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Are capacity deficits in local government leaving the Amazon vulnerable to environmental change?

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ABSTRACT

The last 20 years have seen remarkable progress in monitoring and modelling environmental change in the Amazon region. As a result, scientists and policy makers now have robust and spatially explicit knowledge and forecasts of critical phenomena such as deforestation and bioclimatic uncertainty. However, whether this knowledge is used to support the implementation of policies and initiatives to cope with environmental changes in the Amazon depends on the ability of the political institutions to proactively integrate the scientific evidence into land planning at multiple spatial scales. In Brazil, municipalities are constitutionally responsible for legislating on land planning and therefore have a power to significantly influence the future trajectory of environmental change. Here, we assess the environmental capacity of municipalities in the Brazilian legal Amazon based on data from a self-assessment survey and from the Brazilian Institute of Geography and Statistics database. Municipalities generally have a low level of institutional capacity and there is no evidence that the municipalities most at threat from environmental change are taking proactive measures to reduce their vulnerability. We argue that structural reforms and capacity raising initiatives are urgently needed, especially in smaller, less economically developed municipalities located in areas at high risk of imminent environmental change.

1. Introduction

The Amazon region contains the largest remaining area of continuous rainforest in the world and is considered vital for maintaining regional ecosystem services such as hydrological and biogeochemical cycles (Foley et al., 2007; Malhi et al., 2008). The Amazon rainforest is also one of the regions with the highest levels of terrestrial biodiversity (Antonelli and Sanmartín, 2011; Malhado et al., 2013), and may still contain considerable numbers of undiscovered species (Funk et al., 2012; Scheffers et al., 2012). Notwithstanding its enormous size, the future of many Amazonian forests is uncertain due to the interlinked threats of deforestation, fires and climate change (Davidson et al., 2012; Malhado et al., 2013; Malhi et al., 2008). Indeed, the latest generation of land use models suggest that Amazonian land cover changes due to deforestation may be sufficient to cause ecological 'tipping points' in some regions, transforming tropical forests into deciduous forests or even savannahs (Nobre, 2014; Pires and Costa, 2013). These impacts are predicted to be strongest in transitional forests at the margins of Amazonia and within the highly threatened arc of deforestation region in southeast of the region (Costa and Pires, 2010; Pires and Costa, 2013).

Responding to these complex threats requires actions at multiple scales (Ladle and Malhado, 2007; Ladle et al., 2011). Specifically, it will be essential to effectively integrate policy with the results of land use models to pre-emptively respond to the coupled threats of climate change and deforestation (Ferreira et al., 2012; Ladle et al., 2011). Such actions are not only essential for conservation, but also to ensure regional food security which could also be threatened by wide-scale changes in precipitation regimes (Lapola et al., 2011). For example, one recent model indicated that, due to climate feedbacks, increased

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agricultural expansion in the Amazon will lead to lower agricultural productivity in both new and established areas (Oliveira et al., 2013).

Brazil contains the highest proportion of the Amazon (60%), and is relatively well placed to meet many of these complex conservation and development challenges. The country has some of the most robust and comprehensive environmental legislation in the developing world (McAllister, 2008), and has recently developed a suite of forward thinking policy initiatives such as the Low Carbon Agriculture Plan (Amaral et al., 2012) and various Payment for Ecosystem Services (PES) schemes (e.g. Figueiredo et al., 2013; Zanella et al., 2014). However, despite this impressive legislative framework, Brazil has been far less successful at implementing and enforcing its environmental laws with high levels of non-compliance, especially in the agricultural sector (Sparovek et al., 2010). Environmental policy implementation and the capacity to react to environmental threats is especially problematic over large, sparsely populated areas such as Amazonia, where responsible institutions may lack appropriate resources, infrastructure, personnel, etc.

Brazil has a three-tiered (Federal, State and Municipality) structure of government, with state and municipal administrations having a high degree of autonomy with regards to the development of environmental policies and actions. On-the-ground implementation of environmental policies was largely devolved to local (municipal) government in the 1988 constitution and subsequent legislation. Most importantly, municipalities are constitutionally responsible for legislating on land planning (Castro et al., 2009) and therefore have a critical role in regulating agricultural expansion, urban development, transport infrastructure and, by extension, deforestation. This has proved highly problematic due to low institutional capacity, further exacerbated in some Amazonian municipalities by familial or economic connections between politicians and those involved in the illegal extraction of natural resources (McAllister, 2008). Consequently, local land planning decisions are often in conflict with federal laws leading to protracted and often unresolved legal disputes (Castro et al., 2009). The Brazilian Amazon contains 797 municipalities of widely varying area, resources and infrastructure and which vary considerably in their capacity to deal with the complex environmental threats to both natural and agricultural areas (Dias et al., 2015).

In this viewpoint we evaluate various aspects of the capacity of municipalities in the Brazilian legal Amazon to respond to current and future environmental threats, with a focus on municipalities in areas that vary in risk of future environmental change. The latter on the basis of coupled biosphere-atmosphere models that predict the probability of ecosystem transition due to deforestation-induced climate change (Ladle et al., 2011; Pires and Costa, 2013).

2. Material and methods

2.1. Municipal capacity metrics

Municipalities of the Brazilian legal Amazon region (composed of the states of Acre, Amapá, Amazonas, Maranhão, Mato Grosso, Pará, Rondônia, Roraima and Tocantins) were identified using Brazilian Institute of Geography and Statistics (IBGE) data (http://www.ibge.gov.br/). Information on the conservation capacity for each of these municipalities was derived from two sources: i) a dedicated self-administered survey of municipal institutions with a focus on environmental policy; ii) publicly available data from the 2013 IBGE survey (see below).

The dedicated self-administered survey was implemented in two steps. First, between January and March 2014 all 797 municipalities in the Brazilian Legal Amazon were contacted via email or phone and the individual(s) responsible for environmental policy were identified. These individuals were then invited to take part in the survey over the phone or via email. For municipalities that did not respond to the first approach, several further attempts at communication were made, finally terminating in August 2014.

The self-administered survey questions focused on the capacity of each municipality to deal with the challenges of environmental change (full questionnaire in Supplementary Material A). The questionnaire contained nine questions: questions one to eight concerned infrastructure, policy development, personnel and resources. Question nine asked respondents to complete a self-assessment matrix to ascertain the capacity (on a four-point scale from no activities to high capacity) of the municipality to conduct activities related to conservation, climate change and sustainable agriculture.

Data from the self-administered questionnaires and responses to the 2013 IBGE survey of Brazilian municipalities were tabulated, analyzed and eight capacity metrics were created, three related to policy and five related to the implementation of policy. The policy metrics and their sources were: i) existence of a municipal biodiversity conservation policy (survey); ii) existence of a municipal climate change policy (survey), and; iii) existence of specific legislation to deal with environmental issues (IBGE). The implementation metrics and their sources were: i) self-assessment index (survey − see below); ii) existence of municipal environmental committee (IBGE); iii) existence of municipal environmental fund (IBGE); iv) number of environmental staff (IBGE); and, v) number of permanent environmental staff (IBGE).

The *self-assessment index* was based on how each municipality rated its own capacity to deal with environmental change. Each of ten self-assessment criteria was scored from 0 (no capacity) to 3 (high capacity) with a maximum score of 30 (high capacity for all 10 criteria). The selected criteria consisted of capacity to: i) perform climate change research; ii) evaluate risks and impacts of climate change; iii) combat deforestation; iv) conserve biodiversity; v) restore forests; vi) sustainably manage water resources; vii) develop sustainable agriculture; viii) develop sustainable use of forest resources; ix) deliver environmental education; and, x) prevent and control forest fires.

2.2. Socio-political/geographical characteristics

To better understand the drivers of institutional capacity in Amazonian municipalities we also extracted the following data from the 2013 IBGE survey: i) total area (km^2); ii) population size; iii) population density; iv) Human Development Index (HDI); v) Gross Domestic Product (GDP); and, vi) Gross Domestic Product *per capita* (GDP *per capita*). To these data we added the following metrics; vii) % of area of municipality designated as a conservation unit or indigenous territory (from the ICMBio spatial database of protected areas); viii) accessibility, in terms of minimum time (hours) to travel by an appropriate mode of transport (e.g. boat, car, aeroplane, etc.) from any point in the municipality to a city with > 50,000 inhabitants. This provides a measure of the isolation of the municipality which, in turn, may influence the ability to attract qualified staff and implement environmental policy.

2.3. Risk of environmental change

Finally, we included (ix) a metric of risk of environmental change in order to compare preparedness of municipalities with high and low risk of bioclimatically induced ecosystem transition. This was quantified in terms of the probability of transition from humid forest to savannization or transitional forest. Recent studies indicate that deforestation in Amazonia and central Brazil could change the Amazon's regional climate driving parts of the forest into bioclimatic envelopes that are more typical of savannas (Malhi et al., 2009; Pires and Costa, 2013). We used data from Pires and Costa (2013) to identify those municipalities that, based on current deforestation scenarios, are predicted to develop climates that can no longer support tropical humid forest by 2050. Using spatial overlap between shape files of bioclimatic risk (provided by G. Pires) and shape files of municipalities (from the IBGE database) we classified municipalities as 'at risk' if more than 50% of their territory was predicted to have a high risk of ecosystem transition.