

Competing institutional logics and sustainable development: the case of geographic information systems in Brazil's Amazon region

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This paper examines the possibilities that information and communication technology (ICT) provides for the achievement of environmental sustainable development – one of the key millennium development goals (MDGs). We base our paper on primary and secondary empirical data pertaining to the history of the governance of the Brazilian Amazon and the role of geographic information systems (GISs) in the region. Specifically, we argue that in order for the MDG to be achieved what is required is a thorough understanding of the differing institutional logics that have surrounded the past and current use of GIS in the Amazon region. We will argue that due to conflicting institutional logics the changes that have taken place in relation to the MDG of sustainability should be understood as being both emergent and contested. We will claim that the design and use of ICTs reflects the ways in which these conflicting logics are worked out at any moment in time. We conclude that in order for ICT to contribute to the MDGs, it is important to attend to the historical and contested institutional context and the potential for ICTs to be enacted in unanticipated ways.

Keywords: institutional theory; institutional logics; millennium development goals; geographic information systems; environmentalism; Amazon rainforest; Brazil

Introduction

In September 2000, the 189 member states of the United Nations signed the Millennium Declaration. One of the most important parts of the declaration was the millennium development goals (MDGs), an eight-goal action-plan that the international community agreed to carry out in order to improve life conditions around the globe. These goals included the reduction of extreme poverty, combating AIDS and ensuring environmental sustainability. Many studies consider information and communication technologies (ICTs) as being important in helping countries achieve the MDGs across diverse domains such as in providing greater access to education or in combating HIV/AIDS (e.g. Batchelor et al., 2003; Madon, 2005).

This paper focuses on the role of information and communication technology in relation to the seventh MDG, which refers to ensuring environmental sustainability. This goal comprises four targets, the first two of which are especially relevant to our paper. The first target (7a) aims to integrate the principles of sustainable development into country policies and programs and reverses the loss of environmental resources. The second target (7b) seeks to redress the loss of biodiversity by establishing performance indicators in areas such as conservation, reducing deforestation rates, reducing CO₂ emissions and reducing the use of ozone depleting substances. This paper focuses on the relationship between the seventh MDG and a family of remote sensing-based geographical information systems (GISs) that monitor deforestation in the

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Brazilian Amazon region. Specifically, we report on the major institutional changes that have taken place over four decades that were relevant to their design, implementation and use.

As with the notion of “development” itself (Rist, 1997; Saith, 2006), there has been intense discussion on the definition of “sustainable development” and the suitability of this concept to tackle global environmental issues (Banerjee, 2003; O’Connor, 1988). Most accounts on the role of ICT for development have adopted the United Nation’s definition, which defines sustainable development as meeting “the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987, p. 43). In line with this narrower (and less polemical) definition, many authors have depicted ICT in general and GIS in particular as having an important role in attaining sustainable development (Hajer, 1995; Heinonen, Jokinenb, & Kaivo-ojac, 2001; Meadows, 1998). In this regard, Esty (2001, 2004) argued that the capability of ICTs to store, analyze and disseminate information provides the basis for a “data-driven environmentalism” where continuous streams of precise data in real time allows for the constitution of a virtuous global environmental order.

Remote sensing-based GISs have been one of the most widely employed ICTs introduced to support the sustainable development of tropical forests. This priority was encapsulated as early as 1972 in the first United Nations conference on the environment which recommended the “use of advance technology, such as satellites which use different types of imagery and which could constantly survey all forests” for ecological purposes (UNEP, 1972, p. 5). While this vision remained largely unrealized for a significant period of time, the recent explosion in the availability of satellite images and the post-Kyoto emphasis on linking carbon credits to the preservation of forests has led to a growing interest in the role of GIS in bringing about sustainable development (e.g. Fuller, 2006; Kintisch, 2007; see Fonseca, Davis, & Câmara, 2009).

One strand of the literature that has attended to the role of ICT for development (ICT4D) has pointed to the centrality of social and cultural dimensions in the success and failure of ICT projects (Avgerou & Walsham, 2001; Barrett, Sahay, & Walsham, 2001; Heeks, 2002). Walsham and Sahay (1999), for example, showed that GISs contain a series of “Western” values embedded in them (e.g. use of maps to represent the territory), which may contrast with those values held in different developing countries. Puri (2007) and Miscione (2007) went further and have shown that ICT has the tendency to privilege Western scientific knowledge over traditional local knowledge. Both authors claim that this is important in generating and sustaining inequalities (see also Pickles, 1995). Puri (2006) in a study about the development of spatial data infrastructure in India found that even within the same national context stakeholders may have significantly different “technological frames,” that is, the expectations, assumptions, and knowledge that mediate the understanding and use of technology. For instance, during the development of India’s spatial data infrastructure, scientists from governmental institutions emphasized the need to control access to data due to national security concerns, while government and private sector end users believed that data should be easily accessible. As a whole, one of the main findings that has emerged from the ICT4D literature is that for ICT to be successful developers and policy-makers “must improve their capacity to address the specific contextual characteristics of an organisation, sector, country or region within which their work is located” (Avgerou & Walsham, 2001, p. 2; Georgiadou, Puri, & Sahay, 2006; Miscione & Staring, 2009).

While literature pertaining to the cultural dimensions of ICT for development has been relatively well developed, few studies have attended the historical dimensions of ICT in developing countries (for exceptions see Heeks & Santos, 2009; Madon & Sahay, 2001; Rajão & Hayes, 2009). Furthermore, the ICT4D literature that advocates moving toward “data-driven” sustainable development is techno centric, as it assumes that ICTs will yield the promised benefits (Craglia et al, 2008; Esty, 2001, 2004; Meadows, 1998). Perhaps most surprising is the lack

of attention that the ICT4D literature has placed on environmental sustainability (Silva & Westrup, 2009). Indeed, Walsham and Sahay's (2006) review paper makes no mention of environmental sustainability. This omission is striking as clearly much of the world's natural resources reside within developing countries.

This study seeks to provide a modest contribution to these omissions in the literature by focusing on the ways in which alternate institutional logics have shaped the introduction and development of a number of GISs that have been introduced in Brazil's Amazon region over the last 40 years. Briefly, we understand institutional logics as being socially constructed assumptions, values and beliefs that people draw upon in their day-to-day activities (Avgerou, 2000; Lounsbury, 2007). We argue that in order to assess the possibilities of GIS in the Brazilian Amazon in relation to the MDG goal of environmental sustainability, it is crucial to understand the synergy and competition between institutional logics over this time period. Overall, our paper will argue that the relationship between ICT and institutions should be conceptualized as conflictual, emergent and dialectical (Hayes, 2008).

This paper is organized as follows. The next two sections outline our conceptual underpinnings and our methodological stance, respectively. The fourth section presents the empirical basis of this article. The fifth section provides our discussion of the data. In the discussion, we first identify the key institutional logics pertaining to the development and use of GIS in the Amazon and the synergy and conflicts within and between these logics. Based on this analysis, we then discuss the importance of unpacking the design decisions relevant to the Amazonian GISs, how these systems provide for interpretive flexibility and the importance of focusing on the ways in which they are enacted. The final section considers the possibilities for ICTs in meeting the seventh MDG.

Conceptual underpinnings

This section will outline the institutionalist conceptual underpinnings of the paper. Many accounts within the institutional theory literature have sought to explain the similarity of organizational forms in relation to their similar professional, economic and regulative environments. This has led institutional theory to emphasize isomorphism and stability (e.g. Hirsch & Lounsbury, 1997). A number of scholars have argued that as much of this similarity and taken for grantedness rests upon often unnoticed situated practices, it is important not to "black-box" practice (Hayes, 2008; Hirsch & Lounsbury, 1997; Lounsbury & Crumley, 2007). Instead, several recent contributors claim that there is a need for more attention to be paid to the role of actors in shaping institutions (Lounsbury & Crumley, 2007).

One important set of ideas within the institutional theory literature is the concept of institutional logics. Table 1 summarizes the key ideas. Institutional logics comprise of a set of values that orientate the ways in which institutions are organized, the nature of the changes that take place, the resources distributed and the technologies that are purchased and developed (Thornton & Ocasio, 1999). More specifically, Lounsbury (2002, p. 253) defines institutional logics as "organizing principles that govern the selection of technologies, define what kinds of actors are authorized to make claims, shape and constrain the behavioural possibilities of actors, and specify criteria for effectiveness and efficiency." Institutional logics are thus central in framing social reality and shaping the interpretations that people have of their own work and the work of others inside and outside their institutions (Friedland & Alford, 1991; Marquis & Lounsbury, 2007).

Much of the work on institutional logics has focused on how certain dominant logics uniformly shape institutions and thereby lead to predictable activities and stability within an institution (Scott, 1995). This convergence is claimed to result in conformity and isomorphism.

Table 1. Key ideas relating to institutional logics.

Key theme	Details
Institutional logic	Core values and organizing principles Frame social reality and thereby work and organization
Multiple logics	There may be multiple, fragmented and contradictory logics
Power	Institutional logics are inextricable interlinked with power and control There is likely to be conflict and resistance within and between institutional logics
Periods of transformation	Increased uncertainty arises when dominant institutions are challenged Can lead to the emergence of new logics and practices and a renegotiation of institutional logics

Much of the research that has accounted for transformations in logics accounts for changes as being “period effects that segregate one relatively stable period of beliefs and activities from another” (Lounsbury, 2008). However, a number of recent studies have emphasized the coexistence of (not necessarily cordial) multiple institutional logics (Suddaby & Greenwood, 2009). Lounsbury (2008), and the position adopted in this paper, argues that while there may be an institution that appears dominant, there are always multiple complementary and conflicting institutional logics present. These multiple institutional logics present many different frames of reality to members and thereby shape and are shaped by the practices of actors (Thornton, 2002).

As is noted in the second theme in Table 1, fundamentally, this social constructivist view of institutions suggests that as there are multiple institutional logics, we need to attend to ongoing negotiations and conflicts that emerge within and between institutions (Blackler & Regan, 2006; Townley, 2002). Consequently, institutional logics need to be conceived of as being inextricably interlinked with power and control. For example, Friedland and Alford (1991) argue that due to the diverging logics in societal institutions such as religion, the state, professions and corporations, this often results in conflict (Marquis & Lounsbury, 2007; Thornton & Ocasio, 1999). While power relations in institutions are always ongoing, where institutional logics are contradictory, or when different groups are competing over issues of status and control, then an emphasis on conflict is especially likely (Thornton, 2002; Thornton & Ocasio, 1999). Others such as Marquis and Lounsbury (2007) have focused on resistance to prevailing institutional logics, and in doing so, have tried to counter the claims of isomorphism by identifying the variety of practices that emerge as actors negotiate and shape alternate institutional logics. Indeed, Lounsbury (2007, p. 289) is critical of research on institutional logic that treats “institutional shifts as period effects that segregate one relatively stable period of beliefs and activities from another.”

A number of authors highlight how the divergence between institutional logics becomes particularly apparent during periods of transformation (Hayes, 2008; Lounsbury, 2002). Lounsbury (2002) argues that anxiety is prevalent as an old institutional logic is dismantled and a new institutional logic is put in place. Indeed he claims that:

Periods of transformation are an important focal point for analysis because they are characterized by conditions of heightened uncertainty, under which novel practices can emerge, actors can make new kinds of claims, organizational forms can emerge and die, status orders can be restructured, and rules of engagement can be redefined. (p. 265)

We will argue that it is this emphasis on the emergent, political and negotiated nature of institutional change, and the coexistence of multiple institutional logics that better reflects the differing conceptions and use of the Amazon monitoring system over time. Indeed, we will suggest that the monitoring system can be understood as the product of ongoing negotiation between differing institutional logics.

Research methodology

The case study that forms the empirical basis of this article concerns a number of remote sensing-based geographical information systems that have been developed in the Amazon region by Brazilian federal and regional government organizations over the last four decades (Table 3). The primary data reported in this paper comprised 85 face-to-face interviews held between June 2007 and July 2009, in different parts of Brazil. Figure 1 indicates the location of the main research sites, the National Space Research Institute (INPE), near São Paulo (1); the Federal Environmental Agency (IBAMA) headquarters and government ministries in Brasília (2); and IBAMA’s and SEMA-MT’s (the state of Mato Grosso’s environmental agency) offices located in different cities in the southern part of the Amazon rainforest. This included not only office-based staff but also forest rangers working in the Amazon (3). The interviewees included an ex-president, three ex-ministers of the environment, a state-level secretary of environment and eight senior scientists at INPE (the Brazilian institute for space research) as well as mid- and junior-level officials. Interviews were also conducted with members of NGOs, other governmental agencies, local politicians and farmers (Table 2).

The initial interviewees were selected based on their role in the different organizations (such as IBAMA and INPE). While concluding these interviews, we asked for suggestions about who else we should speak to. A group of 10 key people were interviewed more than once so as to

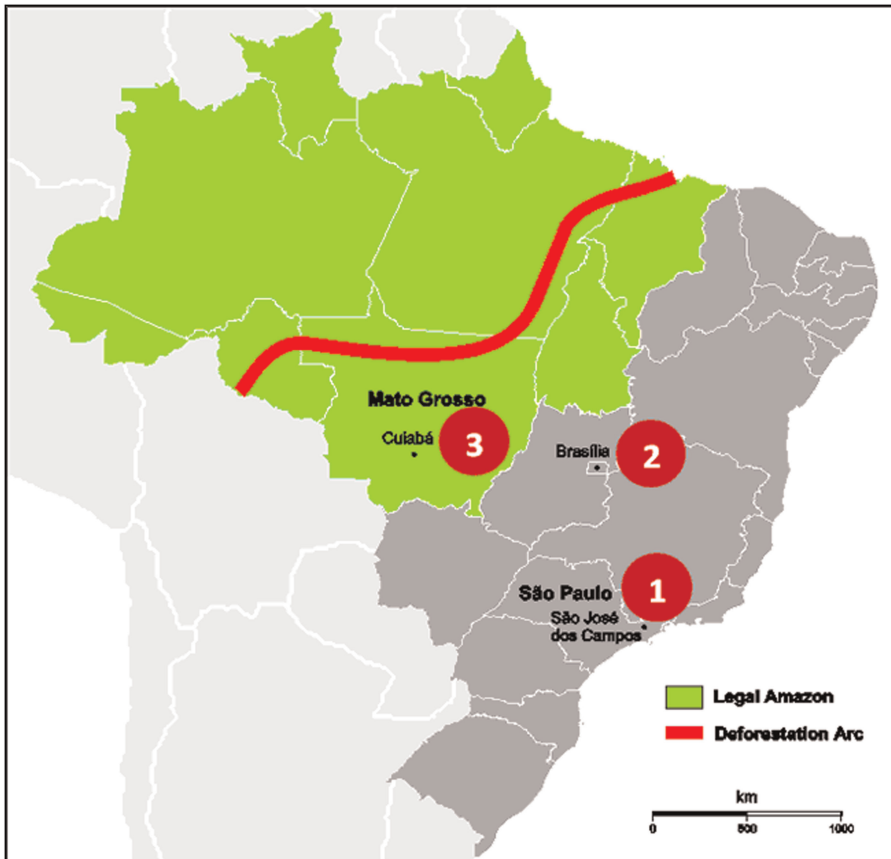


Figure 1. Main research sites.

Table 2. Summary of the interviews conducted.

Institution	Interviews
IBAMA	15
Ministry of Environment	12
SEMA-MT	12
INPE	10
National congress	5
Other governmental agencies	13
Local farmers	11
Non-governmental organizations	7
Location	Interviews
São Paulo	10
Distrito Federal	36
Mato Grosso	35
Other	4

better understand some of the emerging issues, to test our understandings, and importantly to add a longitudinal dimension to our study. While some of the interviews were conducted in English, the majority were carried out in Portuguese. Interviews were voice recorded and then transcribed and translated into English when relevant. When this was not possible, extensive notes were taken during interviews.

Secondary data sources were also drawn upon. These sources were particularly helpful in identifying the history around the use of GIS in the Amazon. These sources included documents detailing relevant aspects of Brazilian law, newspaper archives, reports from governmental agencies and NGOs, technical documents relating to GIS and academic articles and books about the economic, political and environmental history of the Amazon. Several of these documents were provided directly by the interviewees, while others were obtained via websites. The primary and secondary data were then analyzed in order to identify recurrent themes and shared interpretations of the Amazon rainforest and the role of the GISs (Walsham, 1993). Furthermore, in order to confirm the appropriateness of our interpretation, this research was presented to an audience of policy-makers and scientists (including some of the interviewees) and was also discussed with some key informants via subsequent face-to-face encounters, email and instant messaging.

GISs in Brazil's Amazon region

Investment in remote sensing (a key component of modern GIS) in the Brazilian Amazon dates back to the 1960s with the creation of a work group that then became INPE (National Institute for Space Research). Remote sensing was a priority following the military coup d'état in 1964. Initially, the data from remote sensing were used to assist in the economic development of the Amazon region. Remote sensing was initially applied primarily to assess the potential of mining, agriculture and forestry activities in the Amazon region. Consequently, GIS was deployed to support the land settlement projects of small- and large-scale farmers. Further, as the government-induced colonization of the Amazon was gaining momentum, GIS technology was used to check if the subsidies to transform "immense and unknown inland" into pasture and crop areas were having the expected effect (Tardin, 1982). In addition to supporting economic development, many interviewees pointed out that the Amazonian GISs and the development policies were also put in place in order to placate the fears that the Brazilian region might eventually fall

into foreign hands. A congresswoman representing one of the Amazonian states exemplified the concern for the sovereignty of the Amazon stating:

We needed to be careful of those non-governmental organizations that were run and financed by foreigners as they may have gained precious information about the Amazon. [...] During the 1970's the rationale was to occupy and economically develop the region at any cost to guard against the threat of the U.S gaining control of the area. It was the period of the "Mata por Pata" [replacement of forest by cattle].

Toward the end of the Cold War, the attention of the international community shifted to ecological concerns. At that time Brazil's government, which was in a process of transition from a military to a civil regime, found itself as a global environmental villain due to its policy toward the Amazon. At first, the Brazilian government resisted international pressure on the grounds that the discussion of how Brazil manages its territory represents an attack on its sovereignty (McCleary, 1991). However, around 1988, the Brazilian government started to change its policy toward the Amazon. This change came about due to a wide variety of groups with different agendas and understandings of the Amazon exerting pressure on Brazil. World leaders such as Al Gore, François Mitterrand and Mikhail Gorbachev started to exert pressure on Brazil to preserve the Amazon as they feared the consequences of deforestation for the world's ecosystem (Kolk, 1998). Pressure was also exerted by non-governmental organizations who successfully lobbied international governments to force the World Bank to stop their loans to Brazil. Finally, grass-root groups such as the rubber tappers' movement led by Chico Mendes (who was assassinated that year) widely publicized how deforestation was taking away their livelihood (Keck & Sikkink, 1998). This mounting political pressure led to the government establishing the *Nossa Natureza* (our nature) program at the end of 1988, and a new federal environmental agency (IBAMA) a few months later. IBAMA's role was to enforce the new environmental policy in the Amazon (Mello, 2006).

As part of the new environmental policy in 1988, the government also created PRODES (Program for Calculating Amazon's Deforestation) and a few years later SIVAM (System for the Surveillance of the Amazon). PRODES was the first GIS to provide regular data about the extent of deforestation in Brazil's Amazon region. Indeed, Brazil is still the only country in the tropics to regularly provide reliable statistics about its forest coverage, even though the Indonesian government had started to develop a similar system (Fuller, 2006; World Bank, 2006). PRODES calculated (through statistical techniques) the estimated deforestation rate per year (how much rainforest has been lost in km²) and by state by comparing the most recent satellite images of forest coverage with images from previous years (Figure 2). The new environmental policy also led to the Brazilian government developing SIVAM in 1992. GIS technology is one of SIVAMs central components (Table 3).

Despite the Brazilian government beginning to proclaim its environmental credentials, the high-deforestation rates and the expansion of agribusiness in the Amazon during the 1990s suggests that economic growth remained a priority (Figure 2). In addition, a closer look on the ways in which these different GISs were designed and enacted suggests that concerns about national sovereignty remained important. In relation to SIVAM, studies have suggested that the system was more closely aligned to the Brazilian military than it is to environmental concerns. Indeed, SIVAM was designed by the Brazilian Air Force rather than the Ministry of the Environment. Consequently, the majority of resources allocated to SIVAM were invested in the construction of a network of radars for monitoring airspace. Thus, SIVAM was more clearly related to the need to control Brazil's borders than it was to reduce deforestation in the Amazon (da Costa, 2001; Tulchin & Golding, 2002). PRODES was also closely associated to national sovereignty. Following the publication of a report in 1988 by Dennis Mahar, an economic advisor at the World Bank, that claimed there was a steep increase in rates of deforestation

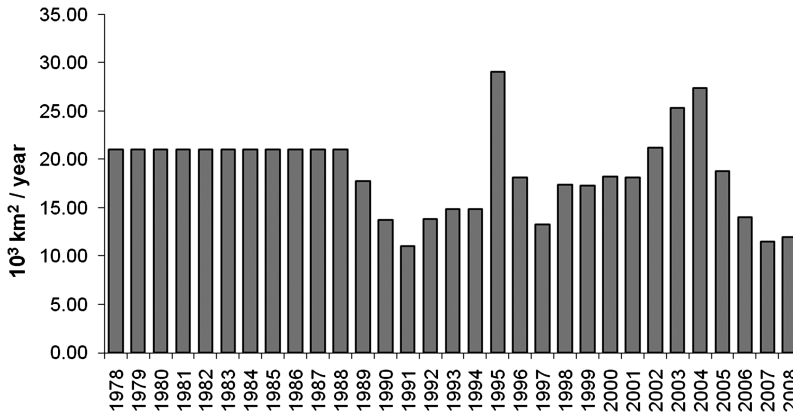


Figure 2. Deforestation rates between 1978 and 2008 (Source: INPE/PRODES).

in the Amazon, the Brazilian government created PRODES so as to dispute this claim. Mahar claimed that 12% of the Amazon was already deforested and that if it continued at that rate, the rainforest would be cleared within the space of a few years. Importantly, PRODES was also a way to ensure that the Brazilian government rather than foreign governments had the most accurate data pertaining to the Amazon. It also allowed the Brazilian government to dispute Mahar’s figures, as a senior INPE scientist explained:

Mahar’s report [...] forecast that by 2050 the Amazon will be completely deforested. He then produced another report that stated that despite the high deforestation rates there was still an opportunity to save the Amazon rainforest and we needed to initiate a program to do this. As a reaction to this we started working on better monitoring deforestation in the Amazon [...] Back then it was clear that

Table 3. The geographic information systems in the Brazilian Amazon region.

Designer/developer	System	Description
INPE (and the Ministries of Mining and Agriculture)	RADAM among others and ad hoc studies (1970–1980s)	Provide data on natural resources and monitor the effect of subsidies for agriculture (i.e. deforestation)
INPE	PRODES (1988–2003)	Provide yearly deforestation rates aggregated by state
Brazilian Armed Forces/ Raytheon (US defense contractor)	SIVAM (1992–present)	Restricted access to deforestation maps Composed of fixed, mobile, and airborne radar, ground sensors, telecommunication networks and databases Parts of the system are available only to military personnel
State of Mato Grosso	SLAPR (1999–present)	Contains the geo-referenced property borders of the farms in the system and monitors deforestation on a regular basis
INPE	PRODES Digital (2003–present)	Open access to the system over the Internet Provide yearly deforestation rates as well their location
DETER	DETER (2004–present)	Open access to the system over the Internet Provide alerts of new deforestation and its location every 15 days Open access to the system over the Internet

PRODES was primarily about having earlier and better information than foreigners had. Because, you know, back then you had the Americans and other people researching the Amazon and the government wanted to be the first to say the numbers.

PRODES data access policy also confirms the Brazilian government's preoccupation with sovereignty. Different scientists explained that the maps identifying the location of deforestation were considered a matter of national security. For this reason, the only data sets published by the government were the yearly deforestation rates that were aggregated at the state level. As the nine states of the legal Amazon region have a total landmass equivalent to the newly extended European Union, these high-level data were not sufficient to enforce the property-level requirements of the law. As a result, different interviewees pointed out that it was relatively ineffective with regard to environmental protection. This lack of effectiveness was summarized by a top INPE scientist, when he explained that when PRODES' deforestation rate was provided annually "everybody cried but in the end nothing was done."

There is evidence, that at the end of the 1990s and the early 2000s, the Brazilian government began to apply GIS technology more directly to tackle environmental issues. Unlike the previous systems, this new generation of GIS aimed to assist in the enforcement of those laws that prohibited unlicensed deforestation. For example, in 1999 Mato Grosso's Environment Agency developed SLAPR, a GIS that contains the coordinates of the borders of specific properties. Similarly in 2004, INPE developed DETER (Deforestation Detection in Real Time). Unlike PRODES, DETER was able to provide the location of new clearings every 15 days directly to IBAMA's forest rangers who were located across all of the Amazon. Based on this data, IBAMA and the state-level environmental bodies are now able to locate and fine the farmers responsible for illegal deforestation. Also, GIS and satellite images are being used by IBAMA's agents as evidence of illegal deforestation, making it more difficult for farmers to contest their fines in court. As a senior INPE scientist explained:

Thanks to those [monitoring] systems, we are now able to constantly monitor the Amazon, and thereby enforce the protection of the region. It is true that if you don't have political willingness, you don't go anywhere. However, also without this monitoring system the illegal activities can go on and nobody will even know about it, or maybe know only afterwards [when it is too late].

As a consequence of this new generation of GIS, farmers explained that they felt that more recently the environment has become an "important issue" and now fear that they may be fined or that companies will not buy their products if they are not in compliance with the law. This fear of detection was evident in a comment made by a local farmer during an informal conversation, who complained that "you cannot cut down a tree without being caught by the satellites!" Similarly, a manager in a major soybean company also explained that the law has had a negative impact on the price of land in the region, as it can no longer be easily converted into land for crops or beef herds. Overall, GIS appear to have played a key role in the significant reduction in deforestation rates between 2004 and 2008 (Figure 2).

Despite the increasing concern for environmental sustainability, economic development and (to a smaller degree) sovereignty concerns remain important issues for the Brazilian government. First, the recent clashes between the government and the military over the creation of the indigenous reserve Raposa do Sol, close to Brazil's borders with Venezuela, highlights the persistence of military concerns with the Amazon region. Second, despite Brazil's environmental agenda strengthening from end of the 1990s onwards, during this period there had also been a substantial growth in the soybean and cattle ranching business in Mato Grosso (the southern portion of the Amazon). Most of this was for export. Consequently, different government officers explained that the concern for economic development often impinged on the

extent and nature of policy-making with regard to environmental protection. A senior representative of the Ministry of the Environment explained the issue by noting that:

The problem is that in order to adopt an environmental model the country will suffer economical losses. Today half of the wealth produced by the country comes from primary products which have environmental impacts.

This struggle between sustainability (i.e. decrease of deforestation) and economic development (i.e. expansion of agribusiness) was evident with SLAPR. SLAPR is a rural property environmental licensing system developed by the state of Mato Grosso (in the south-east of the Amazon) in 1999. SLAPR allowed for better law enforcement as it provided coordinates and other information related to a specific property. Mato Grosso's environmental agency created a compulsory GIS-based registry where individual farmers have to provide their geo-referenced property borders and state their use of the land (i.e. forest, crops, pasture). The GIS allowed the state to identify if the farmers are compliant with the law. This law requires that 80% of the area of all private properties should be set aside as a "legal reserve" of native vegetation. SLAPR's role in reducing deforestation was disputed (Chomitz, 2007; Fearnside, 2003). While many do believe that SLAPR has contributed to the better control of illegal deforestation, there is evidence that others claim that SLAPR was used primarily to identify areas of land that could be legally deforested, and as such, contributed to the overall increase of land clearing in the region (Azevedo, 2009). Furthermore, Mato Grosso government officials and farmers claimed that by only deforesting 20% of the land registered on SLAPR, SLAPR was being used as a way for Agribusiness to claim they had a "green certificate" and thereby ensure that international organizations would continue to buy their soybeans or beef.

Discussion and conclusion

This discussion section argues that in order to evaluate ICTs in relation to the MDGs, it is important to consider the historical trajectory of the broader macro societal context (Barley & Tolbert, 1997). We draw primarily on the concept of institutional logics to understand how broad institutional fields may shape and change the ways in which the different satellite-based GISs in the Brazilian Amazon region were framed and used overtime, and the implications of this in relation to the seventh MDG.

Identifying institutional logics

This first sub-section will identify the alternate institutional logics that have been implicated in shaping the development and use of the different GISs in the Brazilian Amazon between 1964 and 2008. Table 4 provides an overview of the different institutional logics.

Sovereignty institutional logic

The sovereignty institutional logic was pervasive even prior to the introduction of the first GIS in the Amazon region. As Table 4 highlights, over time this logic has comprised two specific sub-logics. Initially, it was framed by the military government and considered the Brazilian-Amazon region as a territory that must be defended from threats to its economic, political and territorial independence. This sub-logic was evident in the projects established in the 1960s and 1970s that encouraged the economic development and colonization of the Amazon. These strategies sought to preserve Brazilian sovereignty over the region. Even following the establishment of the civilian government and the substantial changes in policy toward the Amazon in the 1980s, the sovereignty institutional logic remained powerful. Brazil continued to reaffirm that Amazônia

Table 4. Institutional logics in the Brazilian Amazon region over time.

Institutional logic	Description of specific institutional sub-logics
Sovereignty logic	To ensure territorial sovereignty over the Brazilian Amazon region (1960s onwards – but weaker since the end of the 1980s) To assert sovereignty over decision-making pertaining to the Amazon rainforest (1970s onwards)
Economic logic	To encourage the settlement of small farmers for sovereignty and poverty-relief reasons (1960s onwards) To exploit the region for commercial reasons via large agribusiness corporations (mid-1990s onwards) For it to be economically viability for small farmers and related industries to remain in the region (2000s onwards)
Sustainability logic	To reduce the rate of deforestation and thereby allow for a sustainable planet (1980s onwards) To protect the forest so as to ensure the survival of native Indians and other forest dwellers (1980s onwards) To conciliate environmental protection with economic development (2000s onwards)

is part of its territory, and as such, has resented and resisted foreign governments and NGOs commenting on or influencing policy pertaining to the Amazon region. Even though the sovereignty logic remains important, events such as the creation of an international fund in 2008 backed by promises to reduce deforestation in the region shows that it has weakened considerably since the 1980s.

Economic institutional logic

An economic institutional logic has pervaded the entire history of the Amazon and continues to be extremely important in shaping regional policy. As Table 4 highlights, this comprised three sometimes contradictory sub-logics. First, this logic encouraged the settlement of small farmers in the Amazon region as a response to the perceived threat of invasion. By populating the region, the military government reasserted it as being Brazilian sovereign territory. It was also a poverty-reducing measure as people that moved there were in many cases beneficiaries of new land reform settlement projects. This was evident in the colonization projects during the 1970s and 1980s such as Polonoroeste, in Rondônia. However, since the 1990s, the economic logic has come to overshadow the concerns over territorial sovereignty. This was evident in the establishment of large-scale multi-national agribusiness corporations in the Amazon region from the mid-1990s onwards. This has been especially intense in the state of Mato Grosso. The agribusiness sub-logic has been responsible for the large-scale deforestation as well as the economic growth of the region. Finally in recent times, many of the small-scale farmers (and related industries) that benefited from the early land reforms instituted by the military government have been struggling economically. This, coupled with medium- and large-scale farmers wanting to further expand their commercial activities, has placed pressure on politicians to ensure that new policies relating to environmental sustainability do not mean it is no longer commercially viable for farmers and related industries to remain in the area. This issue is particularly evident in the ongoing tensions in relations between INCRA (the agency responsible for land-settlements) and local politicians and the agencies from the environmental sector of the government. All three of these shifting economic sub-logics have been supported through the integration of the Amazon region with the rest of the country through the construction of roads, electricity transmission lines and other modern infrastructures such

as the improvements to the highway between Cuiabá and Santarém in the heart of the rainforest. It emerged following the colonization of the region first as a way to support the sovereignty logic, and later as a way to support both large- and small-scale farming.

Sustainability institutional logic

The sustainability institutional logic is concerned with the long-term sustainability of human life on Earth. This logic thus is closely related to the seventh MDG. It can be traced back to the Brundtland report (WCED, 1987) and the declaration signed at the 1992 United Nations Conference on Environment and Development in Rio de Janeiro. Broadly defined, the sustainability institutional logic recognizes the impact that human activities have on the environment and considers it crucial to find ways to address the risks and hazards that have come about as a consequence of modernization and industrialization. As such, it requires the government to preserve the environment by adopting sustainable policies and practices (Beck, 1992; Shrivastava, 1995). In the context of this paper, the sustainability institutional logic in the Amazon comprises three specific sub-logics. The first sub-logic relates to a scientific rationale that the region should be preserved due to its role in maintaining the global climate and its biodiversity. This logic is primarily supported by scientists, environmentalists such as Mahar and other groups outside the Amazon region and has had a great influence in the changes in policy that took place at end of the 1980s and throughout the 1990s and 2000s. The second sustainability sub-logic pertains to preserving the forest so as to protect the habitat and livelihoods of native Indians and other forest dwellers such as the rubber tappers and nut collectors. Land clearing has had dire social consequences for such forest dwellers (for a discussion of these two sub-logics within NGOs see Zhouri, 2004). The emergence of these two sub-logics has come to explicitly challenge the dominance of the economic institutional logic. Finally, most recently a third sub-logic has emerged that has sought to combine (sometimes paradoxically) environmental sustainability and economic development. In the Amazon, this sub-logic is especially evident in the ongoing negotiations pertaining to the carbon credit scheme. This scheme would compensate farmers and forest dwellers in return for them to protecting the forest (e.g. Kaimowitz, 2008; Nepstad et al., 2009).

Contestation and synergy between institutional logics

Our institutional account of the history and ongoing use of the different GISs in the Brazilian Amazon region highlighted how multiple institutional logics and sub-logics have emerged, remained, changed and receded over time. Importantly our study has highlighted that differing institutional logics can coexist in synergy or conflict for significant periods of time. It is through this ongoing contestation that a new institutional logic may emerge or an existing logic may become dominant. Drawing on Lounsbury (2008) and our study, we argue that as the three alternate institutional logics frame social reality differently, the use of GISs can support different logics, even in contradictory ways.

Synergy was achieved at the outset between the military's territorial sovereignty logic and the economic logic through the fiscal development of the region. Indeed, the dominance of the military sovereignty sub-logic was very much predicted on the economic logic through the provision of subsidies, low-interest loans, construction of roads, etc. Thus, such synergy between the sovereignty and economic logics meant that the application of the GIS to assess the natural resources of the Amazon so as to ensure that the trees were giving way to pasture and crops made perfect sense. Indeed, this synergy between logics was still evident in the early 1990s, when PRODES and SIVAM were created. Both systems appear to have been shaped mainly by sovereignty, and economic rather than environmental concerns.

With regard to contestation between institutional logics and the ways in which an alternate institutional logic can become dominant in relation to the use of the different GISs in the Amazon, this first became evident as Brazil faced two political crises. First, at the end of the 1980s, the international community's pressure on Brazil to preserve the Amazon rainforest culminated in cuts being made to Brazil's international credit as well as to funding to major development projects located in Brazil's Amazon rainforest. This crisis forced the Brazilian government to succumb to pressure, which led to a change in its official environmental policy. This in part could be understood as coming about as a consequence of a process of coercive isomorphism from wealthy countries, which were keen to impose their understanding of the environment and how it ought to be managed (Banerjee, 2003; DiMaggio & Powell, 1983). The imposition of such financial imperatives was crucial in the establishment of the sustainability institutional logic in Brazil. However, while Brazil started to engage more with the international community by discussing policy changes, the actual use of the GISs at the end of the 1980s and early 1990s remained consistent with the sovereignty and economic logics. Second, the fall of the Berlin Wall and the end of the Cold War led to greater regional political stability throughout the 1990s. This meant that being simply an anti-communist country was no longer sufficient to warrant Brazil's alignment with Western Europe and the USA. Such new internal and external political dynamics meant that the rationale for the GIS remaining in place to defend Brazil's sovereignty over the Amazon and restricting access to these systems was no longer relevant. This led to the military-oriented core values of the sovereignty logic no longer being dominant.

This decline in the importance of the sovereignty logic, coupled with the growing acceptance of the importance of environmental issues led to the economic logic becoming contested by the sustainability logic. International concerns about the importance of environmental sustainability, and the risks associated with large-scale deforestation in the Amazon also became concerns for many Brazilians during the 1990s (and consequently its government). This culminated in Brazil becoming a signatory to the MDG's and the strengthening of the sustainability institutional logic. This signaled a period of transformation where while no single logic has become dominant. This contestation was evident, as while the Amazonian GISs have been used in recent years for environmental protection, the economic logic has also gained new impetus due to the establishment of large agribusiness in the region. Today, the production of soybeans and beef (much of it for export) in the Amazon represents a growing share of the economic output of the country. Indeed, this helps to explain why SLAPR allows for both an increasing compliance with Brazil's environmental laws as well as for legal deforestation. Furthermore, with the recent global recession, it is likely that the agribusiness' economic institutional logic will exert even more pressure on the logic of sustainability. This also highlights the difficulty facing the MDGs in bringing about widespread change, due to the differing core values that shape and constrain what people do. As the economic logic is still significant in the Amazon region, the period following the MDGs can be conceived of as a melding of economic and sustainability concerns, rather than there being an overthrow of one dominant logic to another. In this sense, we concur with Lounsbury (2007, p. 289) who cautions against periods of transformation as being conceived of as shifts between one stable period to another. Instead, such periods should be understood as reflecting especially visible and political contestation between coexisting core institutional values.

Conceptually, our account of synergy and contestation offers a number of insights. First, it highlights that institutional logics should be understood as being provisional and relational. Specifically, our case highlighted that while broad institutional logics may remain over a significant period of time, their focus and content may change. This was evident in all three institutional logics, and especially so with the economic logic. Such shifts within and between institutional logics thus suggest that while some commentators describe institutional isomorphism as being one-sided and stable, the case shows that they can also be provisional and highly

political. Thus, we are critical of institutionalist writers who argue that change can be understood as a shift from one stable period of beliefs to another. Importantly, as institutions are always in the process of institutionalization and deinstitutionalization, using such categories uncritically is problematical (Lounsbury, 2008). Second, our case also highlights how dominant institutional logics can become especially destabilized during periods of uncertainty and lead to the emergence of new institutional logics. In our case, periods of political transformation such as the end of the Cold War or concerted international political and financial sanctions (such as the one against Brazil in the end of the 1980s) allowed for new institutional values to emerge, assert themselves and existing logics to be redefined (Lounsbury, 2002). It is this synergy and contestation that will shape the extent and nature of the ways in which the seventh MDG is put in place in Brazil. In our case, this cumulated with the overthrow of the sovereignty logic and the novel ways in which the sustainability logic could coexist with the economic logic through initiatives such as carbon credits in return for preserving the forest.

Our case also highlights some of the tensions and synergies between differing institutional logics were also evident between the different MDGs themselves. For example, the first MDG aims to reduce the poverty gap and increase employment. This goal focuses on the poorest areas of a nation, which in the case of Brazil includes many areas of the Amazon where numerous people rely on illegal deforestation in order to sustain their existence. However, such a goal clearly comes into contestation with the seventh MDG, which seeks to ensure environmental sustainability and conserve biodiversity. Though not specifically developed in relation to the MDG, a number of commentators have highlighted the contradictory nature of the notion of sustainable and economic development (Banerjee, 2003; Rist, 1997). Further, with regard to the relevant aspects of the seventh MDG, such conceptual contributions suggest that for a sustainability institutional logic to become relatively isomorphic, it will require careful ongoing negotiation and compromise in its relations with alternate institutional logics. For example, it would be possible to conceive of the re-emergence of a dominant military institutional logic if there was a change in the global and/or regional political climate. Indeed, within developing countries, due to the wide variety of interested groups, we suggest that such conflict and synergy within and between institutional logics is likely to be especially complex. The next section discusses the implications of this broad institutional analysis for the study of ICT in relation to the MDGs in developing countries.

Institutional logics and information and communication technology

The analysis provided above has important implications for our understanding of the possibilities of information and communication technology in bringing about institutional change, and specifically the possibilities of the institutional logic of the seventh MDG becoming dominant. One of the main findings emerging from our study refers to the importance of understanding the relationship between ICT and MDGs (i.e. sustainable development) as being neither static nor predictable. Indeed, the case study suggests that ICTs can emerge in accordance with a certain institutional logic (e.g. sovereignty) and later be reconfigured to reflect other institutional logics (e.g. sustainability). We suggest this provides insights into understanding the relationship between IT and sustainable development first with regard to recovering assumptions inscribed in technology, second in understanding the interpretive flexibility of technology, third in helping us make sense of the ways in which people enact a technology over time, and finally in relation to the MDGs.

Historicity of design decisions

One important finding that emerged from our historical analysis of GIS in the Amazon relates to the importance of understanding the ways in which the synergy and conflict within and between

institutional logic(s) frames design decisions. The first GISs were designed very much in accordance with the sovereignty and economic logics. Such institutional logic were thus inscribed into the systems' technical design (i.e. restricted data access) and the data they captured (i.e. natural resources assessments). Further still, our case has also shown that institutional logics may also vary over time. As the sovereignty logic receded, and as large agribusiness corporations moved into the region the economic institutional logic took sole precedence. It is likely that the designers of the Amazonian GISs could not have anticipated that future users would seek to reduce economic activity so as to preserve the rainforest (Akrich, 1992). Consequently, our study has highlighted that subsequent designers of the Amazonian GISs were themselves framed by the ongoing contestations within and between institutional logics at specific moments in time. This ongoing framing was central as designers articulated and rearticulated the subject identities that they envisioned of future users. Most recently this framing has been in relation to the sustainability logic. This highlights the importance of attending to the ongoing production and reproduction of the historical and broad institutional context that has framed design decisions (and users) over time. Further, this broad and historical account complements existing GIS research that has focused on how western values shape design decisions over local knowledge (Miscione, 2007; Puri, 2007) and the literature that has considered how specialisms have shaped the nature and use of GIS (Puri, 2006). Indeed, institutional logics offer an interesting set of ideas to further unpack such research findings, and attend to their historical emergence and change.

Interpretive flexibility and data

A further and related insight pertains to the degree of interpretive flexibility that has surrounded the use and role of GIS in the Brazilian Amazon. Interpretive flexibility refers to "the capacity of a specific technology to sustain divergent opinions" (Sahay & Robey, 1996, p. 260). With regard to Brazil's GISs, interpretive flexibility derived from the data that accounted for the extent of deforestation. These data were first used as a way to monitor that the Amazon was being deforested and that Brazilians were moving to the region so as to exploit it. More recently, the same data are now being used as a means to prevent deforestation and catch those perpetrating it. Further, the same data have become a key resource for scientists to argue about the unsustainability of such practices and the need to marginalize the economic institutional logic. Thus, this measurement data that are at the center of the Amazonian GISs have been and are central in framing our understandings of the region, and with it has been inextricably interlinked with the contestation and changes within and between institutional logics. Indeed, we contend that just as the data central to the different GISs provided the degree of interpretive flexibility necessary for the emergence of the sustainability institutional logic, it also provides the possibility for an existing institutional logic to strengthen or for a new institutional logic to emerge. Consequently, such contestation over data, and the ways in which this is utilized to support the claims of alternate institutional logics is likely to be fundamental in influencing whether, the extent and how the relevant aspects of the seventh MDG are achieved. Indeed, this contestation is central to the ways in which the tensions, conflict and synergy between the economic logic, in part related to the first MDG, and the sustainability logic as evident in the seventh MDG, are worked out.

Institutional logics and enacting technology

While the empirical data presented in this paper are primarily historical, and thus do not attend to the detailed work practices of the developers or users of the Amazonian GISs, we do consider

that institutional logics can not only help us recover the different assumptions and design decisions that have framed its ongoing use but also helps make sense of the ways in which ICTs are enacted (Orlikowski, 2004). Enactments are referred to by Orlikowski (2004, p. 93) as recurrently enacted accomplishments that human actors routinely engage in while undertaking their work. Our case has highlighted that in undertaking such enactments, developers and users were making sense of the synergy and conflicts within and between institutional logics. Our historical analysis of contestation within and between institutional logics highlights the need to better understand how certain technologies are enacted (or put into practice) both temporally and spatially. Paraphrasing Orlikowski (2004, p. 94), such an analysis can better help us understand why it is that though certain outcomes are promoted by the designers of a technology, they may be enacted quite differently and thus used for a different purpose to that intended. The importance of such a perspective is currently evident with regard to SLAPR, as while it was initially conceived and designed mostly within an institutional logic of sustainability, its use has been influenced greatly by an economic institutional logic and thus led to an increase of (legal) deforestation. While such enactments are ongoing during times of relative stability and coherence, our analysis also suggests that during periods of uncertainty, changes in relations within and between institutional logics may emerge (Lounsbury, 2007), and users and designers are especially likely to bring about changes in the ways in which technologies are enacted (Orlikowski, 2004). This analysis highlights that much of the literature is naive, in that it assumes that GIS and other environmental applications, with accurate environmental data such as deforestation rates and temperature trends will necessarily lead to changes in environmental policy and more sustainable practices (Craglia et al., 2008; Esty, 2001, 2004; Fuller, 2006; Kintisch, 2007; Meadows, 1998).

Technology and the MDGs

What does this institutionalist analysis offer in terms of the possibilities of ICTs to achieve the ambitions of the MDGs and especially those aspects of the seventh MDG that are relevant to this paper? Our analysis has highlighted that the different GISs that have been introduced to monitor Brazil's Amazon region themselves were socially shaped by the synergy and conflict within and between institutional logics and an outcome of many contingent turns of history. Undertaking this historical analysis has provided insights into why the Brazilian government sanctioned practices that might seem absurd by today's standard, such as subsidizing the large-scale deforestation of the "world's lungs." Thus, we contend that understanding the historical trajectory of an ICT is crucial if we are to avoid presentisms, namely, judgments based on values different from the time period or place of the ICT (Noir & Walsham, 2007).

In the context of the seventh MDG, such an insight suggests that, first there is a danger that as this logic is so beguiling and compelling (as a cause), supporters may not fully attend to the arguments and positions of alternate and sometimes conflicting institutional logics. Indeed, as Saith (2006) argues, the MDGs are having a negative effect by privileging quantifiable and narrow understandings of what constitutes "development" and overshadowing alternative political agendas. In relation to the seventh MDG specifically, Banerjee (2003, p. 157) pertinently asks "who sustains whose development," suggesting that a blind focus on environmental indicators at the expense of social issues might contribute to increase the distance between the rich and the poor (see also Peet & Watts, 1996). Consequently, our study highlighted that as institutional logics are always provisional and relational to others, then the trajectory of the sustainability logic may not come about in the ways that many supporters of the seventh MDG may desire and envisage. Second, it is important to recognize that the sustainability logic and related seventh MDG represents a relatively new and emerging institutional logic, and consequently

it is crucial for those involved in particular environmental sustainability projects to attend to the specific, political and historical contexts. Currently, as the sustainability logic is inextricably interlinked with the economic institutional logic, we suggest that the ways in which the targets specified in the seventh MDG are to a great degree contingent on international and regional economic policies, as well as how the targets specified in the first MDG (such as reducing poverty) are achieved. The conflicts and tensions between these logics will thus shape the extent and nature of the use of GIS to support environmental protection in the Amazon.

Finally, we suggest as most of the worlds remaining unexploited natural environment resides in developing countries, examining the relationship between environmental sustainability, ICTs and developing countries is a crucial but under researched domain of study (Silva & Westrup, 2009). Internally, developing countries seek to exploit their natural environment to improve the living conditions and public infrastructures in areas such as health and education for their citizens. A developing country's natural environment also provides revenue to many national and international commercial organizations, and is also seen as vital to feed the world's ever-increasing population (Silva & Westrup, 2009). Further still, as environmental sustainable development projects are typically funded by international governments or more usually NGOs who attach funding to the achievement of a target related to some aspect of the internationally agreed MDG, they are likely to comprise of and be shaped by many institutional logics. Working out the synergies and conflicts between these institutional logics is thus one of the central challenges in understanding if and how the MDGs are to be achieved.

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