

Measuring from Space the Efficiency of Local Forest Management: The Successful Case of the Indigenous Community of Cherán, Mexico

FJ Osorno-Covarrubias^{1,2} S Couturier^{1,2,*} and M Piceno Hernández¹

¹ Laboratory of Geospatial Analysis (LAGE), Institute of Geography, UNAM, Mexico City, Mexico

² Research Center for Complexity Science (Centro de Ciencias de la Complejidad, C3), UNAM, Mexico City, Mexico

* Corresponding Author

E-mail: stephcamelo@mailcity.com

Abstract. Remote sensing-based forest cover change maps are usually elaborated for national level baseline information towards environmental conservation schemes. Community forest management is acknowledged as a key component of sustainable use of natural resources. In this research, we provide a means of technological appropriation for the community of Cherán, state of Michoacán, Mexico, to complement their local forest management initiative since 2012, after severe illegal logging occurred all along the previous decade. Participatory mapping, collaborative online cartography and global forest cover products were shared with the Community Council of the Commons. The environmental effect of the governance change occurred in 2012 was assessed using the Global Forest Cover Change (GFCC) product from 2000 to 2016. We find a significant reduction of deforestation in Cherán, due to local empowerment, which contrasts with overall trend in the region. We discuss the potential benefits of an alliance between communities and the academy through the construction of decentralized spatial data infrastructures in Mexico.

1. Introduction

In the context of global environmental change, deforestation critically contributes to greenhouse gas emissions and biodiversity loss. Since the early 2000s, the parties to the United Nations Framework Convention on Climate Change (UNFCCC) have encouraged mechanisms towards the reduction of deforestation worldwide [1]. Forest cover observation from space has become an effective means of measuring deforestation at national and global levels. The derived forest cover change maps have been widely employed by remote sensing specialists and consulting groups in order to document carbon stock baselines in the frame of UNFCCC proposed incentives in tropical countries [2]. However, an important component for the sustainability of forest conservation in the long run is local governance upon natural resources [3]. Specifically, for an effective reversal of ecosystem degradation it is argued that local communities should be considered an active part in the management of forests [4]. In Mexico, most of the managed forest cover is under communal or semi-communal property and much of the management is implemented according to traditional and indigenous knowledge systems. In this research, an academic effort is intended to strengthen the local forest management system of the indigenous community of Cherán, state of Michoacán (Mexico) (figure 1).



Content from this work may be used under the terms of the [Creative Commons Attribution 3.0 licence](#). Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

2. Characteristics of the Study Area

Forestry is a prominent economical sector in the in state of Michoacán (Fig. 1b); 1st national position for resin production, 3rd for wood production. Yet, land use conversions to grazing land and avocado plantation are a direct deforestation threat in this region [5], and frequently occur with the intervention of criminal groups [6]. To this respect, the evolution of forest management in Cherán (Fig. 1b) is a peculiar, emblematic case of community-based management in Mexico: their communal land was allegedly affected by heavy illegal logging from 2001 to 2012, at which date the organized majority of Cherán inhabitants, after repelling the armed illegal loggers, took control over the territory [7-9]. Since then, community forest management has been implemented by the Community Council of the Commons (CCC), with the aim of restauration and reforestation [10].

Under these circumstances, the purpose of this research was twofold: 1) Identify the academic knowledge and technology which might be helpful to the indigenous people of Cherán in their local process of forest recovery; and 2) Bring evidence of any forest cover tendency over the alleged illegal logging process from 2000 to 2012, and then over the alleged forest recovery process from 2012 to 2016, using available global forest cover products.

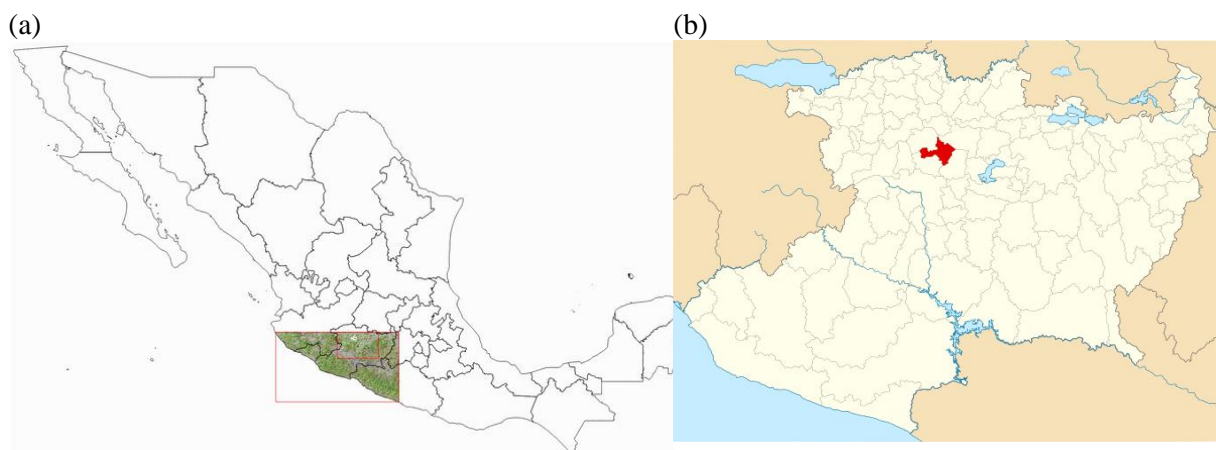


Figure 1. Location of the study area: (a) Purépecha Plateau (small rectangle) within the 10-20N lat., 100-110W long. quadrant. (b) Cherán community (red color) within the Michoacán state.

3. Methods

In order to efficiently accompany the organizational process of local forest management, a strategy of collaborative cartography (within the concepts of Citizen Science and NeoGeography [11]) was implemented, with three major elements: (1) Participatory mapping, (2) Construction of an online cartographic platform, and (3) spatial analysis of satellite – derived global forest cover products.

Following initial visits to the Community Council of the Commons (CCC) in the Cherán community, workshops of participatory mapping were planned, submitted to the CCC and authorized; they were implemented in Cherán in 2015 and 2016 [12]. Then, an online cartographic platform was designed with the open source software GeoNode, intended as a potential Collaborative Spatial Data Infrastructure (CSDI) for the Cherán community. Spatial materials derived from the participatory workshops, as well as freely available satellite imagery were selected and incorporated into the platform.

Finally, the Global Forest Cover Change (GFCC) [13], based on archive Landsat satellite imagery, was downloaded and analyzed. GFCC provides an estimate of the forest cover in year 2000 (“Tree canopy cover for year 2000” GIS raster layer, at 30m resolution, which states for each pixel the percentage canopy closure), as well as a yearly estimate of deforestation rate from 2000 to 2016 (“Year of gross forest cover loss event”, or “lossyear” GIS layer). The latter layer is encoded as 0 (no loss) or a value ranging from 1 to 16, corresponding to deforestation occurrence in year 2001 to 2016. Deforestation trends were assessed according to GFCC for the Cherán community and for a

surrounding portion of the Purépecha Plateau (Fig. 1a) before and after the governance change occurred; that is, from 2000 to 2011 and from 2012 to 2016.

4. Results

The participatory mapping workshops revealed the previous establishment of a local Geographic Information System (GIS) for forest management and the cartographic experience of specific sectors of the population. Forest degradation as well as restoration efforts had been precisely delineated in this GIS, under the supervision of the CCC. On the other hand, many Cherán participants expressed interest in integrating the spatial data collected in the workshop onto online cartography, to complete a collective memory on their territorial defense and establish educational materials (figure 2)

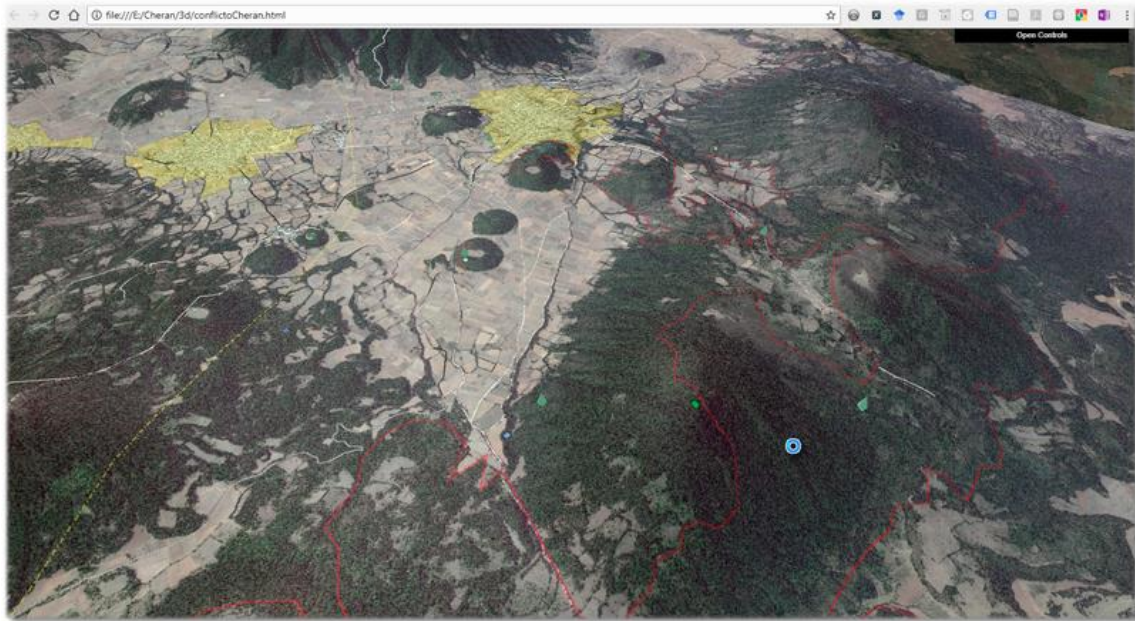


Figure 2. Interactive 3D web visualizer of the Cherán territory, included in the Collaborative Spatial Data Infrastructure (CSDI). Vector data shown were obtained through participatory mapping [12].

Additionally, options of payments for environmental services with international agents was perceived as an interest by CCC, while specific national incentives were perceived with distrust. Based on agreements derived from these workshop, a Collaborative Spatial Data Infrastructure (CSDI) was built, including local GIS information and color composites of satellite imagery (figure 3).

Finally, an analysis was conducted using the GFCC data. Total deforestation in the Purépecha Plateau was 34,143 ha from 2000 to 2016, setting an overall deforestation rate of 2,134 ha/year (see figure 4a). The accumulated forest loss within the traditional territorial boundaries of Cherán was 798 ha over the same period (see figure 4b) and deforestation rate had a peak in year 2011; that year the community confronted illegal loggers and gradually took territorial control within the traditional boundaries of Cherán. After this 2011 peak however, deforestation diminished to low levels in 2012-14, and then was almost null in 2015-16 (figure 4b). This pattern of deforestation reduction contrasts sharply with the increase observed in the rest of the Purépecha Plateau in the same period, reaching a new peak in 2016 for the 16 years observed period (figure 4a).

The spatio-temporal pattern of this process can be seen in figure 5. As of 2012, deforestation intensifies and occurs, almost entirely, outside the perimeter controlled by the Cherán community. This can be appreciated in the location and extension of the red pixels compared to that of the black pixels (deforestation before 2012).



Figure 3. Collaborative Spatial Data Infrastructure (CSDI) proposed to support forest monitoring by Cherán K'eri authorities.

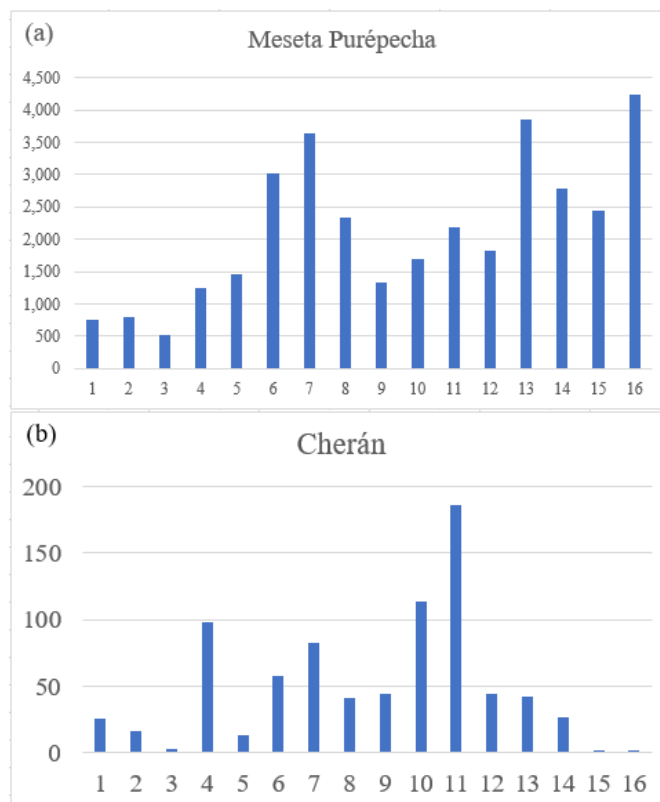


Figure 4. Deforestation rates (ha/year) from 2000 to 2016, derived from the GFCC global forest cover product: (a) Purépecha Plateau (b) Cherán.

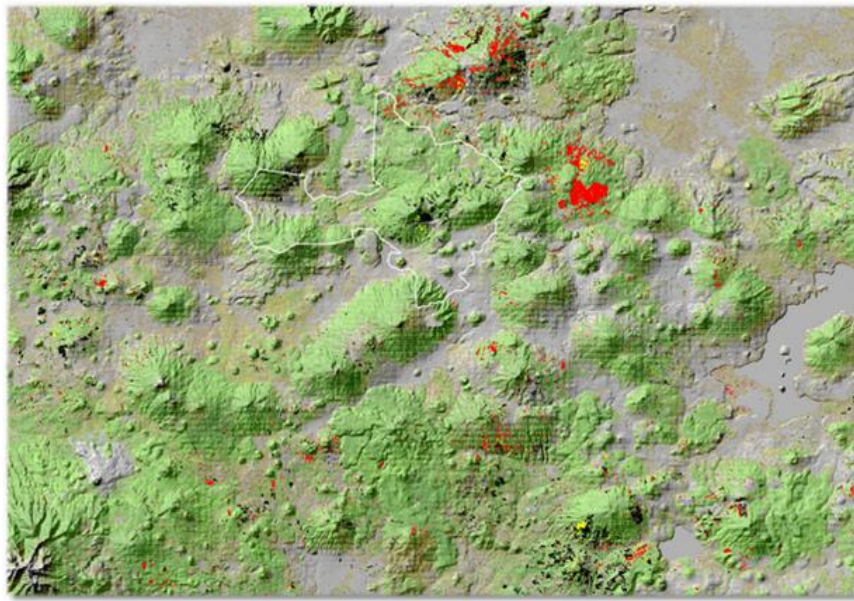


Figure 5. Deforestation pattern in communities of the Purépecha Plateau in the vicinity of Cherán (white polygon), according to the GFCC global forest cover product [13]. Deforestation areas are depicted in black (between 2000 and 2011), yellow (year 2012), and red (2013-2016). After 2011, note the reduced deforestation in Cherán, which contrasts with extensive deforestation in neighbouring communities.

5. Discussion

Previous research from the remote sensing perspective has documented the severe environmental degradation in the Meseta Purépecha; detailed deforestation hotspots in Michoacán [14], and in Cherán before the political shift [7]. The corresponding situation of illegal logging in the Meseta Purépecha and the particular case of Cherán before the political shift have also been studied from a sociopolitical and territorial perspective [6-9, 15]. Within this context, this research builds upon results of a socio-territorial analysis of the emblematic political shift in Cherán [10, 12]. A Collaborative Spatial Data Infrastructure (CSDI) is proposed, which we argue may be in accordance with preparing grounds for *Community Mapping, Measuring, Monitoring* [4] in Cherán, in a framework of Citizen Science.

To support this view, the results of our participatory workshops pointed to a high level of local expertise towards a digital forest monitoring system, which is an asset for the feasibility of a Citizen Science framework [16]. Then, the identification of a few needs from the Community (e.g. the construction of a georeferenced database for a collective memory on territorial defense, the analysis of technical options in view of payments for the environmental service of forest conservation) makes possible the relevance and mutual use of information shared in a CSDI. A special feature of this CSDI was the preliminary analysis of forest cover cartography based on the global forest cover change product GFCC. This analysis proved to be in accordance with the Cherán K'eri version of the situation and provides up to date information on the regional situation around Cherán, potentially strategic to the CCC.

The participatory work with the Cherán Community is still incipient (limited to a diagnosis) and would need more efforts and incentives from the academy in order to offer capacitation in the future, perhaps with the perspective of a community forest management scheme such as the one of nearby Nuevo San Juan Parangaricutiro [17], if ever such perspective is an option in Cherán. Also, from the remote sensing perspective, our study should aim at greater data quality, using available higher resolution remote sensing data [14], because it offers further independent validation on the reliability of citizen science practice [16]. As a first step, we should aim at a rigorous accuracy assessment of the GFCC satellite estimate.

6. Conclusions

In the global context of uncontrolled, increasing human consumption rates, many peripheral territories are affected by severe social-environmental damage. Views from Neo-geography or Citizen Science are that the academy should make an alliance with local actors that suffer these damages and accompany their quest for more social and environmental justice, with the perspective that uncontrolled merchandise production be slowed down to a constrained, more sustainable pace. This is the case of illegal logging for unsustainable wood production in Michoacán, Mexico, and specifically in Cherán, where local defenders of the environment have lost their lives facing criminal organizations. Schemes such as Community Measuring, Mapping, and Monitoring (CMMM) have been proposed to strengthen local forest management systems, where the academy should complement local knowledge with technical / communication tools.

This research seeks to accompany the notorious governance shift undergone by the Cherán K'eri traditional authorities in 2011 towards an autonomous, sustainable resource use in the Cherán territory. For the purpose of helping in the implementation of CMMM in Cherán, we propose a set of methodological steps. First, potentially useful academic tools and knowledge were identified through participatory mapping. Second, a set of these tools was integrated into an online cartographic platform (a Collaborative Spatial Data Infrastructure - CSDI) and visualized in the perspective of *Community Mapping and Measuring*. Finally, we found that the freely available GFCC time series product could be a useful tool to set an external, preliminary reference to *Community Monitoring*. Our analysis of the GFCC product between 2001 and 2016 confirmed the environmental tendencies claimed by the Cherán K'eri authorities along this time period: the community was indeed affected by high deforestation rates between 2004 and 2011 (allegedly caused by the illegal logging criminal organization), and, from 2012 up to our days, deforestation has drastically reduced (because of the expulsion of the illegal logging organization from Cherán, the removal of the former formal government, involved in the illegal activity, and the reforestation policy of the Cherán K'eri autonomous authorities). Our findings also point to a contrasting situation, however, in the Purépecha Plateau, and specifically in communities next to the Cherán territory, where unsustainable logging could be increasing since 2012, suggesting the persistence of illegal logging organizations, warning for a potentially conflictive situation in the vicinity of the Cherán community.

Based on this experience, and under favourable alliance conditions, we suggest similar Collaborative Spatial Data Infrastructures be built to technically support *Community Mapping, Measuring and Monitoring* aimed at local forest sustainable management elsewhere in Mexico and in rural settings of the sub-tropics. Future works in Cherán may include the accuracy assessment and quantitative adjustments of the GFCC-based forest cover figures using the more accurate information of the local GIS developed by the Community Council of the Commons in Cherán, as well as the elaboration of more cartographic products (printed and online) which might help Cherán K'eri authorities document and appropriately inform about the forest cover tendencies shown in this research.

7. References

- [1] Mollicone D, Freibauer A, Schulze E, Braatz S, Grassi G, Federici S. 2007 Elements for the expected mechanisms on 'reduced emissions from deforestation and degradation, REDD' under UNFCCC. *Environmental Research Letters*. 2(4):045024.
- [2] Mitchell AL, Rosenqvist A, Mora B. 2017 Current remote sensing approaches to monitoring forest degradation in support of countries measurement, reporting and verification (MRV) systems for REDD+. *Carbon balance and management*. 12(1):9.
- [3] Pelletier J, Gáñas N, Skutsch M. 2016 The place of community forest management in the REDD+ landscape. *Forests*. 7(8):170.
- [4] McCall MK, Chutz N, Skutsch M. 2016 Moving from measuring, reporting, verification (MRV) of forest carbon to community mapping, measuring, monitoring (MMM): perspectives from Mexico. *PloS one*. 11(6):e0146038.
- [5] Barsimantov J, Antezana JN. 2012 Forest cover change and land tenure change in Mexico's avocado region: Is community forestry related to reduced deforestation for high value crops? *Applied Geography*. 32(2):844-53.
- [6] Del Conde A. 2015 Illegal Logging and its Dynamics of Violence Within the P'urhépecha Plateau. *Landscapes of Violence*. 3(1):6.

- [7] España-Boquera ML, Champo-Jiménez O. 2016 Proceso de deforestación en el municipio de Cherán, Michoacán, México (2006-2012). *Madera y bosques*. 22(1):141-53.
- [8] Fuentes Dáz A, Paleta Pérez G. 2015 Violencia y autodefensas comunitarias en Michoacán, México. *Éonos: Revista de ciencias sociales*. (53):171-86.
- [9] Fuentes-Dáz A. 2014 Autodefensa y justicia en los márgenes del Estado. *Clivajes. Revista de Ciencias Sociales*. (2).
- [10] Lariagon R, Piceno M. 2016 La lutte pour l'autonomie de la communauté de Cherán: reconfiguration territoriale et subjective. *Cahiers des Amériques latines*. (81):133-51.
- [11] Osorno-Covarrubias J, Couturier S, Ricárdez M. 2015 El rol de la Geografía y sus hibridaciones recientes frente a la crisis de sustentabilidad global. *Boletín de la Asociación de Geógrafos Españoles*. (69):93-112.
- [12] Piceno Hernandez M. La cartografía colaborativa como herramienta para la defensa del territorio y los bienes comunes en Cherán, Michoacán [Tesis de maestría]. México: Universidad Nacional Autónoma de México; 2017.
- [13] Hansen MC, Potapov PV, Moore R, Hancher M, Turubanova S, Tyukavina A, et al. 2013 High-resolution global maps of 21st-century forest cover change. *science*. 342(6160):850-53.
- [14] Mas J-F, Lemoine-Rodríguez R, González R, López-Sánchez J, Piña-Garduño A, Herrera-Flores E. 2017 Evaluación de las tasas de deforestación en Michoacán a escala detallada mediante un método híbrido de clasificación de imágenes SPOT. *Madera y bosques*. 23(2):119-31.
- [15] Fuentes-Dáz A. 2015 Narcotráfico y autodefensa comunitaria en "Tierra Caliente", Michoacán, México. *CienciaUAT*. 10(1):68-82.
- [16] Elbroch M, Mwampamba TH, Santos MJ, Zylberberg M, Liebenberg L, Minye J, et al. 2011 The value, limitations, and challenges of employing local experts in conservation research. *Conservation Biology*. 25(6):1195-202.
- [17] Velázquez A. Las enseñanzas de San Juan: investigación participativa para el manejo integral de recursos naturales/comp. por Alejandro Velázquez, Alejandro Torres, Gerardo Bocco. México: Secretaría del Medio Ambiente y Recursos Naturales, Instituto Nacional de Ecología; 203. 595 p.

Acknowledgments

The authors duly acknowledge the participation of numerous inhabitants of Cherán and their authorities (Cherán K'eri), through their Community Council of the Commons (CCC). Field work in Cherán and the elaboration of cartographic materials were supported by the DGAPA UNAM sponsored projects PAPIIT IA300515 and PAPIIT IN302417; The online collaborative platform was developed under the ASTIG (Social Empowerment on Geographic Information Technology) project, in the Research Center for Complexity Science (Centro de Ciencias de la Complejidad, C3) at UNAM; Thanks are also due to the CONACYT national public research funds for the Master's thesis scholarship of the third author.