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Conservation and Development in Cambodia

Exploring frontiers of change in nature, state and society

Edited by Sarah Milne and Sango Mahanty

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3 Lost in transition

Landscape, ecological gradients and legibility on the Tonle Sap floodplain

Andrew S. Roberts

Introduction

> . . . The country, for nearly 100 miles around [Battambang], is flooded with water soon after the commencement of the rains; travelling becomes impossible, except in boats, and wild animals are driven off to the mountains . . .
>
> (David Olyphant King's 1860 report to the Royal Geographic Society of London)

A unique socio-ecological system

The Tonle Sap floodplain is a landscape in motion, perpetually shifting from the terrestrial to the aquatic and back again. Rich in natural resources, it is subject to many, often competing, interests: a source of subsistence, crucial both locally and region-wide; a source of economic development and income generation for the Royal Cambodian Government; an ecosystem of global importance. It defies an uncomplicated characterization. It is the largest wetland and seasonally flooded grassland in peninsular Southeast Asia. It is the site of one of the most productive freshwater fisheries in the world, with annual catch estimates as high as 235,000 tons per year (van Zalinge, 2002).[1] It is also likely the site of the most productive snake harvest in the world, with an estimated 3.8 million snakes harvested per year (Brooks *et al.*, 2010). An estimated 1.5 million people depend upon the Tonle Sap for their subsistence, predominantly through rice production and fishing (Johnstone *et al.*, 2013). Despite the area's richness in natural resources, the Tonle Sap floodplain is home to many of the poorest people in Cambodia (Ministry of Planning and UNDP-Cambodia, 2007).

In the near future, the biological and economic productivity of the region may be subsumed by the dynamism which is a hallmark of this landscape. The grasslands of the floodplain are disappearing rapidly as land is converted to large-scale dry season rice production (Packman *et al.*, 2013; Evans *et al.*, 2005; Sokha *et al.*, 2004). Livelihoods, vegetation, fisheries and

wildlife are all threatened by the potential change in flood regimens associated with both climate change and hydroelectric dam construction along the Mekong River and its tributaries (Arias *et al.*, 2014; Ziv *et al.*, 2012). Floodplain landscapes and vegetation are growing more homogeneous, and the livelihoods of floodplain residents who depend upon them may follow suit (Roberts, 2011). Meanwhile, as elsewhere in the region, rural and urban livelihoods continue to become further intertwined, channelling flows of people, money and ideas back and forth between the urban centres and the countryside (Rigg, 2006). The population in Phom Penh in particular has more than doubled in recent years, driven largely by the exodus of young people from rural areas seeking employment in the city (Ministry of Planning, 2012).

As a production landscape, the floodplain and its communities reflect the myriad multi-scalar social and ecological processes at play today, just as the landscape bears the marks of the recent and distant past. It is this dynamism, and the transitions it generates, which muddy the waters for governmental and non-governmental institutions involved in managing the Tonle Sap floodplain. The complexity of relationships between floodplain residents and the landscape thus remains obscured. Also lost is the importance of local natural resource management systems, as well as resource access rights and claims to land ownership. Lacking institutional validation of their ties to the land (ecological, economic and legal), local households are less resilient. Largely poor already, these households are left even more vulnerable to livelihood disruption, economic hardship and even outright dispossession.

What follows is an exploration of floodplain dynamism, with emphasis on the ecological gradients and transitions this produces. These physical manifestations of socio-ecological processes in motion are important in the livelihoods of floodplain residents, who recognize, produce, manage and utilize them as resources. Though recognized locally, these ecological gradients and transitions remain illegible to institutions attempting to manage and control the floodplain. They slip between the categories used by bureaucrats, technical specialists and development practitioners to understand the landscape. In exploring this problem, I present examples of ecological gradients and transitions I documented in a village on the floodplain, and detail why they are important to village residents and the implications of their illegibility to institutions. While the geographic focus of this study is very narrow, I contend that the critique presented here is broadly applicable throughout the Tonle Sap floodplain and beyond. Of course, local specifics will certainly vary, as the interactions of people, processes and the landscape assume many different configurations.

The flood pulse and the landscape

The great ecological and economic productivity of this region is driven by the flood pulse, with the annual water rise coming with the onset of the

rainy season (Holtgrieve *et al.*, 2013; Arias *et al.*, 2013). This flush of productive waters, originating largely from the Mekong River and the inflow from tributaries around the lake (Kummu *et al.*, 2006), causes the lake to swell from a dry season area of about 2,500 square kilometres to a wet season peak of about 13,000 square kilometres, varying from year to year (Figures 3.1 and 3.2).

Likewise average depth of the lake jumps from 1–2 m during the dry season, to 8–10 m at the height of the flood (Hak and Piseth, 1999). This influx of water brings with it sediments which are deposited largely in the flooding forest at the lake's margin and on the adjacent floodplain (Kummu *et al.*, 2008). It also brings the fish, so important in the livelihoods of floodplain residents, which spawn in the flooding forest and migrate out onto the floodplain to feed and mature, before returning to the Mekong as the floodwaters recede. The aquatic and terrestrial phases of the landscape are connected by other channels as well, including flows of carbon and nutrients from the terrestrial to the aquatic through the breakdown of terrestrial organic matter

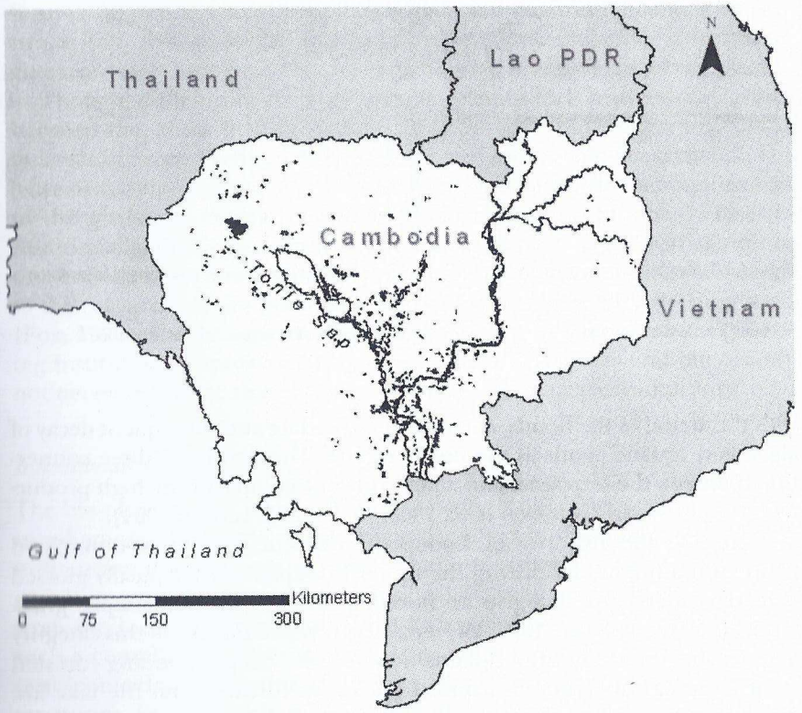

Figure 3.1 Regional map indicating Tonle Sap Lake dry season margin. Data date from March 1999.

Source: Tonle Sap Environmental Management Program/Fisheries Administration.

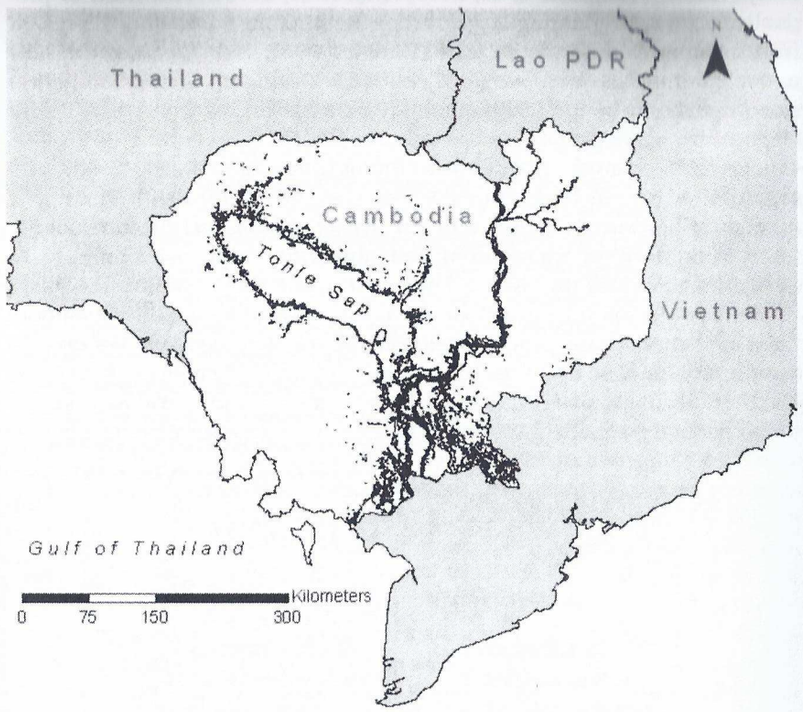

Figure 3.2 Regional map indicating Tonle Sap Lake wet season margin. Data date from October 2000.

Source: Tonle Sap Environmental Management Program/Fisheries Administration.

with the arrival of the floods, and also the stranding and subsequent decay of algae and aquatic plants as the floods recede. The density of these connections between the terrestrial and aquatic likely accounts for the high productivity of this system (Wantzen *et al.*, 2008; Junk and Wantzen, 2004).

Home to the majority of floodplain residents, the grass-dominated plant communities comprising the upper floodplains are typically glossed by geographers and biologists as 'flooding savanna' or even simply 'grasslands' (McDonald *et al.*, 1997; Delvert, 1994). While the use of this category is not inaccurate – the floodplains between the deeply flooding forested areas fringing the Tonle Sap and the uplands further from the lake are indeed covered by open grasslands and wooded savannas – the use of this category masks the diversity of plant communities and landscape features on the floodplain. It gives an impression of a homogeneous environment while concealing the diversity that makes this area so productive. It likewise

obscures the hand prints and footprints of populations of fishers, farmers and herders who have made their lives on the floodplain for more than 1,000 years (Stark, 2006; Fox and Ledgerwood, 1999).

Gradients and transitions

Lacking clear physical, ecological and/or social order, ecological transitions and gradients are a challenge to be rendered into 'units that are visible' (Scott, 1998, p. 183), to be condensed into information which is legible to the sundry institutions attempting to control their management. Such a simplification and categorization is the first step in translating complex situations on the ground into legible schemata which may be used as the basis for institutional decision-making. Illegible, the information which might have been gleaned from ecological gradients and transitions is easily misinterpreted or overlooked. Unbeknownst to their authors, the models, plans and forecasts generated for institutional decision-making thereby remain faulty, lacking potentially important detail. In a more sinister light, simplification of complex floodplain livelihoods and environments may be used strategically to further the political, often predatory, agendas of individual elites, privately held businesses, as well as government institutions.[2]

Though difficult to resolve, the complexity lost between categories, between the 'units that are visible', is important. Here lies a network of linkages between livelihoods, landscapes and socio-ecological systems. This leaves institutions blind not only to these linkages but also to their significance to the goals and central questions posed by the institutions themselves. Additionally, this information left behind is important to local communities. For example, one important criterion for communities to retain access to the resources of the floodplain is to prove that they are managing them (Fox, 1998). Land considered vacant or unmanaged in the eyes of governing institutions is more readily converted to another use, and importantly not necessarily a use that is in the best interests of local communities.

Institutional setting

The bio-physical flux which characterizes the Tonle Sap floodplain is mirrored among the tangle of institutions involved in floodplain governance, influencing development, access to and use of natural resources and law enforcement (Sokhem and Sunada, 2006). They are organized at scales from the local to national, regional and global. As might be expected in such a complicated governance system, institutional perspectives are variously coincident or in conflict, resulting in a patchwork of jurisdictions and territories. Far from a level playing field, personal relationships, political connections and patronal networks are a particularly important factor in determining how institutions fit into in an unstable network of hierarchies of power (Sneddon, 2007).

The Royal Cambodian Government is represented by a number of ministries and other official bodies, each with their own goals and directives, implemented through local offices. These include, in part, the Ministry of Agriculture, Forestry and Fisheries; Ministry of the Environment (responsible for biodiversity conservation and ecotourism); Ministry of Foreign Affairs and International Cooperation (responsible for negotiating treaties and international agreements); Ministry of Water Resources and Meteorology; Cambodian National Petroleum Authority and Tonle Sap Basin Authority. Additionally, a great many international NGOs, foreign aid programs, international research institutions, as well as local NGOs are active in the region.

Operating in an inherently multi-disciplinary field, institutional vision is narrowed by sectoral focus in their mandates and by extension, their personnel (Sokhem and Sunada, 2006). Many specialize in a particular discipline such as agronomy, fisheries or economics, at the expense of a broader understanding of the complexity of the socio-ecological systems in their geographic areas of interest. These can lead to jurisdictional blind spots, which may not formally exist in the laws governing the landscape but take shape in practice in the field. For example, in Kampong Thom the harvest of wood from the flooding forest and shrublands reaching up from the margin of the Tonle Sap Lake is prohibited. These woodlands do not produce high value timber, and so fall outside the jurisdiction of the Forestry Administration, as it is understood by field personnel. The flooding forests are crucial as a spawning site for many economically important fish species. But, they are not themselves a fishery and so fall outside of the interests of the Fisheries Administration. Moreover, gaps in these shrublands are often opened for the expansion of agriculture and grazing. However, they seldom draw the interest of Department of Agriculture officials. As a result, there was little active planning on the government's part for the management of these resources and their use by floodplain communities. Likewise, there was little enforcement of the existing laws regarding wood harvest on the floodplain.

Complicating relationships among institutions, communication and feedback between them are lacking, as are collaborations between decision-makers, practitioners and academia (Nang *et al.*, 2011). Furthermore, these governmental and non-governmental institutions themselves are in flux (Keskinen and Varis, 2012). The waxing and waning of the political power of particular individuals and their patronal networks have a direct impact on the institutional tools used to manipulate the floodplain, including attempts to control resources, allocation of financial support and enforcement of laws (Kim, 2013). The same may be said of NGOs, which are subject to changes in leadership, staffing, funding and program emphasis.

Livelihoods and legibility

Despite such environmental and political dynamism, indeed possibly because of it, the people who make their livings on the floodplain cultivate a diverse portfolio of livelihoods which take advantage of the variety of productive and extractive opportunities offered in such a diverse environment (Roberts, 2011; Brooks *et al.*, 2008; Diepart, 2010; Keskinen, 2006; Balzer, 2003; Delvert, 1994). Livelihood diversity offers the most flexibility, nimbleness or adaptability with respect to change, and as such, the most household stability (Marschke and Berkes, 2006; Mortimore and Adams, 2001). Though, even the most flexible households may be unable to adapt when the pendulum swings beyond the normal range (Sopha *et al.*, 2007).

Dominant activities for most families include rice production, fishing and herding cattle or water buffalo, depending upon the season and household access to capital and natural resources. Relatively few (as little as 5 per cent) support themselves exclusively through commerce and trade (Keskinen, 2006). However, the floodplain is the site of many other productive activities, including both plant extraction (e.g. cutting firewood or gathering grasses for roof thatching) and animal extraction (e.g. collecting snakes and small birds for sale or consumption). As with elsewhere in the region, many families also take advantage of off-farm and non-farm income generating activities through wage labour, small commerce and sales of surplus production.

These many productive and extractive opportunities on the floodplain thus allow households to develop a flexible and diverse *productive bricolage*, fluidly engaging in different activities depending upon the availability of labour, skills and resources (Croll and Parkin, 1992, p. 12; Batterbury, 2001). Such diverse natural resource use portfolios, and the flexibility they engender, are vital for household survival in dynamic environments such as the floodplain (Bouzarovski, 2009; Ellis, 1998).

However, some activities important to floodplain families, as well as their relationships to the changing landscape, remain illegible to outsiders, particularly governmental and non-governmental institutions. This is due in part to the fact that many of these activities leave a light footprint on the landscape (e.g. edible insect collection, fodder collection). They thus range from being very subtle to outright invisible in remotely sensed imagery, commonly used as the foundation for institutional understanding of the landscape and thus broader planning schemes. Moreover, these activities taken individually typically make up small fractions of family incomes and caloric intake (though this is not always the case, see Brooks *et al.*, 2008, for an example). In the eyes of institutions and others focused on rural livelihoods, they are easily overshadowed by activities in the agriculture and fisheries sectors which typically comprise a larger fraction of household income

and caloric intake. If these activities are detected at all, they may still slip between legible categories. Without extensive research at the household level, they are difficult to quantify in both material terms (e.g. aggregate amounts harvested) and economic terms. Harvest and effort vary among households and with the seasons, as does the fraction of products which are sold versus consumed in the home. Inability to value all of the products produced on and extracted from the landscape results in an incomplete accounting of the density, diversity and variability of the economic connections between people and the landscape.

Methodology

In order to explore land use and human ecology on the floodplain, I collected data over the course of three periods of research, focusing on a single village: May 2007–December 2007, March–June 2008 and January–May 2009. I used a range of methodologies; integrating methods from the fields of geography, ecology and anthropology (Brookfield *et al.*, 2002; Cunningham, 2001; Alexiades, 1996; Scoones *et al.*, 1994). These methods included semi-structured interviews and participant-observation alongside key informants (village elders and other local experts, but also including ministerial officers, local extension officers and employees of international development NGOs); field walks with key informants; unstructured interviews with village residents; written surveys focusing on land use (administered to 238 families, nearly 50 per cent of the households in village); as well as participant-observation of village life and resource management practices, joining village residents in their farming, fishing and livestock-keeping activities. I also performed a descriptive ecological inventory of floodplain vegetation, collecting data on both woody and herbaceous plants over 60 transects of 1,000 square metres each.

Research site description

The focal point for this research was Roka Village (in Sangkat Srayov, Steung Sen Municipality, Kampong Thom Province, at 12° 37' N 104° 55' E), a village of approximately 500 families on an old alluvial terrace jutting out from the edge of the Tonle Sap floodplain (White *et al.*, 1997). The village lies between 10 m and 15 m above sea level, and gradually slopes down on three sides to meet the surrounding annually flooding rice fields and grasslands at approximately 10 m above sea level. It is connected to National Road 6, the paved road running between Phnom Penh and Siem Reap, by four kilometres of improved dirt road (Figure 3.3).

The boundaries of the study area were selected based on preliminary interviews with Roka residents in order to incorporate as much of the floodplain utilized by village residents as possible. As a result, study boundaries do not exactly follow administrative boundaries. Rather they more closely

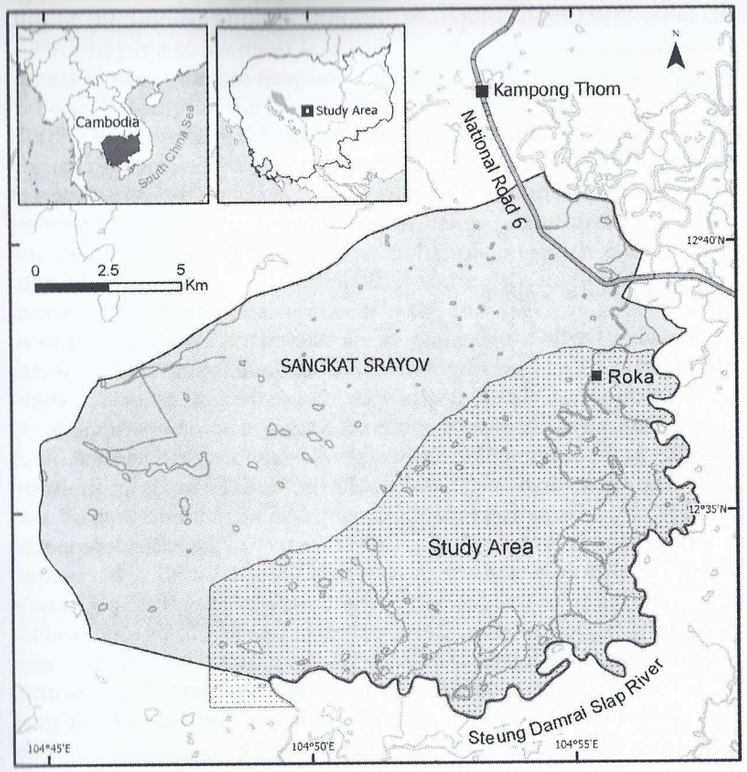

Figure 3.3 Map indicating the location of the study area.

Total area 122 km² south of Roka Village (Sangkat Srayov, Steung Sen Municipality, Kampong Thom Province). Sangkat Srayov is shaded grey, while the area of the study site itself is stippled. Mapping credit: Hannah Stevens, New York Botanical Garden GIS Lab.

follow natural features. The northern boundary of the study area is the administrative border between Roka and Kamraeng Villages. To the east and south, the area is bounded by the Steung Slap (referred to on some maps as Steung Damrai Slap), a river flowing from north to south, eventually turning to the west. West of the village, the boundary follows the dirt road which runs from the village southwest. The boundary ultimately turns due south, straying briefly into Kampong Chhnang Province at Toul Kok Preah. The area forms a rough right triangle of approximately 188 km².

A minority of village residents travel beyond the borders delineated for this study in order to fish, tend livestock or collect fodder and firewood.

However, such trips are not common. The daily activities of most village residents fall within the study boundaries.

Discussion

It is in this context that I now turn to the physical landscape itself, briefly characterizing it and subsequently presenting a typology of ecological transitions and gradients accompanied by specific examples from the village of Roka.

Landscapes (Il)legible to whom?

Topographically, the floodplain may be characterized by a gradual downward slope towards the Tonle Sap lake. But, fine-scale topographic features abound. In many areas the floodplain is punctuated by hillocks, ridges, depressions, ponds, streams and more. However, this microtopography is not legible at broader scales, either geographic or institutional. The 1:50,000 topographic maps prepared by the US Army Topographic Command in 1971 allude to a diverse landscape by noting 'numerous small and intermittent ponds' in some areas. However, many of these landscape features rise or fall as little as a metre or two from the surrounding landscape, and are so subtle as to be invisible on currently available topographic maps or even digital elevation models. Despite their invisibility to outside observers, local residents have detailed understandings of these landscapes, managing them through many different productive and extractive activities. Slight elevational difference from the surrounding plains forms ecological gradients of soil conditions, solar exposure, flood submergence time and more. Plant species vary in their environmental requirements, and therefore distribute themselves according to these requirements (Beatty, 1984; Schoener, 1974). These gradients therefore increase vegetative diversity. Seasonality and vegetative change throughout the year further contributes to landscape heterogeneity and temporal variation in biological diversity.

This landscape is actively managed and utilized by people. As relationships between vegetation and the landscape are locally recognized and managed, and as new ones are produced, an increase in agrodiversity at multiple scales follows.[3]

A simple typology

Different kinds of gradients and transitions pose different challenges in their discernment. To aid in this, a typology may be used, based on the characteristics which make them difficult to simplify and render legible to outsiders. *Interstitial environments* are places in the landscape characterized by a transition between vegetative communities and/or between production or land management systems. *Ephemeral environments* are highly seasonal and

appear relatively briefly, most commonly associated with the rising or falling of the floods. Though there is overlap between these categories, this dichotomy is a convenient lens with which to examine transitions and gradients as they relate to livelihood portfolios, ecological processes and institutional readings of the landscape.

The many products which may be obtained from these spaces and the practices associated with them typically remain hidden, classed outside of landscape-based analyses of land use or livelihoods. Populated, knowingly or unknowingly, with incomplete information, institutional planning efforts undervalue the importance of the landscape in local livelihoods. The omission of information about interstitial and ephemeral environments might be easily dismissed as unimportant in the context of most land use and land cover studies, particularly those encompassing a large land area. Indeed, in areal terms they comprise a small fraction of the landscape. However, the socio-ecological mechanics of their production yield insights into the diversity of products derived from the landscape, how the landscape is managed to these ends and the social relationships involved in gaining access to these products (Ribot and Peluso, 2003). These are vital threads in the understanding of how changes in landscape composition or access might affect the resilience of floodplain households.

Interstitial environments

Interstitial environments are gradients between vegetative communities, production systems or other natural resource management schemes which may be produced purposefully, or may emerge as an artifact of land management performed with other goals in mind. Or, as is the case with vegetative communities associated with floodplain microtopography, they may be the result of plant communities self-organizing through successional processes and in relation to varying site conditions, such as elevation, slope and aspect.

Interstices between more dominant or persistent forms of land cover are readily lost in even a detailed reading of the landscape. On the ground, these environments may appear chaotic; their disorder attributed to mismanagement and neglect (Doolittle, 2001; Padoch *et al.*, 1998). Others, such as vegetation along bunds between rice fields, hide in plain sight and are overshadowed by adjacent land cover. Though in both cases, detailed local knowledge may shed light into these spaces.

For projects using remotely sensed data, detailed local knowledge is invaluable (Shepard *et al.*, 2004). But it is a data source seldom tapped in analyses of landscape and livelihoods. In addition, the use of remotely sensed data imposes its own suite of technical limitations. Some vegetative formations may not be visible at all due to limitations imposed by the image classification method, scale and resolution of an image or the minimum mapping unit chosen by the analyst (Sohl *et al.*, 2004). Even at appropriate

scales of analysis, some may be impossible to discern from adjacent, differing vegetative formations either visually or through spectral analysis.

Moreover, application of remotely sensed imagery also privileges particular visions of the landscape. The perceived scientific objectivity of the technology equates that which is legible with scientific fact. The weight of modernist perceptions of science behind them, inequities in power relations between institutions and those that work the landscape day-to-day are reinforced (Pickles, 1995).

EXAMPLES FROM THE FIELD

Approximately 3 km down an unimproved dirt road running south from Roka Village is the largest permanent body of water within the study area, Boeng Trawsaing. Covering approximately 1 km^2, the lake along with the surrounding shrublands and rice fields supports approximately 20 families year-round, though the exact number likely varies from year to year. However, the area grows more crowded with the recession of the annual floods, around December. More families, by local estimates 60 or more, move into the area at this time to harvest the many fish stranded in the lake and surrounding seasonal ponds by receding floodwaters. Others cultivate small-scale flood recession rice along the margin of the lake, while many both fish and farm. Access to this land for rice cultivation is relatively controlled, with the same families returning year-after-year to the same sites. Many maintain a year-round residence in a village nearby, often Roka. Others travel from as far away as Phnom Penh. The number of fishing families not cultivating dry season rice is less predictable and likely more fluid from year to year as fish in that area, at that time of year, are an open access resource.

The vegetation stretching beyond the flood recession rice fields and the dry season margin of the lake is dominated by *Gmelina asiatica* L. In some areas, the thorny, small-statured tree grows relatively densely, forming thickets. In others, the trees are scattered across open areas dominated by grasses and sedges. While important much of the year for grazing livestock, as well as for the seasonal collection of grasses for thatching roofs, much of this area floods too deeply for the cultivation of all but the longest-growing varieties of deep water rice.[4] This description was confirmed in a land use/land cover classification of aerial photographs, that included 'shrublands', 'savanna' and 'rice field'. However, a closer examination on the ground reveals examples of interstitial environments between these categories. The two presented here share characteristics of all three land use/land cover categories, but are the products of very different social and ecological processes.

Near the lake, nestled among the *Gmelina* thickets may be found what appear to be old, abandoned flood-recession rice fields. Though grass-covered, their irregular gridwork of fields and bunds is still clear. These traits render these fields particularly difficult to identify in an aerial photograph,

appearing as shrubland, savanna or rice field depending upon the resolution and timing of the image and the minimum mapping unit used for the classification. However, discussion with local informants revealed a more complex story. These fields are contingent rice fields. Not cultivated annually, they are brought into cultivation as needed such as when yield on other fields is threatened or when families face other hardships necessitating extra rice for consumption or sale. Unlike the majority of the rice fields in the study area, these fields are not privately owned. They are on commonly held land, but usufruct rights are allocated by the chairman of the community fisheries committee, who could also transfer these rights if the fields went uncultivated for too long. These fields shed light into different social and ecological processes: a fluidity in land tenure not seen elsewhere in the village, which provides a mechanism contributing to household resilience; and a process that maintains gaps in the *Gmelina* thicket, in an area which might otherwise have been a more homogeneous shrubland.

Further from the lake, the *Gmelina* grows more sparsely. Until relatively recently, much of this area had been owned by village residents under customary, locally recognized tenural arrangements. Prior to the civil war, these fields were typically planted with deep water rice varieties, fished when the floods were up and grazed when neither fished nor cultivated. However with the onset of the civil war, security decayed to a point where it was no longer safe to cultivate those areas. As a result, villagers withdrew from these areas and the distant fields lay abandoned up until the late 1990s, meanwhile succeeding back into the *Gmelina* shrubland which dominates the landscape. By the end of the 1990s, this part of the floodplain was calm enough to be returned to cultivation, fishing and grazing. However, due to a shortage of deep water rice seed, and government support for production of modern, high-yielding rice varieties, many Roka village residents left these fields idle. In the coming years, land values began to rise and attract the attention of investors and speculators. Responding to this new interest in what was then uncultivated land, many village residents sold their holdings.

This pattern of abandonment and sales, as well as government interest in the development of large-scale rice production on the floodplain, led to rampant speculation, soaring land prices and triggered further land sales by village residents (Sokha *et al.*, 2004). As a result, much of the land suitable for deep water rice production in the vicinity of the lake and beyond has been concentrated in the hands of a few wealthy investors, many of whom are numbered among Kampong Thom's urban elite (Diepart, 2010). Some of this land remains idle. However, some is being converted from *Gmelina* shrubland and savanna back into deep water rice fields.

These fields are cultivated by tractor, and are much larger in scale than those typical of village residents. Land preparation occurs in at least two steps. Initially, large trees are cleared and the land is ploughed. Typically in the following year, the land will be ploughed again and the remaining smaller trees and new, woody seedlings removed. However, it

is not uncommon to find fields in-between these two stages, as for one reason or another their owners did not yet complete the land preparation necessary for deep water rice production. Some have been caught in-between these two stages for several years, giving the appearance of a young *Gmelina* dominated savanna or a gradient between savanna or shrubland. Even field borders are not always apparent, as they are often less obvious on the lower floodplain than in areas under other forms of rice cultivation. Appearing out of place on the ground, in aerial photographs they appear simply as grasslands or savannas, without any indication that they were a stage in an incremental process of land use change (Doolittle, 1984). Without the help of local informants who provided social and historical context, it would not have been clear what the origin of that vegetative formation was. These fields shed light into incremental processes of landscape change, notably that it is not necessarily teleological as stages in the process do not always follow a set sequence (Padoch *et al.*, 2008, 1998).

The illegibility of these fields complicates land titling. According to an official in the Kampong Thom Provincial Office of the Ministry of Land Management, Urban Planning and Construction, field borders in areas typically planted to traditional tall and floating rice varieties due to the depth of annual flooding, are so difficult to consistently discern in aerial photography that as of 2009, they had been completely omitted from government land titling efforts. Supported at the time by Deutsche Gesellschaft für Technische Zusammenarbeit, titling efforts focused solely on fields closer to the village. These well-defined, shallowly flooding fields typically are used for the production of shorter, more rapidly maturing, modern rice varieties. Thus, ownership of deeply flooding fields further from the village, illegible to the government's formal titling process, assumes less formal arrangements, at best sketch-maps signed by the village chief. This lack of firm, legal documentation results in the increased vulnerability of village residents to land-grabbing or encroachment in these areas. Furthermore, it brings into question the legality of land sales agreements entered into voluntarily by village residents to transfer these areas to large landowners from beyond the village.

The landscape in these areas is beginning to show the effects of this concentration of land ownership. Roberts (2011) analysed changes in the spatial patterns of vegetation types over 47 years in these areas, finding that the landscape is becoming increasingly homogeneous. It also shows signs of more intensive management, as the formerly irregular patchwork of vegetation types near the frontiers of agricultural expansion into the shrublands, gave way to a more ordered, grid-like pattern in the landscape. This simplification of pattern points to increasingly large-scale and mechanized agricultural development. Such farms are privately owned, and typically their establishment leads to the loss of local access to the resources previously available at that location. The emergence of these farms signals decreasing

natural resource-based livelihood flexibility for village residents due to diminishing landscape diversity and changes in access to the landscape.

In other situations, interstitial environments may be found nested within more legible categories. One example common throughout the study area is the rice field bund. Demarcating property and serving as both water-level controls and footpaths, bunds also serve a number of less obvious productive functions. Some farmers plant them to *sbauv*, a common grass on the lower floodplain used for thatching roofs. Aside from producing a useful product, this also adds to the durability of the bund, reducing the demands of annual maintenance. Others allow spontaneous grasses to grow along them, harvesting this as fodder for livestock. In a few areas where bunds are built up higher, or at the intersections of bunds, sugar palm (*'daum tnaot'*, *Borassus flabellifer* L.) and pandanus (*'romchek'*, *Pandanus* sp.) are planted along them. These palms yield a range of useful products from sap and fruit to construction materials. Production techniques associated with bunds are not confined simply to plants. For example, a hole punched in a bund for draining a field may be set with a fish trap to capture any fish trying to follow the water's flow. Simplified by both observers on the ground and those interpreting remotely sensed data as *just* rice fields, these areas nonetheless serve a variety of productive functions which can be important for household resilience.

Ephemeral environments

Environments associated with gradients may also be ephemeral. Particularly important on the floodplain are moisture gradients, their appearance and disappearance tied closely to rising or falling floodwaters, or the initiation or cessation of rainfall. Moisture gradients follow microtopography. Lower lying areas are wetter than higher sites, with many shallow ponds remaining behind in the lowest sites after the annual floodwaters recede. As with interstitial environments, these spaces present their own suites of plant communities and associated land uses. They may form in interstitial spaces as well, but are more strongly defined by their temporal aspect. Their discernment, both in the field or using remotely sensed data, presents many of the same pitfalls as interstitial environments. However, timing of data collection is particularly important. Data gleaned from either an aerial photograph or a field walk will vary depending upon what time of year the data are collected.

EXAMPLES FROM THE FIELD

Roka village residents are involved in a broad range of productive and extractive activities on the floodplain. Most are seasonal to some degree or another. However, some come and go quite rapidly, associated with highly seasonal ephemeral environments. Many appear only once in the annual flood cycle, such as harvesting rats from rice fields with the rising flood

waters or harvesting snakes with gill nets strung in woodlands during the falling of the floods. A few are bimodal, as with firewood harvest in the woodlands on the lower floodplain. This peaks twice in the year: once when the floods are highest and harvest sites may be reached by boat and once when the landscape is driest and harvest sites may be reached by ox cart. In between these two periods, substantial woodland far from the village is difficult to access, particularly when heavily laden.

A NARRATIVE SEQUENCE OF LANDSCAPE CHANGE

Rather than focusing on isolated examples, a spatially situated narrative description of the sequence and flow from one vegetative community and productive activity to the next is illustrative (Lambin *et al.*, 2003; Reenberg, 1999). The following generalized sequence of environments is very common on the flooding grasslands and sparsely wooded savannas 3 km or more to the south of the village of Roka. Land use in areas around hillocks, *Gmelina* thickets, streams and woodlands associated with permanently wet sites will differ somewhat from this sequence. Areas closer to the village share some of the steps in the sequence. However, being higher in elevation and therefore flooded for a shorter period than more distant sites, rice cultivation plays a more dominant role in the annual cycle.

With the recession of the annual floods in December, the grasslands bustle with activity. Cattle are brought from wet season refuges in the uplands beyond the village to graze on the spontaneous grassy pasture which emerges on the newly revealed soil. Water buffalo also graze these pastures, though many spend the wet season out on the floodplain itself, at scattered herding camps on some of the larger hillocks. Many people also move into these areas to harvest the fish trapped in seasonal ponds remaining after the recession of the floods. At this time of year, these areas are treated as essentially open access resources. Access to sites closer to the village may be informally limited to village residents only; but at sites further from Roka, people from neighbouring villages, districts and even provinces also fish, and less commonly tend livestock.

As the dry season wears on, the grasses mature while the ponds are cleared of fish and begin to dry up. With this transition, many fisherfolk and livestock keepers move on to other areas. At the height of the dry season, through February and April, mature grasses are harvested for thatching roofs. This is an activity usually performed in small groups, often by women. Bundles of grass are collected to sell and to pay off debts, often under informal contractual agreements. They are also used in construction and repair projects by the collectors themselves. The season for thatch collection is relatively brief, curtailed as the grasslands are set afire to bring another flush of new growth for livestock. Burning is not in a single, organized event. Rather, fires are set here and there, by individuals engaging in other activities. Geographically, the fires are extensive but not complete in

their coverage. The result is a mosaic of burned and unburned savanna, which changes annually. In addition to producing better pasture, annual burning maintains the patchwork of grasslands and sparse woody vegetation associated with this sequence of land uses (Laris, 2011).

The burning brings with it another flush of grassy regrowth, to the benefit of cattle and water buffalo graziers. With the onset of the annual rains in April and May, grazing tapers off in some areas as the cultivation of deep water rice begins. This portion of the grassland is not uniformly cultivated. Much of the grasslands are uncultivated, remaining open access pasture. Cultivated fields shift in ownership from open access to privately held, and are no longer grazed.

Throughout the rainy season, uncultivated areas of the grasslands are grazed. Once the flood waters from the Tonle Sap rise, fishing begins again throughout the floodplain, on cultivated land and uncultivated land alike. As with much of the rest of the year, access to this resource is not limited to landowners or village residents. Fish are an open access resource. The deep water rice crop is unaffected by this activity, as the shallow-draft boats typically employed in this fishery do not disturb the plants.

The flood tolerance and the elongating, floating stem of the deep water rice are also shared with the weedy relative of domesticated rice, *Oryza rufipogon* L., which forms floating meadows in these areas. It is very important as a source of fodder for livestock at this point in the production calendar. Most pastures are too deeply flooded for cattle to graze, leading many farmers to drive them into the uplands or to keep them in the village. Water buffalo fare better grazing in higher water, giving farmers the flexibility to graze them in shallow areas of the floodplain, keep them in the village or to send them to the uplands with the cattle, depending upon the availability of labour.

Weedy, undomesticated rice is not only important for wet season livestock management. It may be a significant generator of rice germplasm diversity, which is managed and maintained by farmers as they select which seeds to plant from year to year (Niruntrayakul *et al.*, 2009). Growing in proximity to each other allows cross-pollination and gene flow between domesticated rice and its wild relative. This genetic diversity gives farmers a broader palette with which to develop and fine-tune locally adapted rice varieties best suited to thrive in the variable floodplain environment.

Cessation of the rain and the recession of the floods reveal the terrestrial landscape again. Once fields are drained, rice is harvested. The crop is often threshed in the field for a fee by itinerant owners of mechanical threshing machines. Spontaneous pastures appear anew. Again, cattle and water buffalo are brought in to graze on the rice stubble and new grass growth. And, the busiest fishing season of the year begins.

This generalized schema illustrates the range of vegetation types and land uses associated with a single point in space. The sequence is not evident in a single field walk or in the analysis of a single image. Indeed, it is

uncommon to have fine enough temporal resolution in a series of high resolution remotely sensed images to capture this sequence.

A challenge to render into visible units for institutional planning purposes, this sequence reveals nonetheless important information. It yields insight into mechanisms for building and maintaining landscape heterogeneity through burning, grazing and cultivation (Laris, 2011; Cingolani *et al.*, 2005); management of livestock, fishing and other activities in village livelihood portfolios and maintenance and generation of seed varietal diversity. The fine-resolution and temporally continuous view also highlights the importance of grassland to people from beyond the village, especially during the fishing season following flood recession.

Conclusions

Products of dynamism, ecological transitions and gradients abound on the Tonle Sap floodplain. The resultant interstitial environments and ephemeral environments associated with them easily slip between legible categories and the units of measurement used by institutions beyond the village. Illegible, they are easily misinterpreted, overlooked or can be purposefully cast aside. They can also remain obscured from decision-makers and planners, as the dynamics are impossible to incorporate into models, maps and forecasts. Consequently, the local management systems in which they are situated remain unacknowledged. In the absence of detailed accounting of local management systems and their underlying socio-ecological processes, top-down impositions of new land management schemes therefore have few prospects for success. As illustrated by these examples from Roka Village, fine-grain analysis of information typically lost between categories sheds light upon the socio-ecological mechanics of land use and land cover change. To remedy this legibility gap, it is crucial that institutions involved in natural resource management expand methods of data collection and the types of data sought. Simply, they need to ask different questions.

The floodplain landscape is increasingly a contested landscape, as local residents, wealthy elites, governing institutions and development NGOs all struggle for control of the resource base. Rendering the illegible legible and bringing it to the fore may strengthen the case for increased local control and a validation of local management systems, slowing the progress of dispossession which has grown to characterize resource-rich rural areas in Cambodia.

Notes

1 Though widely cited, this figure is not unproblematic. See Lamberts (2006) for a discussion of how this figure was derived, as well as the challenges associated with harvest estimates in a fishery involving so many different fish species, fishing gear and social and legal arrangements for participants in the fishery.
2 While parsed out separately here for the sake of illustration, category lines between individual elite, privately held business and government institution (more specifically, individuals and groups embedded within institutions) are more often than not, blurred.
3 Agrodiversity is a qualitative descriptor of production systems, and by extension livelihood portfolios, encompassing multiple aspects of diversity: agrobiodiversity (plants domesticated, semi-domesticated and managed); biophysical diversity (unmanaged biological diversity as well as physical aspects of the site, such as soils and topography); management diversity (farmers' technical knowledge and innovations as applied to production) and organizational diversity (farmers' allocation of labour). An agrodiverse system is more robust with respect to shocks and perturbations, while at the same time more flexible in allowing for innovation and capitalization on new opportunities (Brookfield, 2001, p. 41; Brookfield and Padoch, 1994).
4 Deep water rice varieties tolerate deep flooding. Their stems elongate to match the pace of the rising water, while the most distal portion of their stems floats atop the surface (Catling, 1992). These varieties are among the slowest maturing, least yielding and, when sold, the lowest value rice varieties planted in Cambodia. However, they fill a particular niche in production systems; thriving in deeply flooded areas far from the village, and requiring little attention from farmers during the growing season.

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4 Can market integration improve livelihoods and safeguard the environment?

The case of hybrid rice varieties in Cambodia's agricultural heartland

Maylee Thavat

Introduction

A key concern for developing countries experiencing rapid agrarian transformation is the loss of different agro-ecologies and on-farm biodiversity. As forest cover diminishes, discussions around environment and conservation often turn to debates over agro-biodiversity and land management by farmers. *Prey Veng* meaning 'Long' or 'Grand Forest' in Khmer, was densely forested prior to French rule; but it is now firmly planted as a central province of Cambodia's agricultural heartland, with the largest area of any province devoted to rice production, contributing around 10 per cent of the country's total annual rice harvest (USAID, 2008). Rice ecologies of the lower Mekong delta can present a seemingly endless landscape of monoculture. To the contrary, however, Cambodia's lowland rice ecologies are highly diverse and productive environments that yield not just rice but a range of flora and fauna important to food security for farmers and potentially the resilience of agricultural systems overall (Shams, 2007). Diversity among rice varieties is also recognized as important in the face of environmental uncertainty and climate variability (IPCC, 2002). Simply put, growing a diversity of rice varieties helps spread the risks of crop failure due to changing growing conditions or extreme climatic events to which Cambodia is prone.[1]

This chapter examines the dynamics of hybrid rice seed uptake by the Prey Veng Rice Seed Company, Cambodia.[2] In particular, it describes how different classes of farmers accessed and used both modern hybrid and traditional rice seeds, through formal and informal markets and the implications of this for on-farm agro-biodiversity and livelihoods. Hirsch (2012) noted that much political *ecology* work on Southeast Asia focuses on upland areas: but what of the agricultural lowlands? Studies of lowland agriculture have traditionally been dominated by political *economy* studies aimed at understanding 'capitalist transformations of the country-side' (Rigg and Vandergeest, 2012). Yet the environmental aspects of such transformations are now increasingly at the fore (ibid). This is because, 'small-scale producers are seen not only as the key to reducing rural poverty, but also as a