CASE STUDY
Category: ICTs and Climate Change Monitoring

Climate Change, Innovation & ICTs Project

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ICT-Based Monitoring of Climate Change-Related Deforestation: The Case of INPE in the Brazilian Amazon

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Initiative Overview

Deforestation is one of the main sources of greenhouse gases; accounting for at least two-thirds of Brazil's emissions (Greenpeace 2011). PRODES and DETER are two satellite-based monitoring systems used for policy-making and law enforcement in the Brazilian Amazon which aim to curb deforestation and, hence, reduce emissions. Over the years the information from these systems has provided a key common ground for policy debates between agencies of the Brazilian government, environmental NGOs and scientists, thus helping the efforts to track and address climate change. The case study of these systems emphasises the role of continuous political support, negotiation and transparency in the successful development of information and communication technologies (ICTs) for the monitoring of climate change.

Application Description

PRODES (program for calculating deforestation in the Amazon) was initially created in 1988 by the Brazilian Institute for Space Research (INPE). The origins of the system can be traced back to the decision of the military government in the late 1960s to invest in remote sensing technology. Following this initial investment INPE became over the years a world-class research institute in the detection of natural resources and land-use change using advanced ICT.

PRODES has been designed to produce a yearly estimate of the total area of forest loss in square kilometres, and the breakdown of this figure to the nine states of the Brazilian portion of the Amazon. In order to enhance transparency, from 2003 onwards INPE started to publish online not only the aggregated figures but also the detailed map of deforestation indicating the location of individual clearings.

Broadly speaking (see Figure 1), PRODES detects deforestation based on satellite images captured through the US Landsat and the Chinese-Brazilian CBERS satellites, which are then processed by computer algorithms and interpreted by a local team of technicians and scientists. Following this process PRODES generates a georeferenced map for the whole Amazon with individual polygons indicating the location of deforestation.

Building upon a similar technological and knowledge base, in 2004 INPE developed DETER (deforestation detection in real time), a satellite-based monitoring system that detects deforestation every 15 days and provides monthly estimates from images obtained from sensors on board US satellites Terra and Acqua (see also Figure 1).

Today PRODES and DETER are used intensively by different groups inside and outside the government. PRODES, given its reliability and comparability over more than 20 years, is still the main

system used for debating major policy changes following the release of its yearly data. DETER, on the other hand, is used mainly to evaluate the outcome of actions on a monthly basis and guide law enforcement actions in the forest.

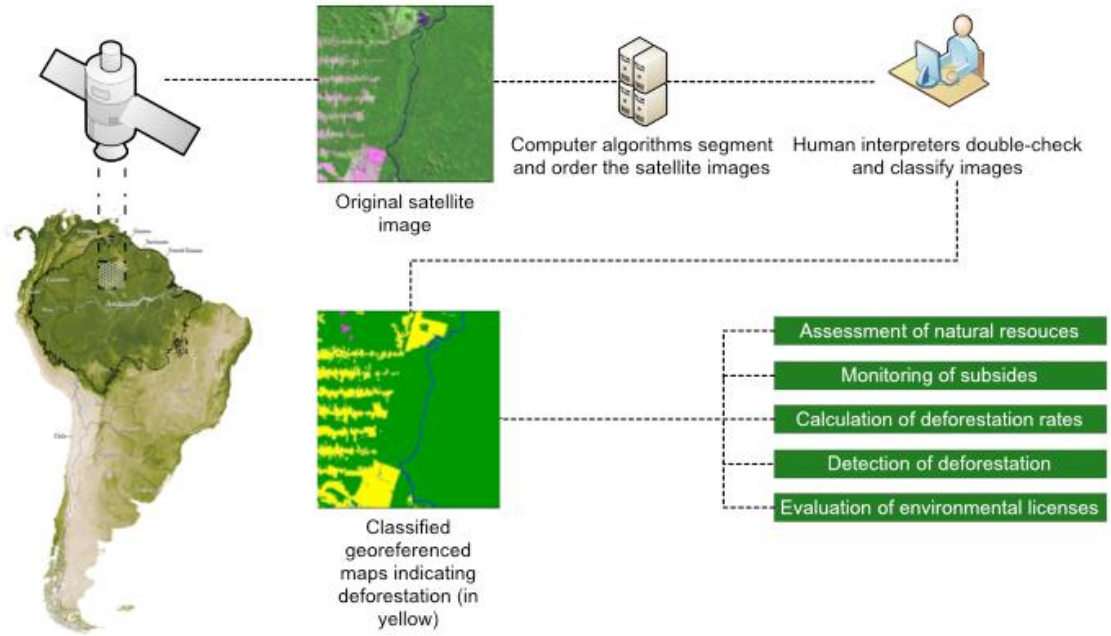

Figure 1: Schematic Representation of the Functioning of PRODES and DETER (Rajão and Hayes, 2009)

Drivers and Purposes

One of the main causes of climate change is the increasing level of greenhouse gases in the planet's atmosphere. While most greenhouse gas emissions are produced by the generation of electricity and production of industrial goods, deforestation (and related activities) contribute around 17% of global emissions (IPCC 2007). In Brazil the proportion of greenhouse gas emissions from deforestation is even more substantial. Here the destruction of the Amazon and other biome represents three-quarters of the country's carbon emissions placing it as the fourth-largest emitting economy (Greenpeace 2011). For this reason there is a growing consensus among scientists and policy-makers in Brazil and abroad that the reduction of ongoing forest loss in the region is a key element of any successful global strategy to tackle climate change.

Monitoring systems based on advanced ICT play a key role in tackling climate change by allowing policy makers and other policy stakeholders to make informed choices about strategies to curb greenhouse emissions. But in order for a monitoring system to be useful in policy making it has to be accepted as trustworthy by the different groups involved. Since the mid 1970s INPE has produced deforestation assessments of the Amazon using advanced satellite technology, but this initial period was marked by an intense debate between scientists, environmentalists and politicians concerning the correct figures for the total deforestation in the Brazilian Amazon.

As a consequence of this lack of agreement the key policy issues in the region were often overshadowed by mutual accusations on basic points such as whether deforestation was under control or increasing due to impact of colonisation policies in the region (policies which encouraged conversion of Amazon forest into farming land). An example of this issue took place in the mid-1980s when the Brazilian government discredited scientists' concerns over the growing speed of deforestation (e.g.

Fearnside 1982) and approved substantial colonisation projects in the Amazon (Hecht & Alexander 1989). It was only after 1988, with the creation of PRODES and a long process of negotiation, that the government had at its disposal widely accepted yearly deforestation figures produced using a consistent and accepted methodology.

One can therefore see the main internal drivers to these projects as partly political, partly informational, with the central purpose being to produce agreed deforestation data. But, in addition, there were external drivers. According to senior scientists and politicians, PRODES also emerged as a reaction to the publication of deforestation projections that led the World Bank to freeze the payment of loans to Brazil. In order to counter these projections the central government requested INPE to produce yearly deforestation estimates based on actual observations of land-use change from satellite images.

Stakeholders

The initial development of PRODES involved senior officials and politicians from the federal government and INPE scientists. During the 1990s and 2000s, however, scientists from other institutes and members from environmental NGOs also started to use PRODES and contribute to its development. These contributions included, for instance, the successful lobbying for the publication of the full deforestation maps on the Internet rather than only the final deforestation figures. With the creation of DETER in 2004 forest rangers from the federal and state-level environmental agencies – particularly from IBAMA, the enforcement agency of the federal Ministry of Environment – then started using INPE's monitoring systems.

Impact: Costs and Benefits

It is possible to identify impacts stemming from the development of PRODES and DETER on different fronts. Thanks to the development of PRODES during the 1990s the earlier antagonism between scientists inside and outside INPE has become a fruitful collaboration. During this period INPE scientists carried out research with some of the scientists that have previously criticised their work, and have integrated in their deforestation detection methodology some of the latter's suggestions. These suggestions included, for instance, the consideration of deforestation prior to the 1970s and the related revision of the total deforestation figure within PRODES.

Furthermore it was possible to see a gradual construction of trust around PRODES as its deforestation figures started to converge with independent studies and its data started to feature more frequently in academic publications and policy reports. With the publication online of PRODES deforestation maps in 2003 and the creation of DETER in 2004 the reputation of INPE as a trustworthy and transparent institution was further strengthened. This trajectory suggests that the continuous investments made by the Brazilian government in satellite technology, its transparency about data sources and calculations, and its openness to negotiation have contributed to a process of capacity building that places Brazil as one of the leading nations in satellite-based deforestation monitoring (Kintisch 2007, Stern 2007).

Today INPE's monitoring systems play a central role in different activities of governmental and non-governmental organisations. Governmental officials, members of environmental NGOs and scientists often use INPE's data as a "taken-for-granted" base to debate policy alternatives and evaluate the outcome of previous actions. Furthermore, given the open access policy adopted by INPE, an increasing number of NGOs and academic institutions are using detailed deforestation data to provide their own policy analysis, and from that offer advice to the government. It is thus possible to trace a relation between hikes in deforestation rates detected by PRODES and DETER and key policy changes. These include the increase in the legal reserve (the compulsory portion of preserved land within total

private lands) in the Amazon from 50 to 80% in 1996; the creation of the plan to protect and control deforestation in the Amazon (PPCDAM) in 2004; the creation of decree 6321/2007 limiting bank credit to farmers in the region; and the expansion of protected areas.

As noted above, from 2004 and the advent of DETER, an increasing number of forest rangers have also adopted this technology for frontline enforcement of deforestation control policies in the Amazon. This has not worked completely smoothly. The "real-time" logic of DETER has not matched well with the logic of work on the ground. The design assumptions within DETER are that rangers would go to an area of deforestation immediately the system detected it. But rangers pointed out that, in reality, due to the low resolution of DETER images, the long distances to be travelled, often poor road conditions, outbreaks of rural violence and limited numbers of rangers, they usually wait until deforestation in a given area accumulates to a certain level and better satellite images are available before it is worth sending in a team of rangers. So instead of using the GIS in real-time, as envisioned by system designers, the rangers may take months to visit an incidence of deforestation pinpointed by the system and issue fines. Nonetheless, in general, the use of technology has clearly improved their ability to identify and prosecute farmers that clear their lands illegally (see Figure 2).

Figure 2: Forest Ranger using DETER and a GPS Device in order to Prosecute Illegal Deforestation in the Amazon (picture by Raoni Rajão, 2009)

There is evidence that some of the policies and law enforcement practices enabled by INPE's monitoring systems have led to reductions in deforestation. Between 2004 and 2010 there was a substantial increase in the number of fines for illegal deforestation in the region. During this same period, annual losses to deforestation fell from 27,000 square kilometres per year to less than 6,500 (Phillips 2011). These both suggest improvements in the governance of the Amazon. Furthermore, according to Soares-Filho *et al.* (2010) the expansion of protected areas up to 54% of the remaining forest was responsible for 37% of the region's total reduction in deforestation. INPE's annual budget for research and development of satellites – among other activities – is approximately US$120 million. Even though it is not possible to assess the benefits of PRODES and DETER without undertaking complex and often controversial calculations of the cost of alternative scenarios, it is reasonable to assert that the benefits of INPE's ICT were much greater than the financial costs involved.

Evaluation: Failure or Success

If we consider the wide acceptance of these systems in policy-making in the Amazon and the related reductions in deforestation, it is clear that the development of PRODES and DETER has been a success. It is therefore reasonable to argue that these monitoring systems have helped tackle climate change in significant ways.

Nonetheless, one can identify some issues that require future attention. In particular, given their wide acceptance across different groups, the data produced by INPE has often become the main baseline for discussing policies in the Amazon. This focus, by its turn, has decreased the importance of the participation of other groups (e.g. indigenous populations and farmers) and other types of data (e.g. ethnographies, local accounts) in the formulation of policies.

Finally, it was possible to observe that INPE's monitoring systems have been the victim of their own success. The relation between the development of INPE's monitoring systems and reductions in deforestation have led some authors and policy-makers to believe that these technological artefacts can deterministically reduce deforestation in the region. This belief, in turn, ignores the ways in which this technology may be reshaped to fulfil the interests of different groups over time. Furthermore, given the focus on technology, some important groups – such as IBAMA forest rangers – have had their voices largely ignored in the development of new systems. While these issues do not compromise the merits of INPE they suggest that in order to ensure the long-term usefulness of PRODES and DETER the Brazilian government will need to change some of its practices.

Enablers/Critical Success Factors

Continuous political support. INPE is above all an academic institute producing world-class research on remote sensing. Thanks to continuous political support from the central government that invested in the institution for more than four decades INPE has been able to maintain a position that is at the same time close to the scientific community but also distant from the specific political struggles involving the data it produces. In this way INPE has been able to avoid the conflicts of interests that may emerge when the same agency that develops the information system is also the one responsible for tackling climate change.

Openness to negotiation and information system adaptation. It is difficult to establish what would have happened if INPE had not accepted the various information system design suggestions from the scientific community in the early 1990s. But one can hypothesise that the ability of INPE to negotiate and collaborate with the broader academic community and, more recently, environmental NGOs – and to incorporate their ideas into its own functioning – has been crucial for the establishment of its information system as a widely accepted base for the formulation of policies in the Amazon. In particular, it appears that the ability of some scientists from INPE to engage with and hear the concerns of the broader scientific community, and more recently the willingness of some politicians to bring the voices of environmental NGOs to the centre-stage of policy-making have proven to be important enablers for the success of this ICT initiative. Negotiation throughout the information system lifecycle has therefore been critical: in planning the information system, in producing the information, and in using that information for decision-making purposes.

Data transparency. The increasing transparency of its monitoring systems also played an important role in INPE's success. In particular, the publication of PRODES and DETER deforestation data on the Internet not only increased the trust in INPE's work but also allowed other groups, such as environmental NGOs, to make their own independent analysis and provide policy advice.

Constraints/Challenges

Absence of key voices from system design. While INPE and the central government have successfully engaged with environmental NGOs and the scientific community, other important groups are still left at the margins. As noted above, forest rangers did not find the real-time provision of data by the DETER system to be particularly valuable. Rather than needing more timely deforestation data, forest rangers demanded in their interviews and informal conversations satellite images with higher resolution, better integration between the GIS and other government databases (such as taxes, ordnance survey, land registry), more training and improved working conditions in order to carry out their work. But the INPE scientists who design the system insisted that feedback from users is unnecessary for the development of better systems.

Recommendations/Lessons Learned

It is possible to identify three main lessons that emerge from the case study. By taking into consideration these lessons it is possible to make some recommendations to other countries on how to develop successful ICT for the monitoring of climate change.

Ensure information provision connects to decision making and action. Information is only of formal value if turned into decisions and then actions. One may argue, then, that the great success of INPE is not so much its provision of climate change-relevant information, but the uptake and use of that information by an eco-system of other organisations both inside and outside government. The design and operation of ICT-enabled climate change monitoring systems must therefore incorporate a clear understanding of how the information produced by those systems will be utilised, and by whom.

Separate information provision responsibilities from decision-making responsibilities. Cross-sectoral political support has made it possible for INPE to grow trusted, professionalised, scientific capacity for provision of ICT-based monitoring of climate change. Such support comes more readily if the responsibilities for such information provision are separated from the responsibilities for then using that information to make and implement both policy decisions (as in the case of the Ministry of Environment) and tactical decisions (as in the case of the forest rangers). Such a separation should be considered in the formation of organisational structures for climate change monitoring.

Make data freely available. This case study suggests that the importance of ICT for the monitoring of climate change lies not just in the final information output of these systems. It also lies in their ability to open up the raw data for use by other organisations. This would include double-checking of the aggregated figures, but also re-use of the data for other types of analysis. INPE's experience suggests that the use of open access channels, such as the Internet, is an important factor in creating the broadest possible value from this type of ICT-based system.

Find ways to close design—reality gaps. Forest rangers find difficulties in using the DETER system because, at root, there is too large a gap between the assumptions built into the system design, and the on-the-ground realities that they face. In other words, too large a design—reality gap. Closing such gaps for ICT-based climate change monitoring systems will be an important route to greater success for such systems. One key pre-condition for this gap closure is that system designers and developers should pay more attention to the way in which their technologies are actually used in reality, and should accept those who use their system – who may be relatively low in organisational rank – as legitimate voices who can make contributions of value to the improvement of climate change information systems.

Data Sources & Further Information

The case study presented above is based mainly on primary data collected by Raoni Rajão (Universidade Federal de Minas Gerais, Belo Horizonte, Brazil raoniguerra@gmail.com) in Brazil between June and August 2007, and between September 2008 and August 2009. During these two periods 85 semi-structured interviews were conducted with politicians (including three ex-ministers of the environment), senior scientists from INPE, and officials from IBAMA, among other groups. Moreover governmental documents spanning the last four decades and direct and participant observations of practices also played an important role in the constitution of the case study. Rajão and Hayes (2009) provides a more detailed discussion of the relation between INPE's monitoring systems and the institutional context of the Brazilian government. Hayes and Rajão (2011) offers a discussion of the relation between INPE's monitoring systems and sustainable development; an issue that is closely related to tackling climate change.

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