CARTOGRAPHY REPRESENTATION OF INDIGENOUS TOWN TERRITORY IN PUREPECHA REGION, MICHOACÁN, MÉXICO.

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Abstract

This study boards territory configuration of the pine-oak forest of the Cheran and Tingambato, two municipalities located in the native region denominated "Meseta Purepecha" in Michoacan State, México. It´s considers that nevertheless the *ejido* is a legally autonomous organ with own patrimony, it is submitted to internal and external pressures that explain not only land covers dynamics, but also the deforestation and fragmentation template forest and so that, the configuration of the rural landscapes in both municipalities.

In this way, I suppose that the conservation and disturbance process of the template forest can't be explained without understanding how some hidden causes that organize and structure the ejidal property favor the actual condition –conservation or disturbance- of the forest ecosystems. It is important to understand how the regional and municipal location of the *ejidos* favors also the negative o positive processes in such as ecosystems.

In order to study the landscape dynamics of the principles processes that have been presented during the last thirty years in both municipalities, it has been employed GIS-ILWIS ver.3.0. Landscape maps were obtained from the interpretation of land covers in 1995 digital orthophotos (scale 1:75000) and 1976 and 1986 Landsat MSS and 2000 Landsat ETM satellite images. At municipal scale, it is explains a general description of each municipality as administrative and political entity. It is also explains the actual condition of the rural landscape and its dynamics related with the processes presented during the last thirty years. Such condition allows contextualizing and relating the processes with the social dynamics and historical information. At agrarian nucleon scale, I analyze socio-economic, cultural and political aspects and also the principal activities, ejidal preparation, internal organization and in-house situation. In order to do that, I recur to bibliographic material such as ejidal census and cartography of the Forest National Commission (CONAFOR).

Nevertheless their geographic proximity, both municipalities show different processes. For example, Cheran municipality shows the conservation of pine-oak forest as the principal process, representing 59.32% of total processes. This representation was similar for the periods between 76-86 and 86-00. The intensification was the second process with the most permanence. Regeneration and disturbance processes show moderated, but more elevating values during the three periods. For example,

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Regeneration exhibited an increase of 0.92% during the first period to 4.34% during 86-00 period.

The municipality of Tingambato is characterized by a clear tendency to exhibit positive processes – conservation and regeneration pine-oak forests. Regeneration, for example, shows 0.66% during the first period and then increases to 8.95% during 86-00. Yet the intensification process decreased during the three periods of analysis, disturbance process, on the other hand, showed values that affected pine-oak forest and secondary vegetation, as demonstrates the increase of this process from 3.60% during the first period to 9.99% during the second one. This tendency allows that, during the all period 76-00, disturbance process obtained almost 12.93%, meanwhile, conservation process lost 3.66% towards 2000 year.

1. Introduction.

México is one of the less world countries that pose a complex agrarian reality (Toledo *et al*. 2002) due to the intricate social and cultural relationships (Orozco 2006). From the first agrarian law of 1915 to the recent constitutional reform of 1992, the Mexican State has contributed to make better the conditions of the mexican field facilitating not only productive rural associations but also credit commercialization and rural participation in civil society, nevertheless with partial results.

After agrarian land distribution of the 30´s decade, the forest resources were on the hand of the mexican rural people, in others words, on the hand of the rural poverty mexican people – agrarians-, group of people without experience for administrating the forest industry. This conduced to federal government to consent forest concessions to the provided sector without rural people intervention in the process of selection.

This situation generated the establishment of regional "vedas" to conserve the most disturbed forest areas, propitiating that "ejidatarios" extracted illegally wood from the forest ecosystems. The restriction of the income of the forest resources for the conservation induced "ejidatarios" groups to participate in deforestation processes and land use change at greater scales. With the Forest Law of 1960, concessions were assigned to companies letting regulated extraction wood activities and so that the forest management in a short time (Muñoz 2003).

Until today, it is unquestionable that the mayor forest area in Mexico is administrating for one of that social systems more complex in this country: the "ejidal" agrarian system. This is true if we remember that half of that mexican national territory is under this kind of land property (103.3 millions of hectares) with proximally 28.2 hectares for each "ejidatario" or "comunero" (Muñoz 2003), so that conservation and disturbance of the mexican forest has been associated to this social groups since that beginning of that last century. This situation takes a real dimension if we consider the social heterogeneity in witch are immerse the forest areas and the national land (29,482

agrarian nucleus, where 92.54% represent to “ejidal” ones and the rest to agrarian communities).

On the other hand, it is estimates that one of five agrarian nucleus counts of forest area, being the third natural resource more frequent in land submitted under the “ejidal” control, territory that represents 66% of the social property at national level. Submitted under human pressure that has no clear rules that limit or restrict the extraction of the natural resources of these ecosystems, mexican forest areas have to face up processes that put in risk its integrity and environmental stability due to the land use changes, deforestation and fragmentation processes.

To the respect, few social studies have focused there attention to: a) investigate the luck or future destination of these natural ecosystems; b) evaluate internal dynamics and its relation with the social differences and the natural of the institutional arrangements that regulate its use (Linck 1997).

This study boards territory configuration of the pine-oak forest of the Cheran and Tingambato, two municipalities located in the native region denominated “Meseta Purepecha” in Michoacan state, México. It´s considers that nevertheless the *ejido* is an legally autonomous organ with own patrimony, it is submitted to internal and external pressures that explain not only land covers dynamics, but also the deforestation and fragmentation template forest and so that, the configuration of the rural landscapes in both municipalities.

Study Area

Mexico is renown for including 10% of the world’s flora and fauna in its territory, being the pine-oak ecosystems particularly important, with over 7000 species (25% of the country’s flora) (Rzedowski 1991, Challenger 1998). However, by the early 1990s the forested area was -30% of the figure reported for the beginning of the twentieth century (SEMARNAP 1998), so that Mexico ranks third worldwide in terms of the highest deforestation rates.

According to Works and Hadley (2004), in the State of Michoacán deforestation started in pre-Columbian times, and intensified in the early 20th century due to commercial licenses granted to foreign companies for timber extraction. Several efforts to control this problem –for example, President Lázaro Cárdenas’ decree (1937) to forbid commercial or industrial deforestation, the federal legislation regulating forest products since the late 1980s, or the most recent government attempts to create organisms regulating the sustainable management of forest areas– have not been successful.

Cheran and Tingambato are two municipalities of Michoacan State, Mexico. They’re located at the west of the state, specifically at the socioeconomic region called “Meseta Purepecha”, which runs across the state following the Trans-Mexican Volcanic Belt.

The altitude of the "Meseta Purepecha" region goes from 2000 to 3000 masl. Both municipalities are extended over volcanic relief formation that allows the formation of one bioclimatic "level" adapted to the distribution of geological structures: pine-oak forests on Plio-Quaternary volcanic slopes (Fig. 1).

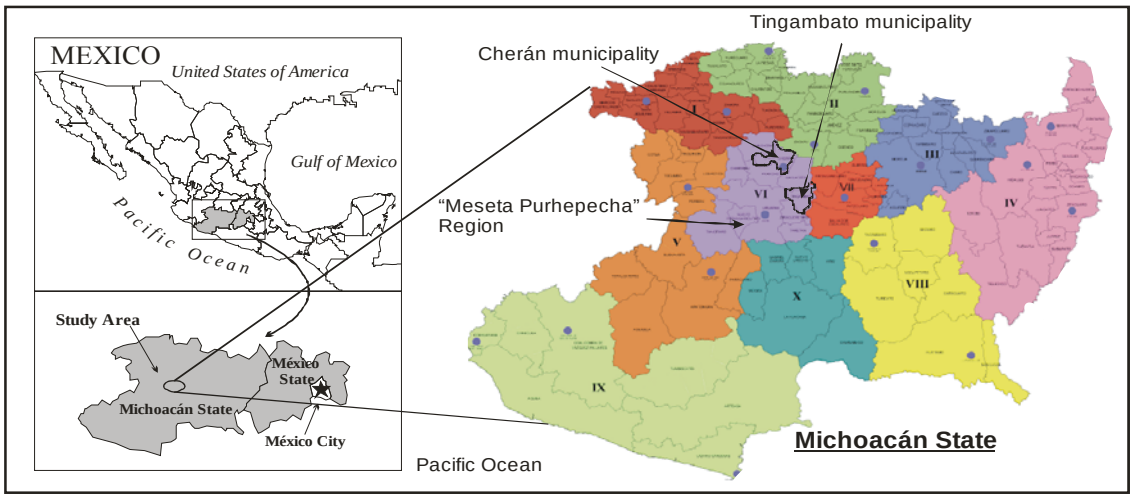


Figure 1. "Meseta Purépecha" location, Michoacán State, México.

2. Method

Landscape maps were obtained from the interpretation in GIS (ILWIS ver 3.0) of land covers in 1995 aerial photographs (scale 1:75,000) and 1976 and 1986 Landsat MSS, and 2000 Landsat ETM satellite images. Photographs were converted to digital format, at a resolution of 500 DPI, and imported to GIS with a resolution of 2m per pixel. Images were georeferenced through the "Tie-Points" method (Maus 1996, ITC 2001), for which the DTM was derived from altitudinal data in DXF format. Control points were taken from the land-use and vegetation map (1:50,000) (INEGI 1983), and the RMSE index, or SIGMA ≤ 2 was used to check the precision (ITC 2001).

In order to maintain the resolution of aerial photographs, the 1995 land-cover map was used as the basis for interpreting satellite images, starting by those with the best resolution (2000 and 1986), followed by the 1976 image, which was interpreted upon the 1986 cover map. The size of the minimum cartographical area was 4 ha (Campbell 1996), and color compounds (red, green and blue) 2,3,4 in Landsat MSS and 3,2,1 (natural color) and 4,5,7 (false color) in Landsat TM were used for a better differentiation of covers. To avoid failures derived to different image resolutions, covers were interpreted through a "visual" method that uses direct, associative and deductive techniques to differentiate landscape "features" (Powers and Khon 1959, Enciso 1990, Mass and Ramírez 1996, Arnold 1997, Slaymaker 2003, Chuvieco 2002).

In order to check the information and set the landscape typology, an INEGI land-use and vegetation cover map (INEGI 1983) was used. Additionally, field inspections and

interviews were conducted, and slope, altimetry and slope-exposition digital maps were reviewed, resulting in 12 landscape classes which differ in terms of origin –natural/cultural– vegetation physiognomic development, type and permanence of the disturbance associated to land use.

Landscape-dynamics trends and processes

In order to assess landscape-dynamics magnitude and trends between the four dates of analysis, cross-tabulations –in GIS– were conducted between landscape maps and landscape systems, and the databases were exported to statistics software to calculate areas, percent changes and Mean Annual Transformation Rate (MATR). For the latter, the index proposed by Nacimiento (1991), multiplied by 100, was used to obtain percentages.

$$\mathbf{k= 100*[(x_1/X_0)^{1/n}]-1}$$

where K = Mean Annual Transformation Rate
x_0 = landscape cover at the beginning of the period;
x_1 = landscape cover at the end of the period; and
n = period duration

Transition matrices were developed between the three dates of analysis in order to determine the change processes (Ramírez 2001; García-Romero *et al*. 2005), resulting in 198 types of changes that were then grouped into two main groups plus 4 variants: *Positive processes:* Conservation –or permanence of mature forests with scattered crops and forest use– and Regeneration –or conversion of a landscape type into another with a higher development and stability, in relation to the mature vegetation. *Negative processes*: Disturbance –or conversion of a landscape type into another less developed one, in relation to the mature vegetation, assuming damage of higher intensity and permanence– and Intensification –or permanence or turnover between landscapes with poor natural vegetation development and with land use other than forest, which assumes an accumulative effect of damage from resource management, leading to negative consequences on landscape regeneration capability and stability (Bastian and Röder 1998). This group includes the permanence of fragmented and highly fragmented forests, which does not clearly reflect the positive or negative direction of landscape dynamics (Figure 2).

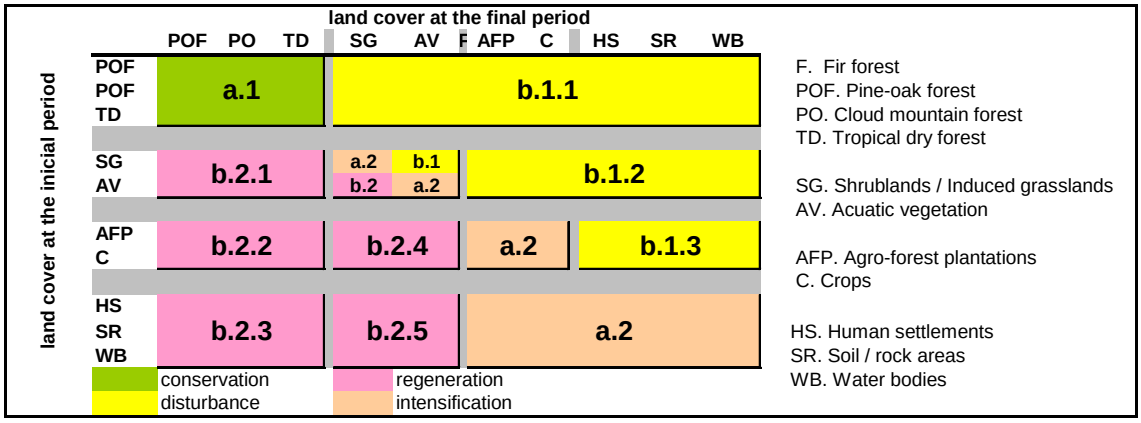


Figure 2. Land cover transition matrices model

3. Results

Landscape actual situation

Cherán municipality

From the total area exhibited of Cherán municipality, 63.68% corresponded to Pine-Oak Forest, follows by Secondary Vegetation (Scrublands /Induced grasslands) with 26.05%, Crops (5.85%) and Agro-forest plantations (2.90%). This municipality is characterized by an extreme number of Secondary Vegetation patches (320) witch represent 87.91% of the total fragmentation; nevertheless its land cover symbolizes only 26.05% of the municipal area. Pine-Oak Forest patches (33), on the other hand, represent 9.06% of total fragmentation and 63.68% of Cherán municipality. The reason of this is that Cherán has two big Pine-Oak Forest patches: one of 9547.69 ha and other of 2488.88 ha, which in group represent 53.69% of the total municipal territory (Fig. 3).

Tingambato municipality

Pine-Oak Forest land cover represents 54.65% of this municipality, following by Secondary Vegetation (31.03%). In contrast to Cherán, Tingambato municipality destines 6.79% of its territory to Agro-forest plantations (avocado plantations) and 6.63% to Crops (corn plantations). Human Settlements are represented by two principal communities: Tingambato and Pichátaro which represent in group 0.85% of the municipal territory. Landscape fragmentation is accused by 111 Secondary Vegetation patches that range from 0.43 ha to 1374 ha, outstanding the patches from 0 to 10 ha (70). A 8400 ha forest fragment stands out in Tingambato while others (16) oscillate between 10 to 100 ha and finally others fluctuate from 2 to 9 ha (12) (Fig. 3).

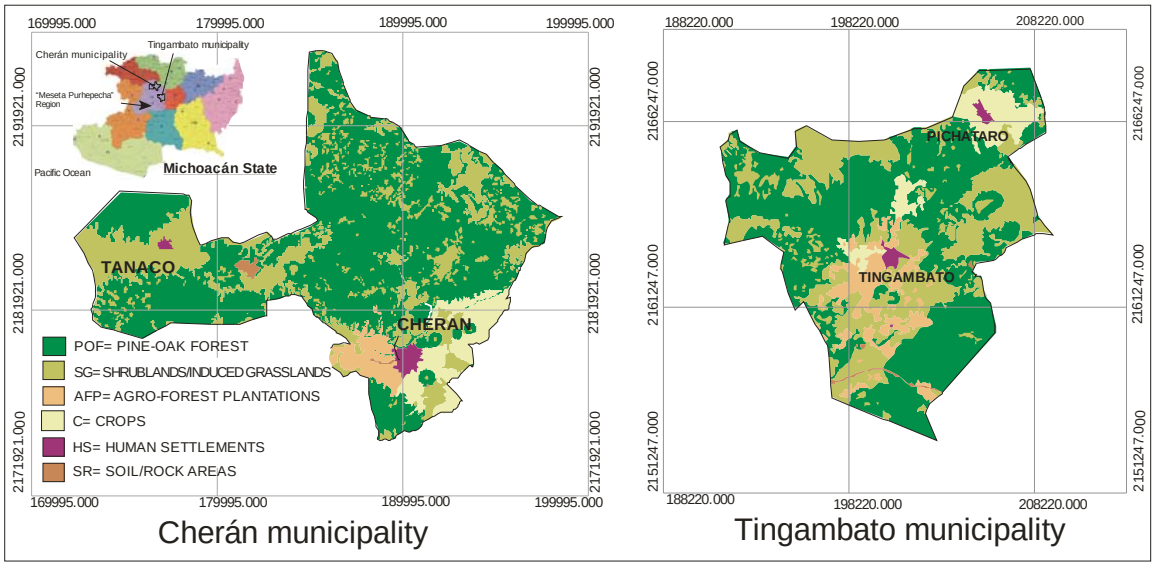


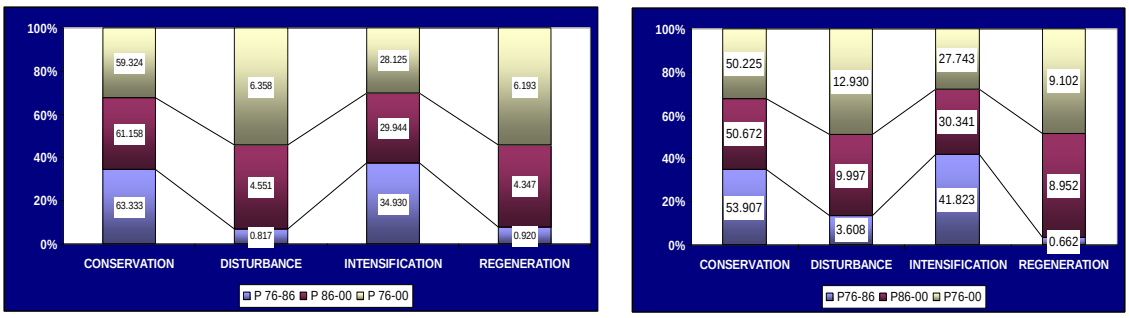
Figure 3. Landscape actual state

Landscape dynamics

Principal processes

During 1976 and 2000, conservation was the most significant process (59.32%) of total processes in Cherán. This representation was almost the same for the periods of 76-86 (63.33%) and 86-00 (61.15%). Intensification is the second process with mayor presence during the thirty years of study. One reason of this tendency is that this process was some kind stronger during the first period (34.93%) then the last one (29.94%). Regeneration and disturbance processes showed high values during the three periods as demonstrate, for example, regeneration that increases from 0.92% during the first period to 4.34% throughout the second, obtaining finally 6.19% for the period of 76-00 (Fig. 4a)

Like Cherán, Tingambato municipality has a tendency to the positive processes, as Pine-Oak Forest conservation and regeneration demonstrate. Resilience process, for example, increased its percentage during 76-86 (0.66%) in compeer with the second period (8.95%). Intensification process presented lower values during the three periods. On the other hand, disturbance was the process that increases from 3.68% to 9.99% and 12.93% during the first and second periods and throughout the total period, respectively (Fig. 4b).



a) Cherán municipality b) Tingambato municipality

Figure 4. Principle processes at municipality scale

Land cover changes

During the last thirty years, Pine-Oak Forest and Secondary Vegetation were the land covers with mayor permanence at Cherán municipality scale. The most significant alteration was the change of Secondary Vegetation to Pine-Oak Forest (4.09%) and from mature forest to Secondary Forest (4.19%). Resilience process is present in those territories where cultivated vegetation activities (Crops, specifically) ceased. At the same time, it is observe that Cherán habitants transform Secondary Vegetation ground to cultivated vegetation (Agro-forest plantations). After a littler while, the field is converted to human settlement. Secondary vegetation is the most dynamics land cover (4.99%), following by Pine-Oak Forest (4.78%) and Crops (1.61%) (Fig. 5a).

The Pine-Oak Forest conservation is the process more palpable in Tingambato municipality during the last thirty years (50.22% of total changes), like Secondary Vegetation intensification process that kept also high values (22.25%). It is not so clear the change that exhibits Pine-Oak Forest, but this land cover was affected by Secondary Vegetation (4.10%), so Pine-Oak Forest lost approximately 0.79 km^2 of its original area during the last three decades. Secondary Vegetation is not only affected by Crops (4.59%) but also by Agro-Forest Plantation that obeys to avocado plantations intensified at the begging of the 80´s. Secondary Vegetation was the land cover that exhibited mayor dynamics (10.46%), following by Crops (6.88%) and Pine-Oak Forest (4.82%) (Fig. 5b).

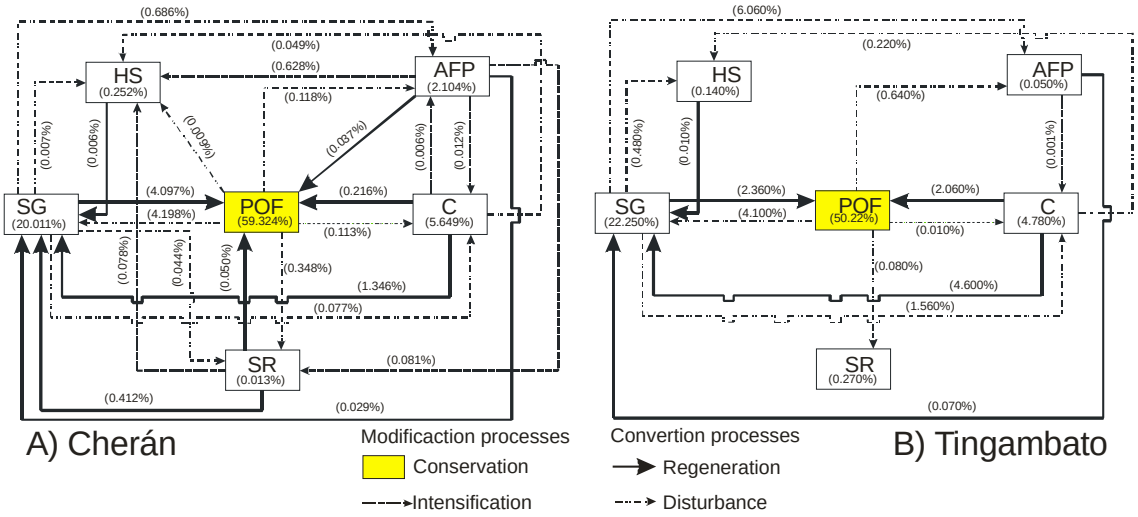


Figure 5. Land cover changes

Mean Annual Transformation Rate (MATR)

In Cherán municipality the Mean Annual Transformation Rate (MATR) shows that during 76-00 period Human Settlement was the land cover with the big change rate (k=0.056) due to high values that this land cover showed throughout the second period (k=0.086). Even though Pine-Oak Forest increased its area between 1976 and 1986 (0.14 km^2), the MART indicates a loss during the second period so the total area of this land cover passed from 143.63 to 142.77 km^2. This behavior reflects MART negative values for Pine-Oak Forest during the total period (k=-0002). The highest MART negative value is acquired by Crops during the second period (k=-0.016) in spit of its increase throughout the first one (k=0.001). Secondary Vegetation did not show significant changes during the first and second periods. In spit of this, this land cover gained 2.31 km^2 of area through the last thirty years, evidencing positive MART values (k=0.002).

Crops obtained the high MART negative value in Tingambato municipality during the last thirty years (k=-0.025) so the area of this land cover decreased from 22.33 km^2 in 1976 to 12.13 km^2 in 2000. At the same time, Agro-Forest Plantations reached high values in 2000 (13.00km^2) in compare with 1976 (0.24km^2), showing in this way positive MART values throughout the last thirty years (k=0.181). This tendency obeys to an increase during the first period (k=0.352), marking the beginning of avocado cultivations. Human Settlement did not exhibit drastic changes during the first period (k=0.010), but intensive development throughout the second one (k=0.113) due to the urban demands of Tingambato city (k=0.113). Pine-Oak Forest showed more moderate changes at the beginning of the first ten years (k=0.009) than the last fourteen ones (k=0.0001) (Fig. 6).

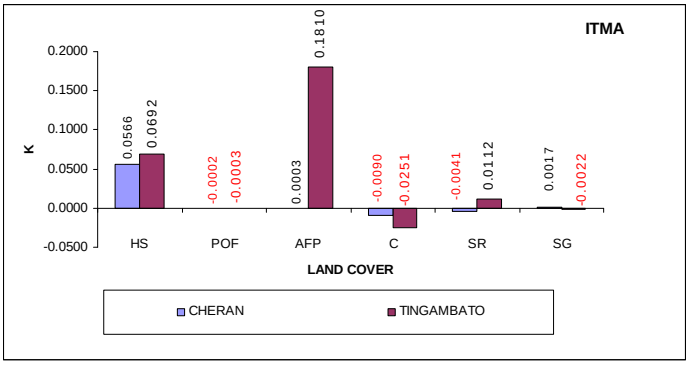


Figure 6. Mean Annual Transformation Rate (k)

The results show that both municipalities present disturbance processes and contrast ones during the first and second period. For example, Pine-Oak Forest resilience process is clear in Tingambato throughout the first period meanwhile Cherán municipality exhibits deforestation process. Pine-Oak Forest resilience process at the second period is due to "Ejidal" forest management improvement. So rural actual landscapes obey probably to deforestation processes before 70´s decade although some authors point out that it could be due to post subjacent causes that demark the actual state of the rural landscapes.

Garibay and Bocco (2007), for example, consider that the restructuration of Purépecha Region is the result of the integration of rural regional market to industrial national market, bringing three big processes: a) regional specialization in forest use; b) avocado plantation and, 3) cultivated corn system loss. It is also important to explain that the avocado plantations increased its production since 1960 (15 000 ha), reaching 23 000 ha and 35 000 ha at the end of the 70´s and 80´s, respectably. Recent studies calculate that today avocado cultivation almost reaches 83 000 ha. (Aguirre, 2006 in: Garibay y Bocco, 2007).

Additionally to the collapse of corn cultivation system and avocado price rise that experimented most of the municipalities that integrate Purépecha region, it is also significant to say that internal situation of the "ejidal" nucleus affects at the same time the actual situation of the template forest –land use changes. Both municipalities, for example, have a deficiency of internal rules for forest management. Moreover, this study identifies that three of each four social properties shows problem borders. Finally, forest training deficiency is another subject that must be considers to explain forest disturbance at study area scale.

It is necessary to go deeply into deforestation subjacent causes and land use changes at more detail scales: agrarian communities and "ejidal" nucleus scales, for example. Also, it is important to identify the principles local actors that participate directly or indirectly on the forest resource exploitation, permitting to answers *who* and *how* forest activities

affects the stability and conservation of the forest ecosystems so that we can contribute to improve sectorial forest programs in Michoacán State.

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