Developing Cost-effective and Resilient Land Administration Systems in Latin America

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Keywords:

SUMMARY

In this paper I briefly review the wealth of experience in Latin America with initiatives to strengthen and modernize land administration systems. The review shows that there is more experience with land administration projects in this region than in any other. I go on to focus on the question of costs associated with formalizing property in an attempt to find an effective means of comparing costs across countries. I approach this by looking at different 'levels' – starting with global budget figures, then narrowing down to specific components and finally by examining the cost of individual tasks required to formalize a parcel. A comparative study of costs in 4 different regions of the world is described together with preliminary conclusions at the global level. The issue of property 'deformalization' is also discussed with respect to transaction costs.

Recognizing that land administration systems, and the economic, social and natural environments within which they operate, are continually changing, I introduce Resilience as an appropriate analytical framework through which to examine changing systems.
Resilience has evolved as a more nuanced framework for understanding the sustainability of socio-ecological systems. Unlike previous approaches, it accepts that a system will always be subject to disturbances, whether they are due to climate (hurricanes), policy and political administration changes, or demographic shifts due to urbanization or migrant labor markets.

RESUMEN

Esta exposición revisa la gran experiencia en América Latina sobre las iniciativas para fortalecer y modernizar los sistemas de administración de tierras. El repaso indica que hay mas experiencia en este region con pryetos de adminsitracion de tierras que en cualquier otra region del mundo. El primer parte enfoque en la cuestion de costos vinculado a la formalización de la propiedad con el motivo de identificar medios aptos para comparar costos entre diferentes paises. Esta analisis incorpora el estudio de costos en diferentes niveles – empezando con costos presupuestos globales, despues enfocando el nivel de componentes individuales y finalmente se examina los costos para diferentes actividades en el proceso de formaliza una propiedad. Se discutir un estudio de costos en cuatro diferentes regiones del mundo y ciertos conclusiones preliminares al nivel global. Esta discusión incluya tambien la cuestion de 'deformalización' de propiedad con respeto a los costos transaccionales.

Reconozco que sistemas de administración de tierras, y el ambiente económico, social e ecológico en que el sistema opera, siempre esta cambiando, se introduzca el Resiliencia como una rama analítica apropiada para analizar los dinámicos del sistema.
Finalmente, examinaré los sistemas de administración de tierras a través del lente de 'resilencia.' La resilencia se ha desarrollado como un marco matiz para examinar la sostenabilidad de sistemas socio-ecologico. A diferencia de previos acercamientos, éste acepta que el sistema siempre esté sujeto a disturbios, sea a consecuencia del clima (huracanes), cambios políticos o administrativos, o a desplazamientos demográficos a causa de la urbanización o migración de mercados laborales.

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INTRODUCTION

It was appropriate to hold the recent regional FIG conference in Costa Rica as this country was one of the first countries in the region to implement what today would be regarded as a land administration project. The 1964 USAID-funded "cadastral survey project" was the pioneer land project in Central America (Goldstein 1974). The focus of that project was to improve the property tax system and complete a topographical mapping project which would provide information for tax, land planning and development purposes. Similar projects followed soon afterwards in Panama, Nicaragua and Guatemala, all focused strongly on property taxes, with additional components addressing natural resource management and land titling in some cases.

During the 1980s the World Bank began to fund several large land projects in Latin America and elsewhere. The first two to be completed were the projects in Thailand and NE Brazil (Holstein 1993). The Thailand "land titling project," the 'mother' of all land titling projects, started in 1985. This has been a significant project for two reasons. Firstly, it is regarded as a highly successful project. Secondly, it has been the proving grounds for the evolutionary theory of land rights (ETLR) which served as the underlying rationale for many of the subsequent land projects that followed in the next two decades. Many of the assertions or hypotheses internal to the ETLR have been empirically proven using the experience of Thailand (Feder et al 1988). Data was gathered and analyzed to demonstrate the correlation between titling and access to credit, reduction in property disputes, facilitation of the land market, and increasing land values (Feder and Nishio 1996). Based partly on these positive outcomes in Thailand, land administration projects proliferated throughout the developing world.

Within Latin American the North East Brazil "national land administration project" was the forerunner of a series of land administration projects in the region (World Bank 1985). USAID continued to fund land titling projects throughout the 1980s, including the "land titling projects" in Honduras and Ecuador (USAID 1985). However, the most successful of the USAID-funded projects may have been the "Land Titling and Registration Project" in St. Lucia (USAID 1983). The island-wide land adjudication process was completed within the originally scheduled time – this by itself may be a unique achievement amongst land administration projects which invariably stretch beyond the time frame set out in the project design.

The World Bank has funded land administration projects throughout Latin America, and even by 1998 a study of World Bank projects revealed that there were "..115 projects with land-related activities in the Bank's portfolio…[and] ..of those, about 40% are in Latin America."

(World Bank 1998, p. 10). Subsequent land administration projects ensued in Bolivia (1995, 2001), Brazil (1995), Guatemala (1996, 1997), Honduras (2000), Panama (2000), Nicaragua (2002), Honduras (2003), and El Salvador (2005).

The Inter-American Development Bank has also played a lead role in funding land administration projects in Latin America and the Caribbean especially over the past decade – including Trinidad and Tobago (1995), Nicaragua (1995), Dominican Republic (1997), Belize (1997), Colombia (1997), Honduras (1998), Jamaica (1999), Costa Rica (2000), Ecuador (2001), Panama (2002), Brazil (2002), Mexico (2003), Bolivia (2003), Paraguay (2003), and the Bahamas (2004).

While this is not a complete list of projects it does illustrate the huge amount of investment that has gone into land administration and property formalization and therefore the wealth of experience in the region. In the following section of this paper I bring this experience to bear on certain key land administration issues, namely the question of costs.

COMPARATIVE ANALYSIS OF COSTS

While significant resources have been invested by the donor community in modernizing land administration infrastructure around the globe, there has been little systematic discussion and documentation of actual costs. Better understanding of the underlying issues and the trade-offs involved in choosing among different technical, legal and institutional options of providing land administration services is needed. Even though the World Bank, IDB and other donors have long supported titling interventions all over the world, surprisingly little is known about the actual costs of such interventions, both in terms of project implementation and comparative transaction costs once the new systems are in place. Until recently, little effort has been made to disaggregate costs into the specific activities required to formalize a piece of land.

In reviewing previous studies that dealt with costs, there are several worth mentioning. In 1985 Janice Bernstein at the World Bank documented a study she carried out entitled “The costs of land information systems.” (Bernstein 1985) She compiled information on the topic through “a review of the literature and illustrative programs as well as discussion with experts in the field…” (p. 5) She concluded early on that “..there is a great need for coordinated research among international organizations and training institutions focusing on the economics of land information..” (p. 11) The report focused largely on the potential for lowering the cost of cadastral surveys through inertial surveying and GPS, which were just becoming operational at that time. It also focused on methods for estimating the cost of photogrammetric mapping. A fully operational GPS/GNSS system, the higher precision of today’s satellite imagery, and airborne GPS have essentially reduced the value of this information to one of historical interest. The study also contributes little towards the development of a comparative methodology.

Two years later in 1987 a symposium entitled “The Economics of Land Information” was held in Baltimore, MD, under the auspices of the Institute of Land Information (ILI 1987).

This issue was topical in the US at that time as GIS was becoming mainstream and county offices were in the process of digitizing their land information. Approaches discussed at the ILI and other forums at that time included: (i) an avoided cost approach, where benefits are construed as the avoidance of downstream costs by making upstream (often public) investments in, for example, geodetic infrastructure[1] – creating the information now means that it does not have to be repeated at a later time; (ii) a 'use and value' approach whereby benefits are gauged relative to frequency of use – information that is used more often has more value even though it may have cost the same to produce. The 'avoided cost' approach may have some value, but it focuses more on future costs than more defensible present or past costs. However, both approaches are not that useful for developing a comparative methodology as they focus more on benefits than costs.

Other cross-country studies include work done by Dale and McLaughlin (1988) and Holstein (1993). Their breakdown of costs by activity is compared with that given by Bernstein (1985) in Table I below.

TABLE I. Percentage Distribution of Costs by Activity

Source	Mapping	Adjudication	Surveying	Registration	Institutional Strengthening
Bernstein[2]	38%	29%[3]		6%[4]	13%
Dale/McLaughlin	20-25 %	30-50 %		20-25%	10-15%
Holstein	24%	18%	22%	23%	13%

None of these three studies provide a robust comparative analysis methodology, although they do suggest focusing on activities such as mapping, adjudication, surveying, etc. Even this can be problematic as surveying may sometimes be included as a sub-component of adjudication (Dale and McLaughlin 1990).

Gross unit costs are typically used to compare costs across different projects, without taking into account the significantly different contexts and approaches. As a result, cadastral and land registration interventions are often viewed as expensive activities that do not generate sufficient benefits to justify their costs. Furthermore, no systematic template exists for collecting data across different countries. The cost issue came to a head in a 2001 e-conference on "Lessons Learned in Land Administration" organized by the World Bank (Deininger 2003; Barnes 2003). One participant shared information on the Peruvian Titling Project (PETT) which had reduced the cost of formalizing a parcel to approximately $47 per parcel. In response to this, another participant countered that in Eastern Europe they were titling at the cost of $1.05 per parcel! Either these two participants were talking about two completely different processes and products or else the contextual setting of these two cases

[1] See Epstein and Duchesneau 1984
[2] Based on the NE Brazil Project Costs. Other components included Support for Land Restructuring" (9%), Project Administration (4%) and Studies (1%)
[3] Land Tenure Identification
[4] Cadastre Implementation and Titling

was incomparably different. Clearly there was a need to 'unpack' these numbers and develop a framework for comparing the same process or product.

Following this conference we developed a template of questions and tables that could be administered at the country level. We approached this by identifying costs at three different levels – starting from global project figures and then considering costs at the level of project components, and finally examining specific costs entailed in converting a parcel of land into a formal registered property. We also recognized the need to contextualize these studies so that the cost figures could be considered against the specific context within which the project was being implemented. Subsequently, the template was expanded to include an analysis of the effectiveness of the land administration system. This 'template' was then applied in seventeen countries in four different regions - Latin America and the Caribbean (El Salvador, Peru, Bolivia, Trinidad and Tobago), E. Europe and Central Asia (Armenia, Kyrgyzstan, Moldova, Latvia), Asia (Indonesia, Karnataka, Philippines, Thailand) and Africa (Ghana, Mozambique, Namibia, South Africa, Uganda). Subsequently, four regional reports were prepared that summarized the country-level reports (Barnes 2002; Adlington 2002; Land Equity 2003; Augustinus 2003). Finally a global report was prepared comparing all countries across the four regions (Land Equity 2007).
Instead of drawing on the general data for the global comparison, I have widened the LAC scope by considering 11 projects within the region. The data are drawn from the many project documents I have in my own library as well as others which are listed on the LandNet Americas portal. [5]

[5] See http://www.landnetamericas.org/ for list of projects

TABLE II. Global Comparison of per parcel Costs - Total Project Costs/Total Parcels[6]

Project	Total Budget US$M	# Parcels	Dates	$/parcel	Area (MHa)	$/ha
Peru (PETT1)	36.5	1,000,000	1997-2002	37	na	na
El Salvador	70	1,700,000	1996-2005	41	1.9	37
Peru (PETT2)	46.7	170,000	2003-2007	62	3.6	13
Costa Rica (IDB)	92	520,000	2002-2007	177	na	na
Bolivia (PNAT)	28	10,000	1995-2003	2800	3.7	8
Bolivia (St. Cruz)	15	140,000	2006-2010	107	na	na
Ecuador (PRAT)	16	135,000	2003-2007	119	0.6	27
Nicaragua (PRODEP)	2.4	90,000	2003-2010	27	1.4	2
Belize (LMP)	8.9	40,000	2003-2006	223	na	na
Panama (LARP-IDB)	72.3	120,000	2003-2008	603	0.75	96
Panama (ProNAT)	47.9	80,000	2001-2007	599	1.1	44
Average	**40**	**420,000**		**436**	**1.9**	**21**
Average (without PNAT)	**41**			**200**		

This kind of comparison is of minimal use partly because it assumes that the total budget can be associated with the number of parcels that are either titled or regularized in some way. Costs associated with legal reform, institutional strengthening, equipment purchases, etc. are examples of costs that have no relation to parcels, but are still included in the comparative figures given in Table I. Although the parcel is the unit of choice when assessing the extent and cost of surveying and regularization, its cross-scalar nature produces unwelcome complexities. A ‘parcel’ may include any of the following tenure units:

- small urban lots (e.g. 20m x 30m)
- peri-urban lots
- small agricultural parcels (minifundias)
- medium rural parcels
- large rural parcels
- large communally-held parcels (e.g. indigenous communities)

[6] na = data not available

The scale of a parcel may therefore vary from a small urban lot to a communal property that may approximate the size of a municipality. Additionally, at the project design stage the number of parcels in a jurisdiction or area is often the weakest data available. The whole motivation for adjudication and titling stems from the fact that there is no reliable formal parcel information in the registry or cadastre. Therefore parcel information may be available at the end of the project, but during design it can only be inferred through estimating average parcel sizes or consulting census data.

Costs are also estimated on an area (per hectare) basis? Using the project documents as a source again, those costs that are available are shown in Table I. Four out of the eleven projects in Table I do not list area to be titled or regularized in the project document. In the remainder, the per hectare costs range from $2/ha in Nicaragua to $96/ha in Panama with an average of $21/ha. This approach to unit costs suffers from the same problem as mentioned above – it assumes that the cost per unit area is uniform, ignoring the fact that the multiple scales of parcels contradict this especially in the fieldwork component. Those projects that contain several large parcels, such as indigenous communities, skew the cost per hectare numbers (such as in Nicaragua). It is therefore necessary to look deeper than these global figures if we are to effectively compare these projects. It may be more productive to consider the costs of an average size parcel.

At a more specific level we can examine costs by focusing on procurement type. Once again, this data is easily available in project documents, and the results for a small sample of countries is given in Table III below

TABLE III. Breakdown of Budgeted Costs by Procurement for Five Countries

Procurement Type	**Bolivia**		**El Salvador**		**Guatemala**		**Panama**		**Paraguay**	
Source	Amount	% of total	Amount	% of total	Amount	% of total	Amount	% of total	Amount	% of total
Civil Works	0.7	2.5	2	2.9	2	5.2	13.13	18.1	16.6	40.4
Goods			5.7	8.1	3.3	8.5				
Equipment	1.3	4.8					8.87	12.3	2.1	5.1
Training	0.7	2.4	1.6	2.3	0.9	2.3	1.93	2.7		
Service Contracts	11.8	43.5	15	21.4						
Consultants	3.5	12.9	31.1	44.4	9.1	23.5	15.88	21.9	2.8	6.8
Salaries	6.6	24.2								
Regularization					14.4	37.1	19.13	26.4	12.1	29.4
Information Campaign			3.5	5.0						
PPF			2.1	3.0	2.1	5.4	12.95	17.9		
Recurrent	2.6	9.7	9	12.9	6.7	17.3	0.47	0.6	7.5	18.2
Other					0.3	0.8				
Total	27.2	100	70	100	38.8	100	72.36	100	41.1	100.0
Source	(p. 86)		(p. 22)		(Ann.6)		(p.70)		(p. 25)	

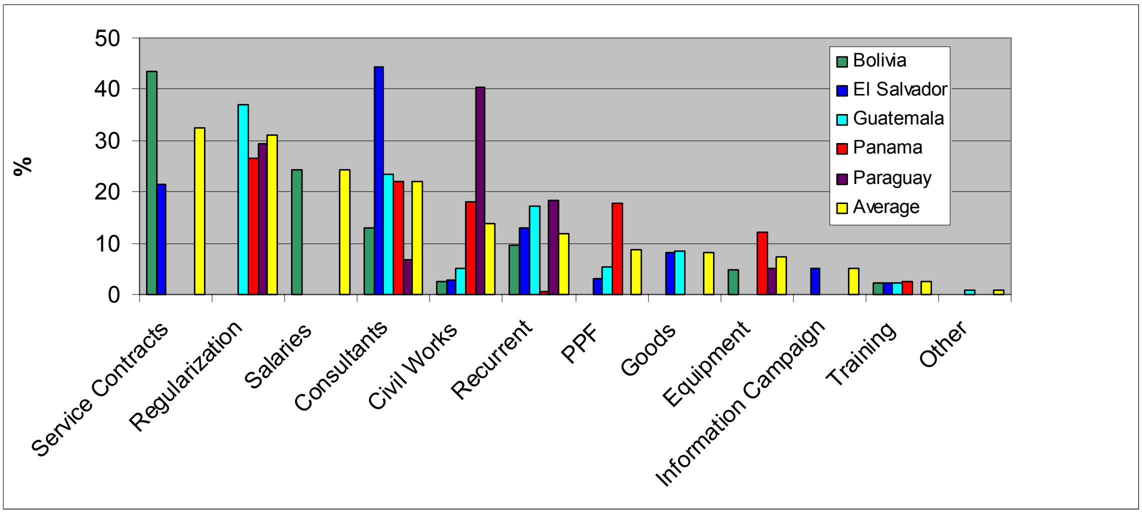

FIGURE 1. Percentage of Budget by Procurement Method

Figure 1 shows that two crucial elements underlying the success of land administration initiatives – training and information/communication – rank last in terms of "procurement type." However, it is risky to draw any conclusions from these data partly because several categories in Figure 1 overlap. Training, for example, may be treated under a separate category in some projects, while in others it will be included under institutional strengthening. Adding to the complexity of comparative costs are differences in technologies, variations in implementation strategies (in-country or through international bid), and differences in the quality of existing cadastral and registration data, access and boundary complexity.

Finally, the third level that we examined in the comparative cost study was the cost for each task required to convert a parcel from informality into a fully registered property (see Table IV).

TABLE IV Breakdown of Costs to Formalize a Parcel (Land Equity 2007, p. 94)

Table 16 Breakdown of Systematic Registration Costs from Case Studies (US$/parcel).[23]

	Armenia	Kyrgyzstan	Moldova	Indonesia	Thailand	El Salvador	Perú (urban)	Perú (rural)
Pre-Field					**4.89**			
1 Geodetic Network	-	-	5.66			-	0.39	
2 Cartography	0.20	-	7.08			7.05	0.24	11.26
3 Compilation of existing records	0.02	0.03	1.53			1.30		
4 Publicity Campaign	0.02	0.31	0.55			1.94	0.42	
5 Acquisition of Government equipment	0.68	0.91	-			1.50		
Field					**19.32**			
6 Collection of claimant information	1.00	0.30	3.77				0.23	3.62
7 Boundary investigation, survey, marking	4.57	2.09	7.64			9.67	1.61	10.50
8 Conflict Mediation	-	-	-			0.06	0.08	
Post-Field								
9 Quality control	0.12	0.14	0.94				0.05	10.00
10 Legal validation	1.00	0.15						0.56
11 Public display of field results	0.02	-					0.02	
12 Conflict Resolution	-	-						
13 Prepare land record	1.00	0.04	2.92			2.89		1.40
14 Prepare cadastral maps/plans	0.82	0.04	1.98			1.44	2.37	1.68
15 Cadastral/Registry database design	0.50	1.06	3.77					
16 Data entry	0.10	0.03	0.19					
17 Register property rights in registry	0.05	0.14	7.55					5.44
18 Issuance of titles to beneficiaries	-	0.01	0.94					1.95
19 Administration/management	3.25	5.30	1.89			3.89	7.27	9.28
20 Total per parcel cost	**13.35**	**10.55**	**46.41**	**16.30**	**24.21**	**29.74**	**12.68**	**55.69**
21 Amount paid by beneficiaries	-	-	-	-	**2.55**	-	-	-
Total Cost	**13.35**	**10.55**	**46.41**	**16.30**	**21.66**	**29.74**	**12.68**	**55.69**

The number of gaps in the above table shows either that countries are using different approaches that do not include all of the 19 tasks listed in Table IV above and/or costs are not always reported at this fine a resolution. It is also important to distinguish between urban and rural as the Peruvian case indicates rural parcels can cost almost five times as much as urban parcels.

Looking through even a finer lens at a single cost sub-component – cadastral survey (#7 in Table IV) – reveals the extent to which cost can vary at this micro level. Cadastral survey costs for a single parcel can vary considerably depending largely on four factors: the quality and scope of the recorded cadastral information, the nature of the terrain, land value, cadastral evidence (e.g. original monuments/markers, fences) encountered in the field. In Figure 2 below I have related how these factors combine to either increase or decrease the survey costs.

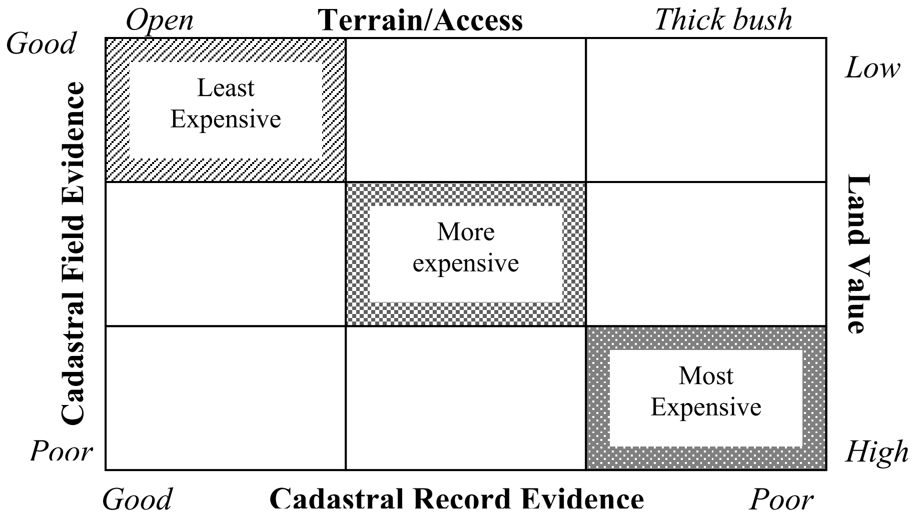

FIGURE 2. Four Factors affecting Cadastral Survey Costs

If land adjudication (saneamiento) is to be done systematically (barrido) across an area then the expectation is that this will generate economies of scale, thereby dropping the per parcel costs. Furthermore, additional efficiencies can be gained by using methodologies based on GPS which, unlike conventional approaches, does not require line of sight between all surveyed points. To what extent do these two factors – economies of scale and the use of GPS – reduce the survey costs. We were faced with this question in designing the IDB land administration project in Belize in the mid-1990s. At that time private surveyors estimated their survey fees on the basis of this simple formula: US$200 √ area of parcel in acres. In other words, the survey fees for a parcel of 20 acres would be approximately $900.

Drawing on the experience of the South African cadastral surveying system, which for more than 60 years had a tariff of fees that incorporated a factor to account for increasing economies of scale as more parcels were surveyed, the following figures can be computed in the context of Belize.

TABLE V. Cadastral Survey Fee Structure accounting for Economies of Scale

Number of Parcels	Scale Factor	Factor applied to Belize Survey Costs[7]
1	1	$900
2	0.7	630
3	0.6	540
4	0.5	450
5	0.4	360
10	0.4	360
20	0.3	270
100	0.3	270
200	0.2	180
400	0.2	180
1000	0.2	180

The scaling factors therefore bring the per parcel costs down to $180 per parcel assuming that a surveyor is contracted to survey at least 200 parcels. In addition to these economies of scale, efficiencies through the use of GPS were estimated to further reduce the measurement and mapping time by a factor of four. We therefore concluded that the combination of scale economies and technological efficiency could reduce the per parcel costs down to as little as $90 per parcel (Barnes 1995).

Given the large number of variables in just the cadastral surveying, adjudication, land titling and land registration costs for formalizing a parcel of land, it is not surprising that we are faced with an "apples and oranges" type of comparison of costs. I have just considered initial registration costs in this section, but there are other costs – especially those relating to subsequent transactions – that may be even more crucial to the success and sustainability of a land administration system.

TRANSACTION COSTS

Informality results when landholders perceive that the costs and benefits of the formal system do not match those of the informal system. In other words, landholders who believe that the costs of formalizing transactions outweigh the perceived benefits that flow from such formalization will conduct their transactions outside the formal system. This is particularly true when informal transaction costs are further reduced because the parties to the transaction are members of the same family.

Douglass North's work on transaction costs, property rights and institutions has perhaps been the most influential work in terms of providing a comprehensive approach towards analyzing this area. North distinguishes between transformation and transaction costs:

[7] Assuming an average cost of US$900 for an individual 20 acre parcel

The total costs of production consist of the resource inputs of land, labor and capital involved both in transforming the physical attributes of a good … and in transacting – defining, protecting and enforcing the property rights to goods.. (North 1990, p. 28)

When entering into a transaction, such as purchasing a parcel of land, costs are incurred in the search for information about the land (quality, value, history, etc.) and the seller's valid claim to the land (title, transaction history, third-party claims, etc.). As North explains:

The costliness of information is the key to the costs of transacting, which consists of the costs of measuring the valuable attributes of what is being exchanged and the costs of protecting rights and policing and enforcing agreements. (p.27)

I believe that high transaction costs following subsidized titling efforts are causing substantial 'de-formalization' of titled property. Based on research in St. Lucia and key informant interviews in the field in numerous countries, we have observed a tendency for titleholders not to register transactions after they have received title. Our research in St. Lucia revealed that approximately 28% of the register was out of date some two decades after an island-wide titling project, mainly due to informal generational transfers within families (Griffith-Charles 2004; Barnes and Griffith-Charles 2006). We believe that the situation in many other countries will be substantially worse than this.
Comparing the de facto and the de jure situation of land parcels is also problematic. Collecting de jure data may simply entail a visit to the registry to extract data on the formal situation. However, even though most registries in Latin America are '*registros publicos*' they most often restrict public access. Access to property registries may be limited only to those individuals with a valid interest in a transaction. There is often a fear that documents will be defiled unless they are handled by competent public officials. On the other hand, if one does gain entry into the registry large amounts of data on transactions can be obtained in a relatively short period of time. Not so with de facto data. This requires more research and a well-designed sampling strategy that allows researchers to not only select a representative sample of the total parcel population but also to be able to link that parcel with the relevant information in the registry and/or cadastre. Without reliable geographic information for the registered parcels this can become extremely challenging.

We can also conclude that institutional differences amongst countries, including rapid changes in political administration, levels of decentralization, etc all need to be contemplated when examining costs. The recent focus on land for the poor also raises the issue of affordability. We currently do not have a good idea of what poorer landholders can afford to pay for formalizing subsequent transactions. Finally, in order to come to grips with land administration dynamics we need to understand the processes of change that are occurring in the surrounding environment, in the landholding population and in the infrastructure and services that meld together the social-ecological system. Resilience has emerged as a useful approach towards understanding system change.

A RESILIENCE APPROACH

Phenomena such as global warming, increases in natural disasters such as hurricanes and unpredictable market dynamics remind us daily that our planet is a highly complex system. Through drawing disciplinary boundaries – defining social sciences, natural sciences, etc. - we have in effect parsed our world into more manageable pieces. However, in the process we have disassociated social systems from ecological systems and made it more difficult to understand complex human-environmental interactions.

Over the past decade ecologists and others have defined a resilience approach to study complex dynamic human-environment interactions (see, for example, Gunderson and Holling 2002; Carpenter et al 2004; Anderies et al 2006; Walker and Salt 2006). Resilience "stresses the importance of assuming change and explaining stability, instead of assuming stability and explaining change." (Folke et al 2003, p. 352) A resilience approach recognizes that there is no single stable state in a social-ecological system (SES), but that the system is exposed to different 'shocks' that challenge its fundamental identity and make it dynamic. A resilient system is able to absorb shocks and adapt without changing its fundamental structure and function (Gunderson and Holling 2002). Shocks may be stochastic (e.g. tsunami, land policy reform, major macro-economic changes), cyclical (flooding), or occur at different temporal scales – decadal (e.g. drought), annual (e.g. hurricanes, labor migration) or at smaller time scales.

Through funding from the National Science Foundation, we are investigating the resilience of social-ecological systems in the SW Amazon. We focus on connectivity as the primary agent of change, specifically the trans-oceanic highway that is being paved and will eventually link the Pacific and Atlantic Oceans. The highway will radically change the connectivity in the region of our research, which includes the states/departments of Made de Dios (Peru), Acre (Brazil), and Pando (Bolivia) and is commonly known as the MAP region. We hypothesize that resilience will increase as connectivity improves; however, at some level of connectivity it will begin to become less resilient due to its over-connectedness and consequent over-dependence on external factors. In short, a graph of resilience (Y axis) and Connectivity (X axis) will reveal an inverted U shape.

One of the many challenges of operationalizing resilience analyses is defining what constitutes the 'fundamental structure and function' of a system. In our own research at the University of Florida we have attempted to do this by examining social, ecological and social-ecological measures of this identity. Within the context of land tenure this may be construed as the land administration framework and the decisionmaking with respect to land and its associated resources. What does it mean to focus on change within a land administration system? At a basic level, cadastral and registration systems are constantly changing as the land market operates and property is sold and new parcels are created through subdivision. All successful land administration systems should be designed to accommodate this constant change, otherwise they will quickly become out of date. This suggests that the focus in land administration should be on those parcels that are undergoing the most change (parcels changing hands or being subdivided) or which may be susceptible to change (parcels on the frontier). There is one change that we know will occur in all systems and that is the eventual death of the landholders. The mechanism for dealing with this change, namely inheritance, is presenting a key challenge to the maintenance of land administration systems in the developing world.

Resilience is best measured when a system has been subjected to some shock which challenges its continued existence. Extreme shocks that impact land administration may include natural disasters (e.g. hurricanes, floods) or anthropogenic fire. A resilient land administration system is one that can most quickly return to 'normal' operation after a shock. If the shock pushes the system beyond a certain threshold, it will "flip" into a fundamentally different system. Within the Amazon region, for example, we can observe indigenous forest areas flipping into treeless ranches which are composed of entirely different structures (owners, resources) and processes (land uses). Within the land administration context this may not be as dramatic, with, for example, a flip from registration of deeds to registration of title.

There is a recent but growing interest in the resilience of land administration systems in the face of natural disasters such as hurricanes and tsunamis. UN Habitat and others are realizing that the resilience of land administration system and how it is governed play a key role in recovery and reconstruction efforts following natural disasters. The resilience framework is highly appropriate for trying to not only understand the role that land administration systems have played in past disasters, but more importantly how we can strengthen these systems to better support recovery and reconstruction in future disasters.

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