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A Multi-Scale Approach to Land Governance in Complex Contexts in Bolivia and the Lao PDR

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FINAL REPORT

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PROJECT TITLE:

A multi-scale approach to land governance in complex cultural, environmental and institutional contexts. Development of a comparative GIS methodology linking land use, land cover and land tenure from the cases of Bolivia and Lao PDR

ABSTRACT:

This exploratory research project had the objective to understand land governance in terms of its spatial expression across multiple scales by assessing the interactions between local social-ecological systems and overarching governance configurations. The two first contributions showed that land redistribution and titling in Bolivia as well as village resettlements in Laos affect forest cover. Yet these national policies must be linked with international development agendas, which have geographically visible strategic priorities within both countries. Meso-scale typologies of social-ecological systems based on land cover change and socio-economic data allowed to identify challenging land governance configuration including cash crop expansion areas, areas settled by smallholders with gradual levels of market integration and remote areas with unexpected high deforestation. Yet these configurations are linked with specific actors' interests and their criticity is not value-free. We introduce the prospective, applied concept of land governance "critical zones", as potential and indicative areas where different interests and pressures from different sources arise, which have to be identified in a collaborative, multi-stakeholder effort of knowledge production.

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COVER PHOTO :

Nam Khan Valley, Luang Prabang, Laos, 2013, Joan Bastide

1. Research Plan

Underlying causes of land use and land cover change rely to both socio-economic and institutional drivers that operate at multiple scales (Lambin et al. 2001; Turner et al. 2007). This exploratory project had the objective to understand land governance in terms of its spatial expression across multiple scales by emphasizing the interactions between local social-ecological systems and overarching governance configurations.

Assessing the spatial expression of socio-economic, socio-political and ecological variables that are relevant to land governance is particularly challenging because of the very large number of variables (Ostrom 2009), and also because these variables are usually not assessed at the same scales (Rindfuss et al. 2004). This project's approach builds on two ways of addressing this complexity. First, data produced at different scales can be spatially harmonized using aggregation and spatial reach estimation of socio-economic variables. Second, complex systems can be addressed through the recognition of clustered and chained drivers and processes, and their arrangements in levels (Simon 2000; Messerli et al. 2009). These approaches are expected to contribute 1) to the development of typological theories that specify independent variables, delineate them and provide generalizations (George and Bennett 2005; Ostrom and Cox 2010), and, 2) to the development of applied methods and tools to provide planning and policy advice by highlight critical zones of land governance.

This project focuses on the recognition of processes using the concepts of pressures, where demographic, economic and political drivers increase the resource use need of a specific socio-economic actor, and frictions, which happen where resource use claims and spatial initiatives of different actors overlap (Giraut 2011, 2013). The main hypothesis of the project is that there are observable "land governance hotspots", where pressures and frictions overlap and might lead to an accelerated competition over land resources. The Lao PDR and the Bolivian lowlands are both areas where low population density, high forest cover and cultural and socio-economic diversity are expected to make these processes visible.

The research questions to be addressed by the project were the following:

1. What are the spatial relations between socio-economic characteristics of actors and land use and land cover change at different scales of analysis?

2. What are observable spatial patterns of socio-political initiatives, highly disputed land tenures, areas of rapid land use changes, and areas of high or low biological diversity at different scales?

3. How are different land governance contexts reflected in the local frictions between actors and in pressures on local institutional arrangements governing land tenure and use among different socio-economic and cultural actor categories?

4. What are trends of land cover change pathways and social differentiation processes in land tenure in relation with land policy reforms and the uneven reach of economic integration that are observable in both countries?

Empirical work was carried out at national, sub-national (regional) and local scale. Our contributions can be grouped in five main topics addressing key aspects of land governance (table 1): national and transnational policies, regional and local pressures and frictions, and co-production of knowledge.

Theme/topic	Bolivia	Laos
National Policies	Land policy, accessibility and forest cover change	Resettlements policy, population, land access and forest cover change
Transnational Policies	Geopolitical land governance hotspots from land survey funding data	Geocoding development interventions
Pressures	Census data and forest cover change: from a multivariate approach to a typology of social-ecological systems	
Frictions	Potential and actual land conflicts assessment	Exploring land use trade-offs: rubber plantations and tourism
Co-production	Mapping local knowledge and cultural heritage at the meso-scale: a reflexion on risks and opportunities	

2. Results

2.1 National land policies and land cover change

Laos and Bolivia have been enacting and applying different land policies which entail land allocation and redistribution, use regulation and incentives. In Bolivia, redistribution was put back in the political agenda since 2006, especially in the lowlands, and comes along with a land title formalization process that has accelerated since then. In this context, title formalization is established as a means to verify that private lands are effectively used (the "socio-economic function" of land), or revert them to the State if they are not. In Laos, national land policies have sought to combine conservation with development by curbing slash-and-burn cultivation and improving access to state services and market facilities for rural populations. This includes resettlements of dispersed and remote population to clustered villages along roads, and land allocation through land planning at village level. On the other hand, the Lao government has started to lease large land concessions to national and foreign investors for the development of cash crops.

2.1.1 Are commons more remote? Land policy, accessibility and forest cover change in Bolivia

This contribution (Boillat et al, in preparation a) elaborates on the hypothesis formulated by Bottazzi and Dao (2013) on the base of a case study in the Bolivian lowlands, that forest in common lands is less converted than in private lands, mainly because common lands are located further away from roads.

Three datasets were used to test this hypothesis at larger scale and drive conclusions about the effects of Bolivian land policy on forest cover change: data on forest cover change at national level between 2000 and 2010 elaborated by the protected area service (SERNAP), cadaster data on land tenure types provided by the Bolivian Protected Area Service of the National Institute of Agrarian Reform (INRA), and data on travel time from roads and urban centers.
Travel time data were elaborated through an accessibility model which maps travel time at a resolution of 90 m for the whole country. The model allowed to calculate

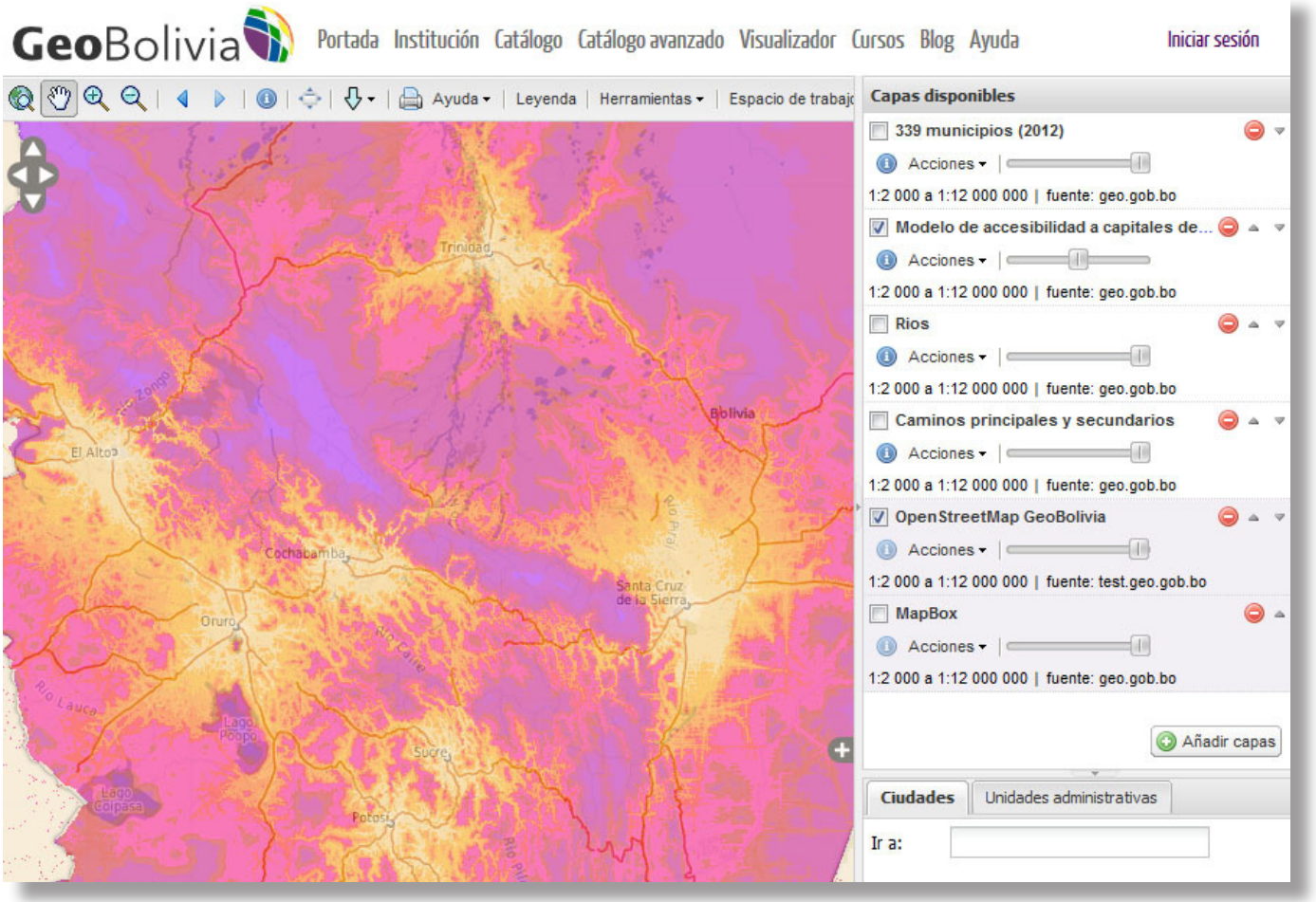


Fig. 1: Accessibilty Model Publicly available on GeoBolivia

travel distance in hours from the department capitals, municipal capitals, communities and main roads (http://geo.gob.bo/catalogapp/?any=accesibilidad). (Figure 1).

The assessed distribution of land tenure types by travel time to main roads showed that as expected, small and medium private properties are usually located near roads and towns, collective lands and indigenous territories in more remote areas, and state lands in the most remote areas. Forest conversion by tenure type also showed to be higher in privately held than in community held properties.

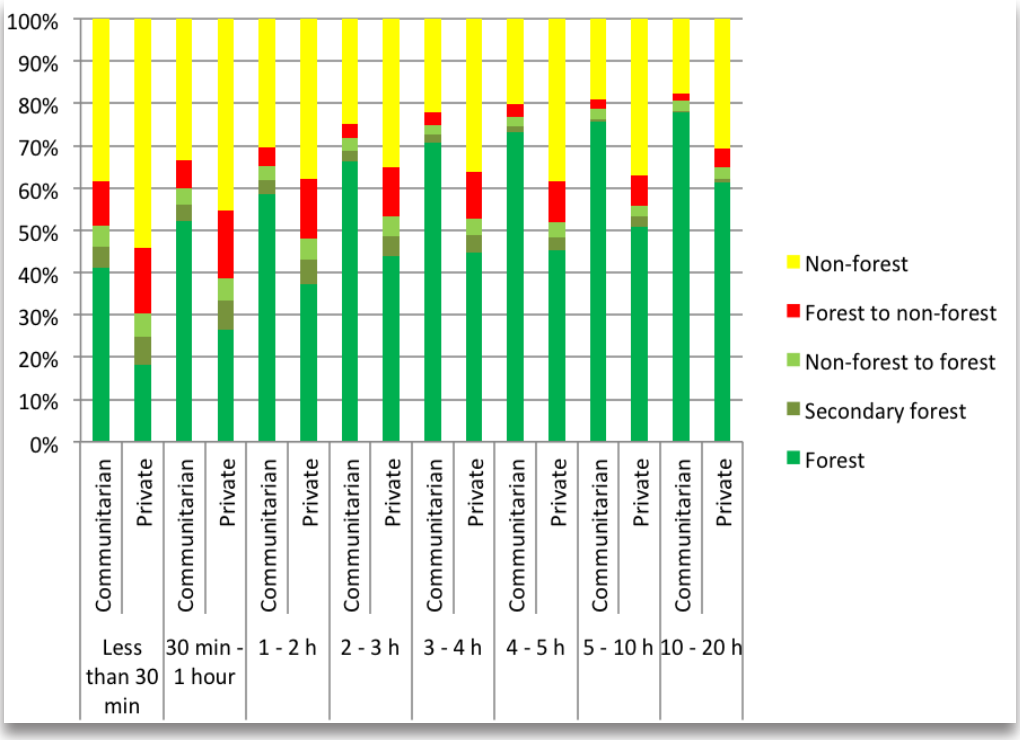


Fig. 2: forest cover change (2000-2010), land ownership and travel time from main roads

Nevertheless, forest cover change for communitarian and private lands with similar accessibility values showed that even for similar remoteness, more forest is converted in privately held lands (Figure 2)

These findings show that accessibility alone does not explain forest conversion, and that land tenure also plays a role. Since private lands are subject to the "socio-economic function" but not communitarian or indigenous lands, the redistribution policy acts as an incentive for private owners to clear more forest, as was observed in the Santa Cruz region and confirmed through field interviews by Redo et al. (2011).

2.1.2 Resettlements, population, land access and forest cover change in the Lao PDR

This contribution (Boillat et al, submitted a) aims at understanding how resettlements might affect land use in the concerned villages, especially focusing on forest cover change. We assessed and compared forest cover change in resettled and non-resettled villages using a subset of the Global Forest Cover Change dataset (Hansen et al 2013) covering the Lao territory, and data from the Lao National Agricultural Census of 2011.

We found significant differences (non-parametric Mann-Whitney test with $p<0,05$) between forest loss, forest gain and area with both loss and gain for resettled (n=847) and non-resettled villages (n=7628). In the whole country as well as in 9 of 17 provinces, resettled villages tend to experience more forest loss, but also more forest gain as well as more areas with both loss and gain. Total agricultural population (assessed by the 2011 census) appears however significantly lower in terms of both numbers and density in resettled villages, and the number of ethnic groups show no significant differences.

These data were complemented by a case study performed in two villages (Sopchia and Houay Si Nhoua (HSN)) of Phonexay district in the province of Luang Prabang. A survey of land access performed with 60 households showed that contrary to natives, most newcomers from relocated villages do not have access to irrigated paddy fields. Inversely, most people (83%) who had access to irrigated fields were established for more than 20 years in the village (Stich 2013).

We conclude that land scarcity for newcomers in relocated villages might push them to clear more forest, despite the strict land allocation policy and measure taken against slash-and-burn cultivation. Resettled areas can thus be considered critical areas, which are located at an intermediary stage between remote areas and economically more integrated areas in the lowlands. In these areas, several government interventions – often backed up by international cooperation – overlap and might lead to contradictory or unexpected outcomes.

2.2 Transnational land governance: the geopolitics of development interventions in Bolivia and Lao PDR

This section addresses specific patterns of interventions linked to foreign aid that are relevant to land governance. Because the available datasets for both countries were different, no direct comparison is possible. In the case of Bolivia, we focus on the spatial distribution of the international financing of the land survey between 1996 and 2013 (Lerch 2014). In the case of Laos, we assess the distribution of development intervention from the databases recorded by the Ministries of Planning and Investment (MPI) and Agriculture and Forests (MAF) (Bastide 2014).

2.2.1 Approaching geopolitical land governance hotspots from land survey funding data

This already published contribution (Lerch 2014) is based on rural cadastral INRA data with information on donors. The data were used to calculate the "donor diversity" for each community in Bolivia, to assess where international stakeholders of land surveying funding had focused their interests. This analysis was completed with participative observation and semi-directed interviews with key informants active within international aid system and Bolivian public administration.

Fig. 3 shows the diversity of land survey donors at national level in Bolivia. All communities with high donor diversity are located in low lands and some valleys, and can be considered "land surveying geopolitical hotspots". A geographical comprehensive typology built on the basis of previous contextual data (interviews and "grey" literature like institutional documents) allows sorting the communities in 4 geopolitical hotspots corresponding to different problematic and areas:

1. The Amazon basin, with funding from the United States, Denmark and multilateral organizations appears to be linked with border monitoring, carbon economy and biodiversity control. In this case, land survey is a necessary step to enable payment for ecosystem service schemes.
2. The Chapare coca-growing region, where an extremely detailed land survey has been financed by the European Union and the United States and is linked with population control and illicit / licit market regulation.
3. The Corumbá (Brazil) - Santa Cruz corridor, mainly funded by the USA and Inter-American Development Bank (IDB), where access to mining areas as well as transport of commodities from Brazil and Bolivia to the Pacific Ocean are at stake, and land survey acts as a negotiation tool with local communities affected by these activities.
4. The Andean piedmont in the South of Bolivia, the territory of numerous indigenous Guaraní communities and the most important natural gas deposit in the country, mainly funded by Denmark and the United Nations Development Programme (UNDP).

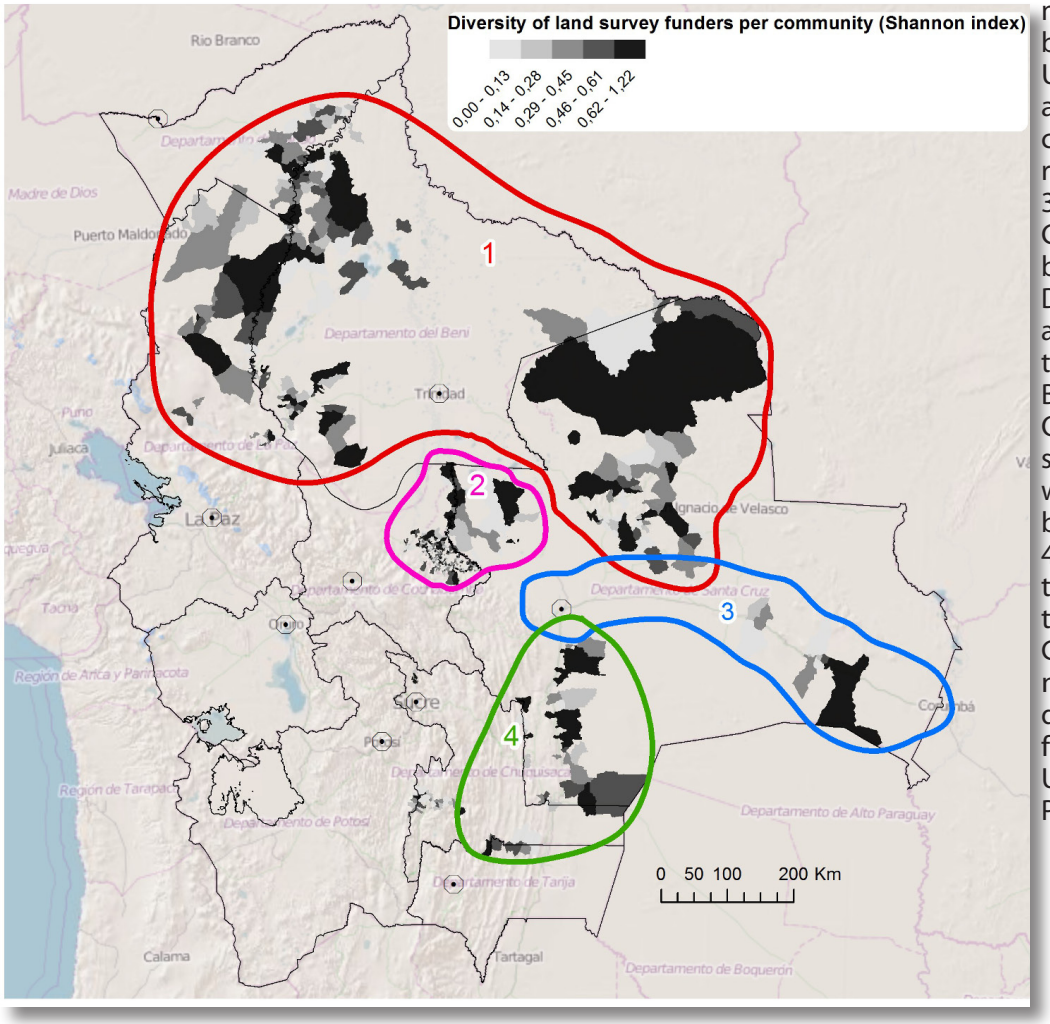


Fig. 3: Donors involved in land survey in Bolivia

2.2.2 Geocoding development interventions in Lao PDR

A part of a PhD thesis in progress (Bastide 2014), this contribution had the objective to assess the geography of foreign development interventions in the Lao PDR by geocoding their activities down to the village level. Two databases were used: 1) the Aid Management Platform held by the Ministry of Planning and Ministry of Planning and Investment (MPI), which lists all development projects (about 800) in the country, their respective sector of interventions, quarterly disbursements and implementing partners; and 2) the Ministry of Agriculture and Forests (MAF), who keeps a database of all international projects in which it is involved. Additional information was collected from District and Province authorities on aid projects, private and public investments and household surveys were conducted in 4 villages to assess the importance and impact of development projects on people's livelihoods and coping capacities.

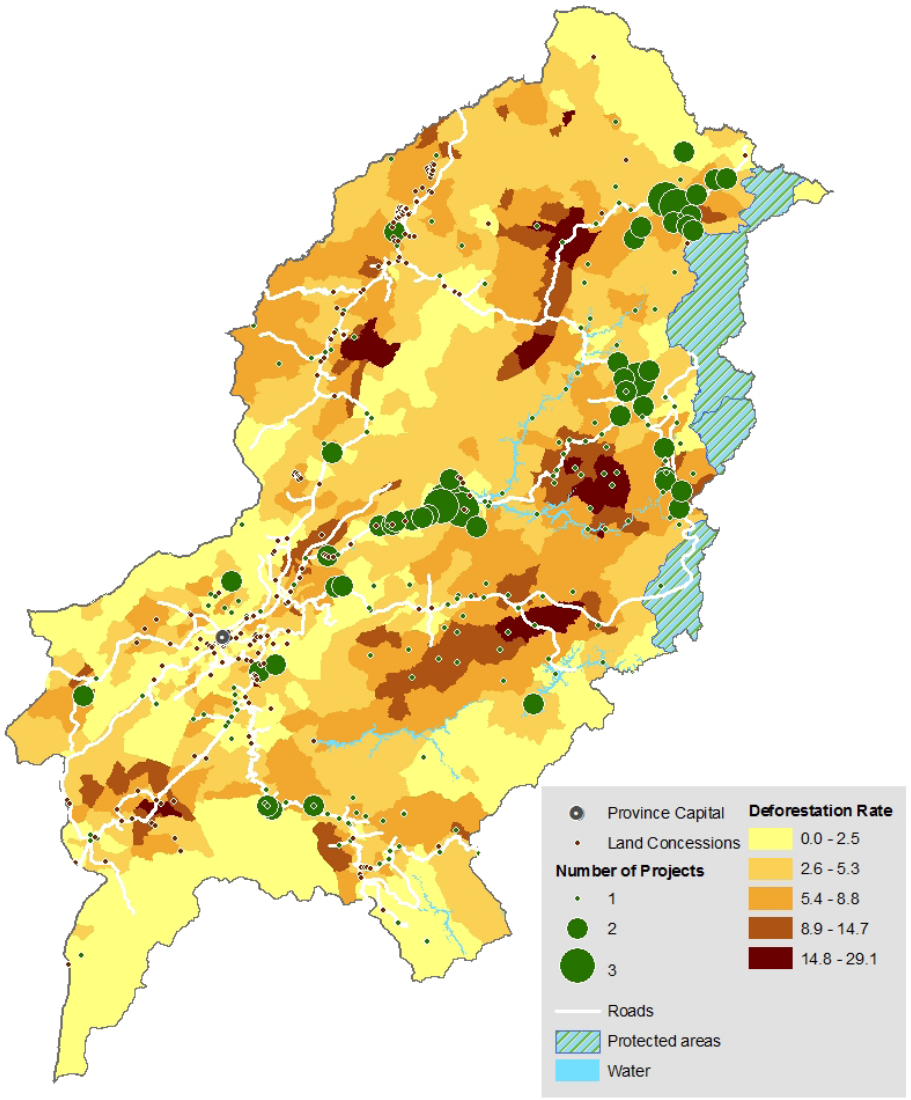


Fig.4: Development interventions and deforestation rate in Luang Prabang Province

Up to now, the MAF database has been fully geocoded, and the MPI one will be processed thanks to a partnership with the Centre for Development and Environment at the University of Berne, for which the author of the work has been hired. The location of development projects was overlayed with the "geography of needs" including accessibility, poverty and land cover change.

The initial results of this set of analysis indicate that most projects' activities are located in areas with good physical accessibility, largely close to the roads (Figure3). This confirms the assumption that choice of target areas by international actors is at least partially determined by pragmatic considerations, over in-depth needs analysis. This pragmatic approach to targeting is also partly confirmed by interviews of project designers and managers.

At this stage, no direct correlation between the concentration of development interventions and land use changes could be identified. More surprising, no clear evidences of links between the distribution of poverty and of development projects have been found. However, no conclusion on these two aspects can be validated at this stage, as 1) the analysis is limited to current projects, and do not take into account the history of interventions; 2) the intervention inventory is limited to aid funded projects and does not systematically integrate public and private investments; 3) the poverty information used are outdated (2005) and do not show the temporal dynamics.

2.3 Integrating census data and forest cover change: from a multivariate approach to a typology of social-ecological systems

This contribution (Boillat et al, submitted b) focuses on the relationships between forest cover change and socio-economic variables at "meso-scales" defined as a local to national scale of observation (Messerli et al. 2009). It explores links that can be derived from data available for a relatively large number of cases in a defined region. Four regional case studies were chosen, in Bolivia, the North of La Paz forest landscape (NLP, 259 communities), and the Santa Cruz agroindustrial area (SCA, n=626), and in Laos, the provinces of Luang Prabang (LPP, n=765) and Luang Namtha (LNP, n=341) (Fig. 5).

We assessed the relationships between data derived from censuses (population, poverty and ethnic groups), GIS analysis (area covered by protected areas and concessions, as well as mean accessibility), other databases (land tenure in the case of Bolivia), and forest cover change, assessed through supervised classification of Landsat 5 images at three points in time (2001-2005-2010 in Bolivia and 2000-2005-2010 in Laos). Contrary to most studies on land change that are based on pixels, we chose local communities as observation units. Because these communities are located as points by both Lao and Bolivian censuses, we used accessibility models to calculate community polygons limited by equal travel time. The method already performed in Laos by Messerli et al. (2008) was adapted and applied to Bolivia, computing 14000 community polygons.

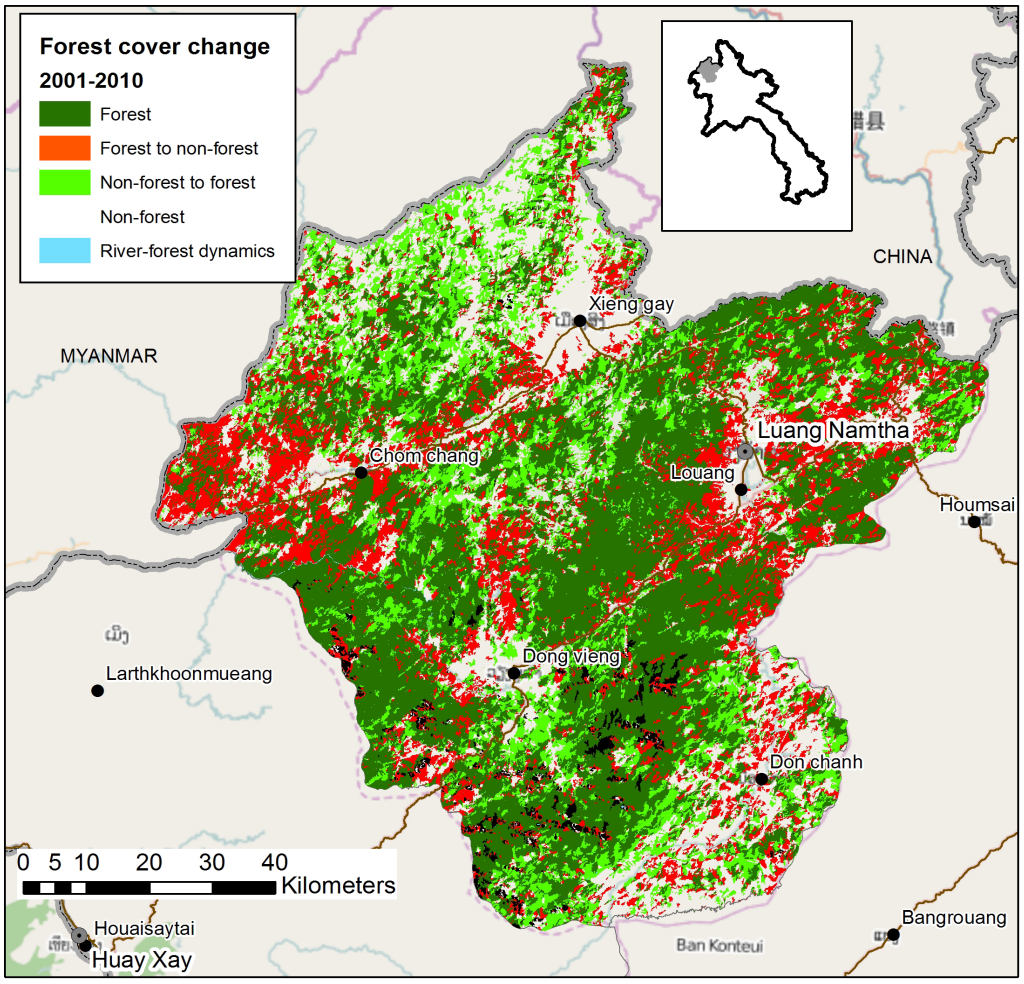


Fig. 5: Forest Cover Change in Luang Namtha, Lao PDR

We found significant relationships (Pearson correlations) between variables of population density, road and urban center distances, poverty, and ethnic groups. In Laos, we found that poverty and low population density correlates with distance from districts and province capitals, and the presence of Austroasiatic ethnic groups. In Bolivia, poverty is not related with distance from roads or towns, but with the presence of Andean (Quechua and Aymara) ethnic groups and high rural population density.

Forest cover change shows different relationships with socio-economic variables: in Bolivia, forest loss correlates with population density and accessibility. While in the NLP case, it is related with extreme poverty, this is not the case in SCA. Furthermore, in NLP forest loss is also related with forest gain and the presence of Andean settlers, which is not the case in SCA. Lowland indigenous people correlate negatively with forest loss but also with distance. Land tenure appears to be partly linked with ethnic groups and corresponding forest cover change: small private lands with Andean settlers, indigenous territories with lowland indigenous peoples. However, in SCA mestizo and non-indigenous people are not related with medium and large landholdings, but rather with non-formalized lands.

In Laos, the LNP case shows a gradient between remoteness, highland ethnic groups and moderate forest loss and gain, and higher forest loss, ethnic mix and access to urban centers (fig.5). The LPP case is more intriguing: forest

loss tends to occur in more remote, sparsely populated and poorer areas, but with forest gain as well, showing possible areas of slash-and-brun cultivation. The presence of protected areas and concessions showed less clear trends, with less deforestation in PAs only in two of the four cases (SCA and LNP).

These results show that population density, poverty, ethnicity, accessibility and forest cover change tend to

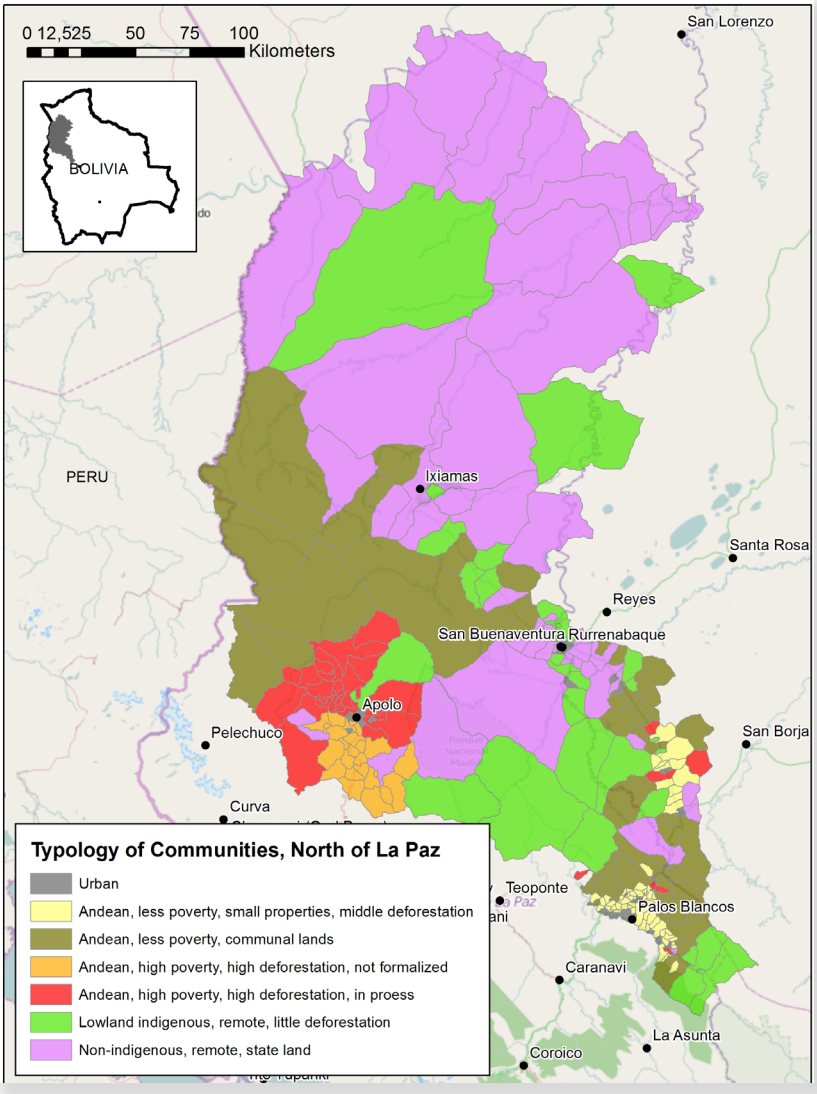


Fig. 6:Typologie of specific land changes processes

be related, though not in the same manner, in the four cases. We used these dependencies to produce a typology of communities into 4 to 6 classes on the base of these variables through k-means cluster analysis (Fig. 6: one case). Typologies allow to identify clusters of specific land change processes and social-ecological characteristics, with three main configurations emerging from the analysis:

- Cash crops expansion areas with high forest loss and insignificant gain: rubber in Laos and soybean in Bolivia, typically showing lower poverty rates, good accessibility and inhabited by dominant ethnic groups. Within these areas, there are cases with high ethnic mix and high poverty but good accessibility, suggesting the emergence of high socio-economic inequalities
- Smallholder areas typically feature both forest cover loss and gain. Forest loss gradually overcomes gain with decreasing remoteness and increasing private property, from lowland indigenous people areas in Bolivia, slash-and-burn cultivation areas in Laos dominated by ethnic minorities, and easily accessible Andean settlements along roads in Bolivia.
- Remote areas with low population, high poverty and high deforestation (found in LPP and NLP) appear intriguing and are difficult to interpret in absence of field information. Unverified reports on a possible expansion of coca cultivation in a remote sector of the NLP area might be an element of explanation.

2.4 Frictions over land resources: trade-offs and conflict assessments

These two contributions address trade-offs and possible conflicts linked to different land uses. Again, it was not possible to obtain comparable data in Bolivia and Laos. The contribution from Bolivia consisted in elaborating and comparing three independent datasets on land management conflict potential and record in Bolivia (Sandoval and Boillat, in preparation). The contribution from Laos consists in a case study looking at the consequence of the "rubber boom" in the province of Luang Namtha and its consequences on other land uses (Guntern 2013).

2.4.1 Are land management conflicts predictable? An empirical approach to "land governance hotspots" in Bolivia

Two approaches were used to assess potential conflictivity over land uses on the base of the calculated community polygons in Bolivia. First, the potentiality approach consisted in calculating a productive potentiality index (1-5) for different uses (agriculture, livestock production, forestry, ecosystem and species conservation) for each community of the SCA on the base of productive potential, biodiversity, conservation status and concession data. These uses were plotted against each other in a conflict potential matrix (Fig. 7), qualifying the conflict potential between pairwise productive potentials as low, moderate and high, and calculating an overall conflict potential for each community. Secondly, we used a multi-criteria approach and computed a series of socio-economic, ecological and

These potential conflict maps were compared with an independent dataset on actual land conflicts. This dataset was produced through the development of an experimental geocoding web platform to map reported land management and territorial limit conflicts using a database on Bolivian written press media (Fig. 8). In collaboration with the NGO "Centro de Documentación e Información de Bolivia" (CEDIB), we mapped 396 press articles using the database of localities of Bolivia provided by the National Census of 2001, with 43'000 entries.

and potentialities approach. Since land tenure diversity, ethnic diversity and concession area does not correlate with population density, this last variable cannot explain the presence of conflicts alone.

Contingency analysis showed overlappings between the presence of concessions, protected areas and conflicts for whole Bolivia and lowland Bolivia, but not in the SCA case. However, the reported conflicts as well as mining concessions also strongly overlap with the presence of

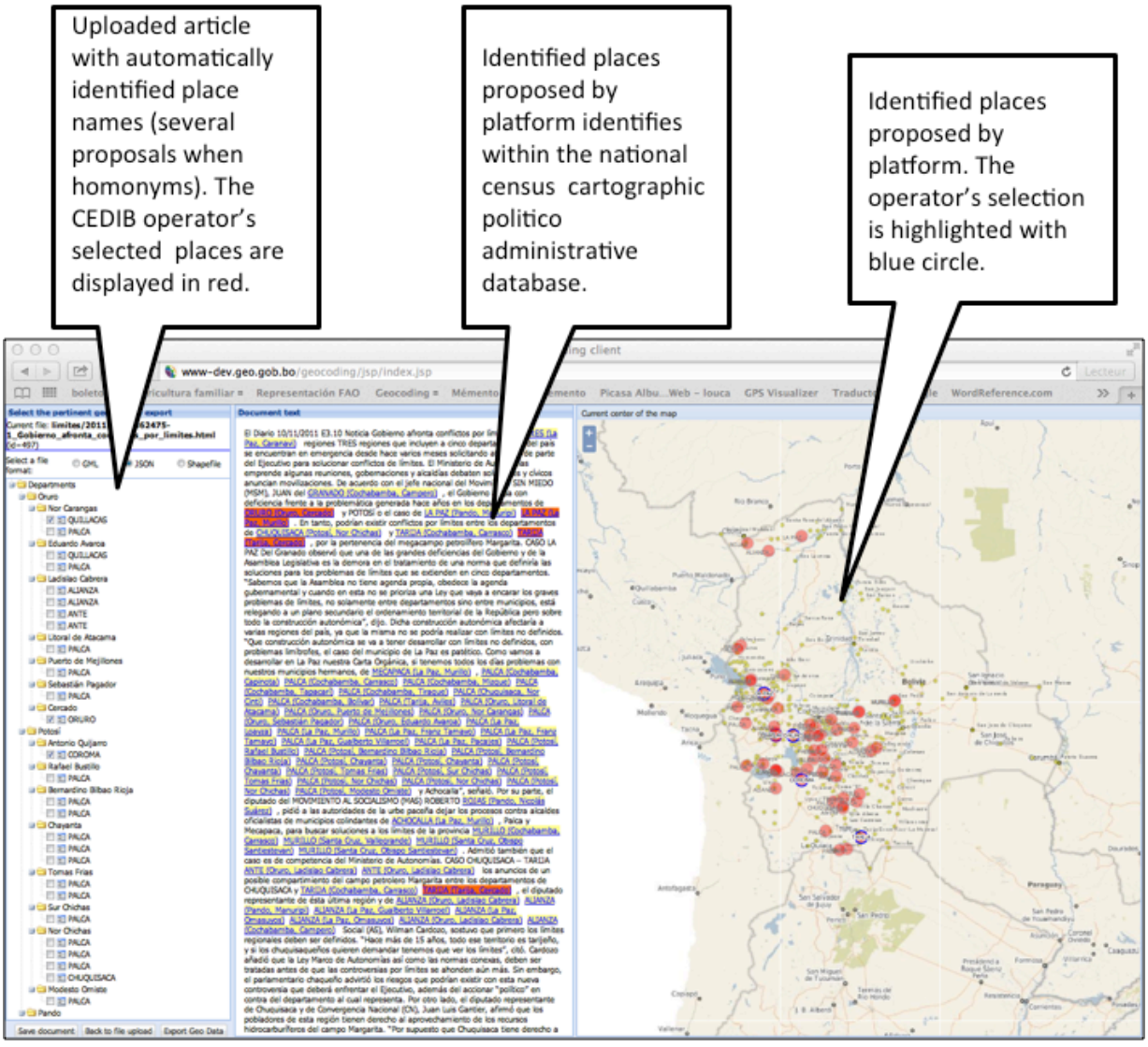


Fig. 7: Territorial Conflicts Database

Mann-Whitney tests comparing conflict potential values for areas which effectively experienced a conflict and for those who did not, showed that for whole Bolivia as well as lowland Bolivia, population density, land tenure diversity, ethnic diversity and area under concession are higher in areas that experienced conflicts, and poverty rate is lower. These relationships are however no longer visible at regional level in the SCA case for both multi-criteria

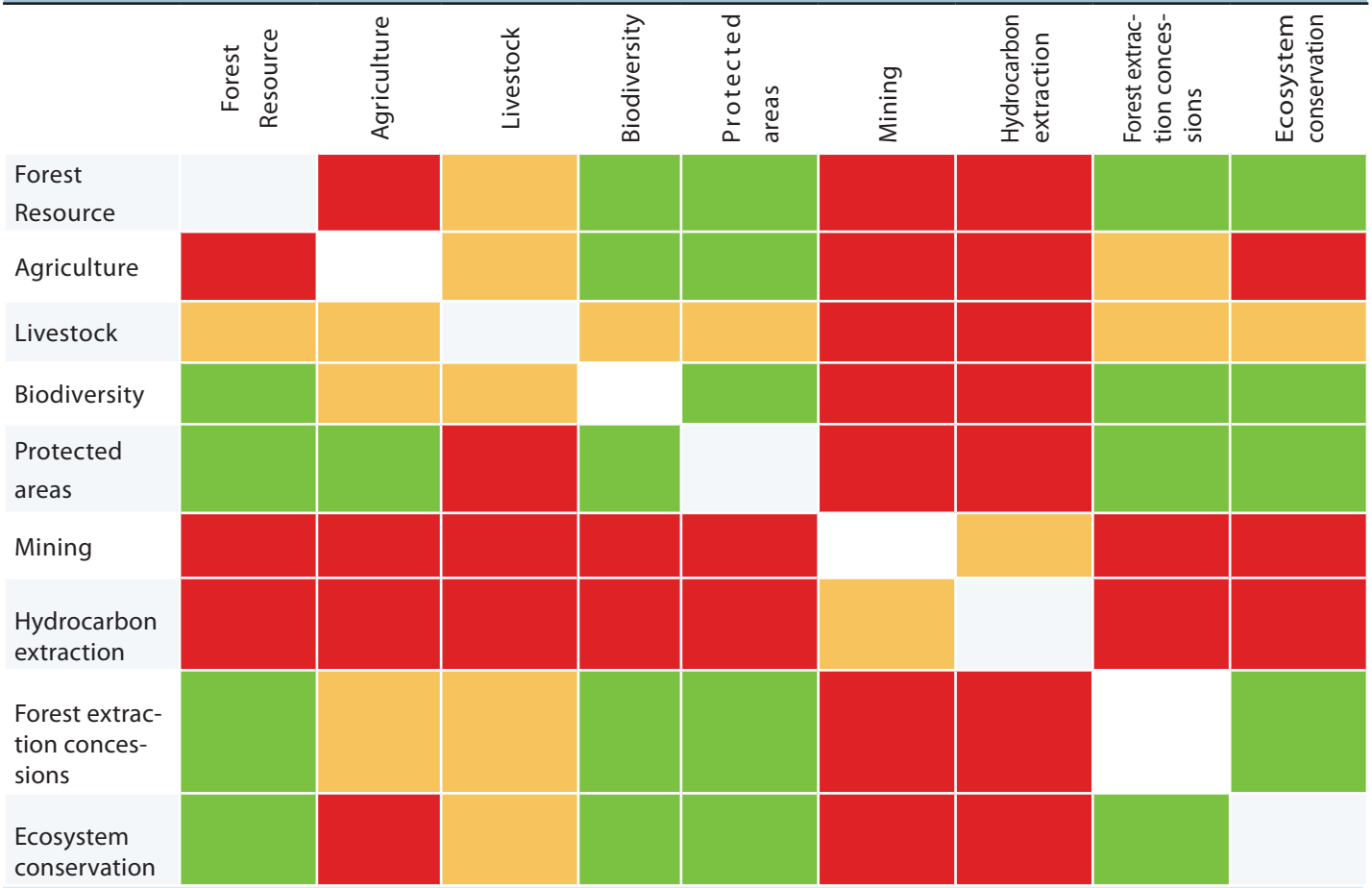
municipal capitals. One can interpret these results to the fact that on the one hand, land and limit management conflicts are often expressed at local government centers, which constitute the arena where the different involved actors confront themselves, and for which conflicts are usually reported, and on the other hand, that population centers (especially mining centers) tend to be established where extractive resources are available.

2.4.2 Exploring land use trade-offs: rubber plantations and tourism in Luang Namtha

This case study (Guntern 2013) looked at the impact of land use changes, especially the "rubber boom" on local livelihoods and tourism activities, which grew significantly in the LNP between 1990 and 2010. In addition to resettlement policies, this region has experienced a dramatic increase in rubber plantations and other extensive crops, due to economic reforms and the influx of foreign investments. Household surveys were performed in 3 villages, and complemented with semi-open interviews with foreign tourists, local guides and tourism stakeholders, and participating observation during treks. Important changes in livelihoods and coping strategies were observed, with significant decrease in non-forest timber products (NTFP) availability and reduced access to land. Nevertheless, economic opportunities related to the rubber boom have led farmers to modify their practices and behaviours towards a more market-oriented production and distribution strategy.

In most observed areas, the rise or rubber plantations combined with other above mentioned changes have generated a heavy pressure and numerous frictions with the tourism sector, which was previously based on the beauty of natural landscapes and richness of local traditions. Local stakeholders complained about the lack of government support and reactivity towards the badly affected tourism sector, which was once the key development driver in the region. Indeed, monoculture plantations have replaced the natural landscapes, and the traditional villages have turned into market-oriented production units, thereby damaging all the comparative advantages of the province as a tourism destination.

Fig 8: LAND USE CONFLICTIVITY MATRIX



HIGH

MODERATE

LOW

Conflictivity matrix of land uses: the matrix shows the incompatibility of relationships between existing natural resources and different land-based production and exploitation activities which overlap in a given territorial space. The matrix was elaborated intersecting resource and activities with each other and determining the conflictivity impact that could in case that both activities would overlap within a local community.

These findings allowed to elaborate a conflict matrix (Fig. 8) between main land uses in the area. While the new situation has clearly negative impacts for some people, others have largely benefitted of the new economic opportunities offered by the rubber industry. However, negative externalities and frictions created over land allocation could have been dealt with more effectively had the process been more transparent and carried out with more a stronger engagement of local stakeholders.

Fig 9: CONFLICTUALITY MATRIX - Luang Namtha

	Rubber Plantations	Tourism	shifting cultivation	Non timber forest product (NTFP)	Nature conservation
Rubber plant.		X	X	X	X
Tourism	X	X			
Upland Agric. shifting cult.	X				
Non timber forest product (NTFP)	X				
Nature conservation	X				

2.4.2 Mapping local knowledge and cultural heritage at the meso-scale: a reflection on risks and opportunities

A literature review of 92 scientific papers (Mathez-Stiefel 2014) about GIS and knowledge, mapping and indigenous knowledge, and GIS and cultural heritage was performed, completed with expert interviews, to assess opportunities and challenges in representing local knowledge and cultural heritage geographically at scales that go beyond the local.

Three main approaches of using GIS with indigenous and traditional knowledge were identified: 1) participatory GIS, which emphasize community involvement in the production and/or use of geographical information, often used as a basis for natural resource management, 2) use of GIS for cultural heritage mapping and management, including databases on of archeological and historical sites, and 3) more recent methodological developments in landscape planning and mapping for ecosystem services, inducing cultural services.

These approaches, especially participatory GIS, represent opportunities for politically disadvantaged groups by granting equal validity to their knowledge, make marginalized groups visible and enable them to engage in negotiations on spatial decision-making, as well as documenting historical and cultural memory.

One of the challenges met by local knowledge mapping is dealing with non-quantitative and non-cartographic data, fuzzy boundaries and orally transmitted and produced knowledge. Though new forms of GIS are being developed to represent different forms of knowledge, holistic world-views, distributed knowledge and complex systems (McCall 2003; Turnbull 2007), the question of "freezing" dynamic knowledge in digital records remains open.

Another challenge is information control: local knowledge may often be the only resource that the poorest groups control (McCall 2003). In this sense having local groups engaged in decisions related to include or exclude information and maintaining control over it is crucial and should include the right to withdraw information at any time, complying with ethical procedures in doing research with indigenous and traditional communities (International Society of Ethnobiology 2006). The question of information control could be approached with more detail in light of the indigenous water rights mapping project carried out in Bolivia (Villarroel and Boillat, in preparation). The projects' outcomes shows that as stated by Scott (1998), a distinction has to be made in making indigenous knowledge visible, meaning acknowledging its relevance, and legible, which would mean providing enough details to enable resource management by external actors.

Mapping local knowledge and cultural heritage at a meso-scale is confronted to the high variability in availability and reliability of the data, as well as the removal of knowledge from its local sociocultural context. Therefore, meso-level GIS structures that include local knowledge

and perspectives must be collected at the local level. Due to lack of existing data in Bolivia or Laos and also the impossibility of carrying out extensive fieldwork, this could not be performed in the framework of the BOLAO project. However, the influence area mapping and the typological approach is currently being used in Bolivia as an analytical framework to integrate local knowledge on ecosystems in 9 municipalities of Bolivia in the framework of the SDC supported BioCulturas programme.

3. Discussion of results

We found that national land governance policies which among others aimed at conserving forests through improved tenure security have led to unexpected outcomes. In Bolivia, accessibility alone does not explain forest conversion, and the redistribution agenda coupled with land title formalization seems to act as an incentive to clear more forest in private properties. In Laos, resettlement policies also have had an impact on local livelihoods, land access and ultimately forest cover.

Blaming governments would, however, give a partial and ultimately erroneous picture. In both cases, land polices have responded to strong external influences, which the geography of external development interventions proved an excellent tool to uncover. In the case of Bolivia, though the need of land titling responded to national agenda, the challenge of financing it led to involve international cooperation agencies who clearly had their own strategic priorities (Lerch 2104). In the case of Laos, the imperative of leaving the status of least developed country has led to accelerated development policies. There as well, however, international development interventions appear rather to match strategic priorities than development needs.

These policy outcomes must neither been seen as completely negative: in Bolivia, by far the largest area of titled lands have been under common regimes, which tend to experience less forest loss, and in Laos, land allocation and planning also might contribute to strengthen local organizations. Finally, land policies also have different levels of reach according to geographic and socio-economic context, the above considered policies being meant for lowlands in Bolivia and for highlands in Laos.

Pressures on land resources have been found to be strongly differentiated in both geographic and socio-economic spaces. This is especially the case of cash crop expansion areas appeared to be limited to specific contexts with easy access and social groups able to invest capital. Though smallholder areas also experience forest loss, these areas include forest gain as well. Our results clearly challenge the common belief that common lands tenure regimes and poverty increase deforestation.

3.1 Are there "land governance hotspots"?

The multivariate assessment with communities as observation units and the typological approach clearly allowed to identify challenging configurations for land governance: private lands under "verification" in Bolivia; resettled villages in Laos; cash crop expansion areas; areas settled by smallholders with gradual levels of market integration; remote areas with unexpected high deforestation, and land concessions. Some of these areas also experienced frictions among actors linked to land uses, yet the potential conflict assessment must be understood as a risk assessment: the exact location and time of a conflict cannot be predicted.

Challenging land governance configurations or "hotspots" are, nevertheless, not naturally given. They respond to the interests of specific actors: meeting development objectives through resettlements and cash crop income, or meeting redistribution and/or tenure security agendas. Therefore, the outcomes of challenging configurations are judged differently according to value scales. As a "value-free" concept, the notion of hotspot cannot capture the diversity of these development views.

The identification of challenging land governance configuration requires therefore a multi-stakeholder, collaborative effort, which would seek to identify areas where different interests and pressures from different sources arise. These critical zones differ from governance hotspots in the sense that they are explicitly recognized as stemming from a normative process. In this context, the critical zones approach constitutes a prospective tool, part of applied research linked with land governance processes at local or regional scale (Sandoval et al. 2013).

Critical zones may function as transaction nodes, or spaces of communicative action, where different actors are mobilized. These spaces would allow to deliberate trade-offs between actors' initiatives and problematic sectors that call for mediation and consensus among actors, at the scale of a whole territory that contain the critical zones which appeared to reveal existing contradictions. The compatibility matrices which were set up through fieldwork in Laos and Bolivia can provide useful tools to identify critical zones.

Understood as a foresight tool, critical zones can be of 2 main types: 1) potential critical zones according to potential resources and land use dynamics and projects (potential friction and conflict assessment), and 2) indicative critical zones, according to the spatial distribution of actual land use systems with related diagnosis and risk assessment from different perspectives (typological approach).

3.2. Policy Implications

While the SNIS BOLAO project allowed to develop the methodology and the concept of critical zones, it could not be yet tested as a land governance tool in multi-stakeholder contexts. This option is now arising with the interest shown by the development and land use planning communities. The following projects are currently being set up:

- The BioCultura programme: implemented by the Bolivian Ministry of Environment and the Agroecology Programme (AGRUCO) of the University of Cochabamba. Supported by Swiss Development Cooperation (SDC), the programme is currently performing an assessment of "life systems" around land-based natural resources in nine pilot areas of Bolivia, and using the typological approach as an input for multi-stakeholder deliberation and knowledge co-production spaces. Geobolivia, the Bolivian spatial data infrastructure is expected to play a role of data diffusion and facilitation in the process.
- Ongoing work in the Lao PDR include the further development of the Decide Info spatial and statistic data platform with the inclusion of the results of the Agricultural Census as well as geocoded development initiatives, also with support of SDC. A similar project is under study to be implemented in Burkina Faso

Other policy implications of our results include:

- Highlighting the need of multi-sectorial approaches to land governance: policies addressing land-based resources often stem from different sectors: agriculture, forestry, extractive industries, environmental conservation urban planning, leading to contradictory outcomes and unexpected effects.
- Enhancing data sharing: spatial data infrastructures play a key role in making geographic and statistic data transparent and accessible to enable collaborative efforts and co-production of knowledge.
- Understand land-based resources as commons: land is too often understood as an inherently private resource, leading to "tragedies of enclosures" at least as often than to "tragedies of the commons".
- Setting up land governance multi-stakeholder spaces at different levels; unlike other resources (climate, oceans, atmosphere, water), there is no international land governance convention, commission or organization.

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