RMS of 0.003. Then vector data were rasterized, and final layer had a pixel size of 50 x 50 meters, and 392 rows by 294 columns. Then DEM was generated using a linear interpolation algorithm (INTERCON) within IDRISI (Eastman, 1992).

4. Results.

Both land cover maps would be used for change analysis within 18 years (map 1). Further, maps derived from DEM would be used for to determine relief influence in land dynamics/stability.

Mapa 1. LAND COVER CATHEGORIES OF TONALA.



As variable used are oridinal, we have performed a cross-tabulation analysis (Table 1), which allows to detect thematic categories changes (Bosque, 1992, p. 320-321). Automatic overlapping of both land cover maps generated a double input table, which give information about stable and changing category areas. Changing areas were lesser than stable ones. Stable surfaces (pixels) corresponds to diagonal positions, while changing ones are situated at other positions.

Table 1. Land cover maps cross-tabulation. Data referred to number of pixels.

1971 / 89	URBAN	DRY-FARMING	IRRIGA-TED	FOREST	SHRUB-LAND	GRASS-LAND	MINING	WATER	TOTAL
URBAN	421								421
DRY-FARMING	1.613	5,866						4	7,479
IRRIGATED	33		3						36
FOREST	4	137		1,924				4	2.069
SHRUBLAND	70	236			4,038	154			4,498
GRASSLAND	102	16				1,154			1,272
MINING		75					120		195
BARE SOIL	17				31	57			105
WATER								231	231
TOTAL	2,260	6,330	3	1,924	4,069	1.365	120	239	16.310

Changing and stable categories values were obtained by recoding. Stable surface includes 1,375 has, i.e., 84,34% of municipality, while dynamic area were 2,552 ha, 15,65%. As map 1 shows, most part of dynamic area is situated in north-east part of municipality. Note that bare soil category had disappeard in 1989. Table 2 shows statistical information about topographical variables for each former land cover type evolutions.

Table 2. First order statistics of cover types according to topographical characteristics.

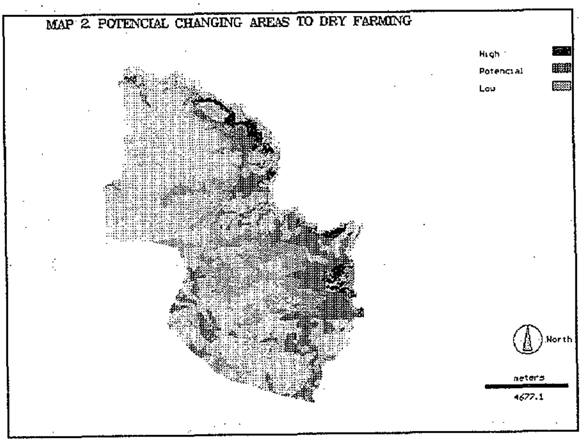
	SLOPE (%)		ALTITUDE (METERS)	
	STABLE	DYNAMIC	STABLE	DYNAMIC
MINIMUM	0.00	0.00	1,090.00	1,325.00
MAXIMUM	158.21	84.35	1,720.00	1,720.00
MEAN	11.03	4.81	1,537.47	1,586.35
STAND.DEV.	15.17	4.86	89.50	56.16

This data values indicate that stable zones have lower altitudes than dynamic ones, in other words, areas affected by land cover changes trend to be more elevated and they appear from over 1,325 m. Since, both zones reach to the maximum altitude of the municipality (1,720 m). On the other hand, it would be observed that slope mean value is lower in dynamic zones, for which it would be stated that stability appears in roughed terrain.

It would also be stated that built area had absorbed 1,839 has from other types and includes 72,06% of dynamic area. On the other hand, dry farming extended to 464 has (18,19%), while grassland only could gain 210 has (8,29%), and little changes appeared in shrublands and water bodies.

From these observations, we could conclude that built area and dry farming types were the more change-affected categories. Therefore, we could consider necessary to determine relief influence in culture areas, and thus by mean of frequency analysis between variables (slope, altitude) and dynamic cartography of dry farming, we have generated a culture area growth trend map (CEOTMA, 1993, p. 681). This would became an important document, in case of demographic pressure increases over this zone.

Map 2 was been obtained by recoding frequency indices. This map shows the distribution of this potential changing areas to dry farming, that would be mainly located in areas separated from cities.



5. Conclusions.

From 1971 to 1989, land cover distribution in Tonalá had known some transformations. Briefly, these processes had shown the following trends:

1) Moderate increase of grassland.

2) Slight diminution of forest land: forest elimination was strong in those areas which presented a low density forest cover and low topographic roughness. Generally, there was a close correlation between clear-cut advance and both grassland and dry farming expansion.

3) Considerable increase of infrastructure areas and settlements in culture lands, which represented in 1989, 13,86% of municipality surface.

4) Strong decrease of culture lands, mainly devoted to dry farming, because irrigated lands included, since 1971, a very small area.

5) Moderate loss of sub-tropical shrubland, meanwhile these category still covers large surface in the south part of the municipality.

Finally, we could check out GIS's usefulness for to study factors those explain the dynamic of human occupation of territory, since this allows to quantitatively evaluate the relationship between the variables.

6. References.

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