FIRES IN BRAZILIAN AMAZON: WHY DOES POLICY HAVE A LIMITED IMPACT?[1]

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1 Introduction

Scientific research has accumulated evidences that point to the increase of Amazon's ecosystem flammability (NEPSTAD et al., 2001; MALHI et al., 2009; COE et al., 2013). This transformation comes in the wake of changes in the regional climate, which include precipitation reduction by 20% and a 2 to 8° C leap in temperature by the end of the century (NEPSTAD, 2007; COE et al., 2013). As a result, the forest will be structurally altered, with the possible "savannization" of 40% of its extension (MARCOVITCH et al., 2010) or transition to seasonal forest (MALHI et al., 2009). Dry seasons will become more recurrent and longer, which is already occurring, leading to the reduction of humidity and favoring fire propagation in both forested and agricultural lands (COE et al., 2013).

The perpetuation of agriculture fires, in this scenario, will impose major social and environmental losses, given the increased risk of accidental fires. Mitigation of consequences requires policy, which have in fact been effective in curbing regional deforestation (ASSUNÇÃO et al., 2012). The same, however, cannot be said about fire detections (CARMENTA et al., 2013), which in the last ten years have not followed a clearly downward trend (Figure 1). In fact, the dissociation between deforestation and fire is being increasingly attested by studies of remote sensing not only across time, but also across space (BARLOW et al., 2012; ARAGÃO, SHIMABUKURO, 2010; VASCONCELOS et al., 2013).

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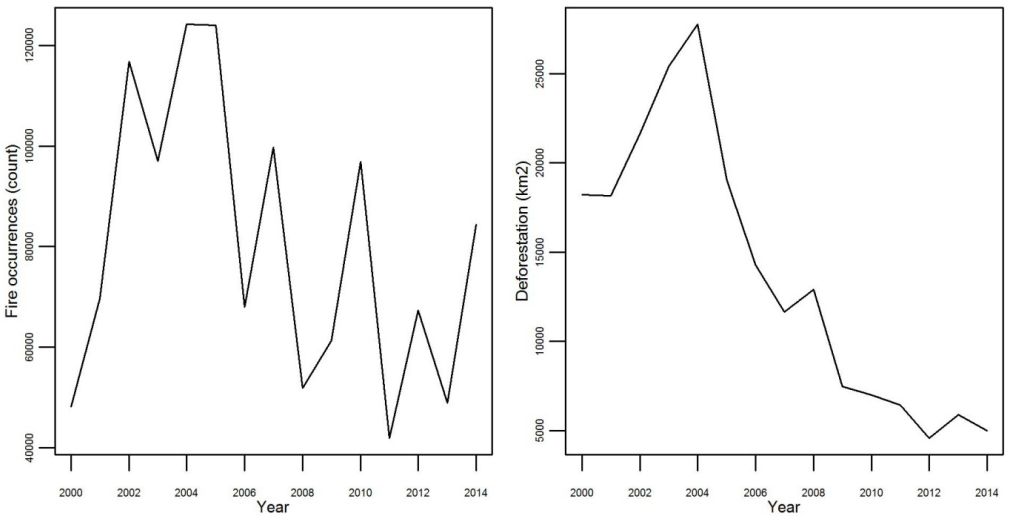
Figure 1.Fire detections (left) and deforested area (right), Amazon biome, 2000-2014.



Source: official fire detection and deforestation data retrieved, respectively, from INPE (2016) and INPE (2015). The deforestation rate of 2014 is estimated.

This paper aims to shed light on the factors that have limited the impact of policy on Amazon fires. The second section presents the conceptual basis for the analysis of current policies, evidencing, in addition, the socioeconomic importance of agricultural fire. Section 3 analyses the main actions and limitations of environmental and agricultural policies regarding the reduction of fires. Section 4 summarizes the main aspects of the performance of existing instruments and reveals similarities with the experience of other countries. Finally, recommendations for the improvement of existing policy instruments are presented.

2 Conceptual basis

Agricultural fires are part of the technical foundation of a structure of social relations that generate occupation, income and food security for a multiplicity of individuals. Among them, there are not only farmers, which are directly responsible for the fires, but also middlemen, suppliers of inputs and equipment, transport service providers and the final consumer.

The year of 2006 is the most recent period for which it is available data on the number of farms using fires (IBGE, 2010). In such year, annual crops accounted for the largest proportion of the value of agricultural and agroindustrial production of municipalities with more than 50% of farms using fire. The prominence of cassava "in natura" and as flour is notorious (Table 1). These municipalities were responsible for half of Amazon's cassava flour production (Table 1).

Several studies suggest that cassava is one of the most important products of fire--based agriculture, both in terms of production value (Table 1) and in terms of labor effort (CARMENTA et al., 2013; DENICH et al., 2005). The economic importance of cassava, therefore, is a reasonably satisfactory proxy for the importance of agricultural fires.

Regarding food security, cassava is one of the main components of the diet of indigenous and traditional peoples such as caboclos, riverine and quilombolas, and also of low-income households. Considering the area planted with cassava in the Legal Amazon in 2006 (IBGE: 2015a), 695,600 hectares, and the coefficient of two household workers for each three hectares grown/year (JESUS et al., 2012), the estimate for the number of occupations directly generated by the activity is of 464 thousand for the year 2006.

It should be highlighted that cropping was detailed in the previous paragraphs not for being the main driver of detected fires, but yet because there is more information available to characterize it. There are, in addition, other motivations for the use of fire, among which pasture management should be highlighted as it generates accidental fires with high probability (NEPSTAD et al., 1999).

The "fire economy", which in Amazon encompasses farming and related activities, has three foundations, which act as underlying causes for the perpetuation of fires and, consequently, for the maintenance of a relevant level of accidental fire risk. The first is the high effectiveness of fire to remove residues from land cover conversion, which is accompanied by a considerable fertilizing power of the ashes (COCHRANE, 2010, p.391). This high effectiveness translates into high economic return measured as avoided expenditure in land preparation, compared with manual or mechanized land preparation. The second foundation is the low probability of fires in an environment still dominated by rainforest and where high precipitation rates prevail (VASCONCELOS et al., 2013, Table 9). This implies that the flammability of the Amazon landscape, although increasing (BARLOW et al., 2016), is, in average, relatively low. In fact, the Amazon biome had a fire risk level below the national in 2015 and 2016, according with the fires detected by the National Institute for Space Research (INPE, 2016).

The third factor is the low degree of agglomeration of the population in general (and therefore of workers and consumers), as well as the low density of infrastructure (especially for transport), that characterizes rural Amazon, more notoriously in frontier regions. This gives rise to a low "economic density" measured in accumulated wealth per hectare in both "liquid" and "solid" forms. I.e., respectively, money in current accounts and physical goods (that are therefore subjected to be damaged by fire) such as facilities, fences, crop fields, pasture, etc. The spatial dispersion of solid wealth makes the impacts of accidental fires look like isolated events, and the scarcity of liquid wealth prevents investment in fire-free practices (NEPSTAD et al., 1999 and 2001).

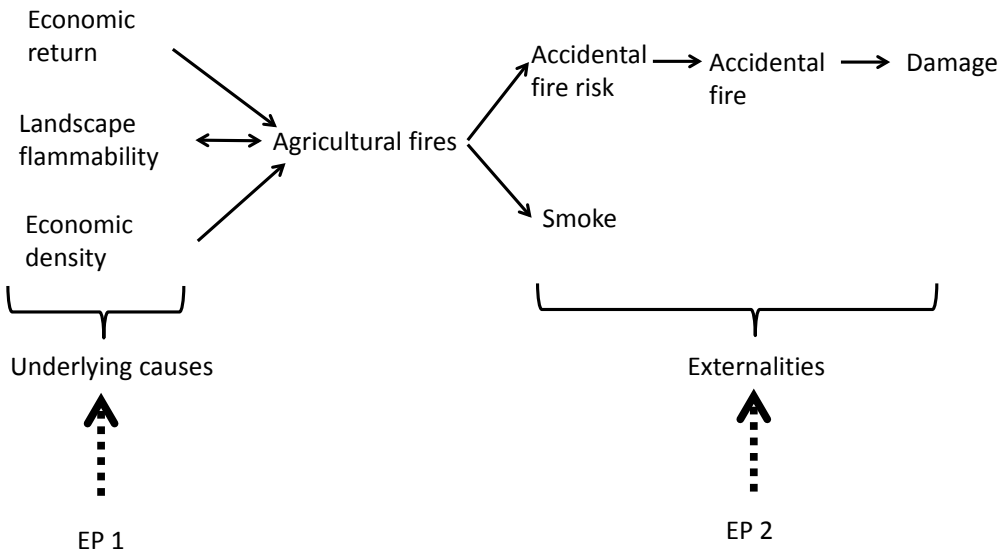
The article is based on the principle that accidental fires are externalities of agricultural fires, and, therefore, the underlying causes of the latter are also underlying causes of the former (Figure 2). The same applies to other externalities such as pollution and greenhouse gases.

At this point it is necessary to make explicit the theoretical premise that behind agricultural fires there are limitedly rational and autonomous agents whose behavior is

guided by individual cost-benefit calculations. Therefore, the government cannot directly control the process that defines the level of accidental fire risk, since it results from multiple decentralized decisions taken by those who benefit from the fire economy. However, there are two categories of entry points that can be explored by policy in order to reach the target in question. In the first place (EP 1, figure 2), the underlying causes of fires. Secondly (EP 2, figure 2), the risk of accidental fire and derived damage.

The understanding of the causes of agricultural and accidental fires just presented (figure 2) is the basis for the analysis of current policy, conducted in the following sections. It is focussed strictly on policies designed to reduce fires or to influence factors clearly related with fires.

Figure 2. Agricultural fires, accidental fires and entry points (EP) for policy.



Source: formulated by authors

Table 1. Value shares, municipalities and activities, municipalities with agricultural fire rate over 50%, Legal Amazon (AML), agricultural and agroindustrial production, 2006

Share measure / Product	Annuals except cassava	Cassava	Perennials and animals	Cassava flour	Other agro-industrial
Municipalities in AML's total value of the product	4%	20%	12%	50%	19%
Product in the total value of municipalities	27%	21%	25%	23%	4%

Source: count of farms with agricultural fires and value of agroindustrial production, including cassava flour: IBGE (2010); Value of agricultural production: PAM, IBGE (2015a) and PPM, IBGE (2015b).

3 Policy evaluation

3.1 Prevention and control of accidental fires

3.1.1 Main actions

The forest fire prevention and control policy is planned and implemented by three levels of government. At the federal level there are: (i) the National System for Forest Fire Prevention and Control (Prevfogo), a "Specialized Center" of the Brazilian Institute for the Environment and Renewable Natural Resources (Ibama) and; (ii) the Chico Mendes Institute for Biodiversity Conservation (ICMBio). Regarding state and municipal governments, they generally work through state fire brigades and environmental departments (the latter named "secretarias" and "orgãos").

Prevfogo's structure is decentralized, comprising the National Coordination located at IBAMA headquarters in Brasilia, state coordinations located in 21 states and three regional coordinations in the Legal Amazon (PREVFOGO, 2013). After the enactment of Supplementary Law 140/2011, Prevfogo's actions restrict to two categories of federal land, the agrarian settlements of the National Institute for Colonization and Agrarian Reform (INCRA) and the indigenous lands under the management of the National Indian Foundation (Funai; PREVFOGO, 2013). In protected areas, the institution responsible for fire prevention and control is, since 2009, ICMBio, but there is, whenever requested, Prevfogo's support (PREVFOGO, 2013).

In land owned by states, actions are conducted by state governments, often organized by State Fire Prevention and Control Committees. At the municipal level, the responsibility falls on municipalities which are generally supported by state governments (PREVFOGO, 2015a). The prevention and control actions developed by the three levels of government belong to four categories:

(1) Near-real-time monitoring of fire detections by satellites, information used as the basis for the geographical allocation of surveillances and fire brigades;

(2) Funding, training and planning of the positioning of fire brigades;

(3) Support to small-scale farmers' communities (agrarian settlements, protected areas, indigenous and quilombola lands), including instruction and training on fire control practices, fire-free farming and fighting of accidental fires;

(4) Environmental education on forest fires for society in general and specifically for elementary, middle and high school students, universities and communities of small--scale farmers.

A fifth action is licensing and monitoring of agricultural fires. In the past, the national and state coordinations of Prevfogo have conducted these actions. Currently, the responsibility is with state and municipal environmental authorities. It is only in federal lands (protected areas, INCRA settlements and indigenous lands of Funai), that Ibama and ICMBio licence and monitor.

3.1.2 Main limitations

Budget allocation

Prevfogo's annual budget is predominantly allocated to firefighting rather than for accidental fire prevention (PREVFOGO, 2015a, 2015b). The amount of resources invested in mitigation of fire's externalities is, therefore, superior to that invested in influencing fire's underlying causes. There is, however, an internal effort to increase the allocation of human and financial resources for preventive actions (itens 3 and 4 of section 3.1.1), which have been implemented with assiduity in the last ten years (PREVFOGO, 2015a, 2015b, 2015c).

One of the reasons why pro-firefighting budget allocation prevails seems to be that it is easier to persuade the top-level decision makers that define the budget to favor firefighting. This makes sense because firefighting can be defended based in actual data on active accidental fires, whereas prevention can only be defended based on forecasts, i.e., on estimates of accidental fire likelihood.

Geographical limitation

Prevfogo keeps in Legal Amazon, currently, 29 fire brigades that serve 44 federal areas comprising agrarian settlements and indigenous lands. The complete extension served corresponds to 159,872 km^2 or 3.19% of Legal Amazon (PREVFOGO, 2015a). The protected areas, under ICMBio's responsibility, correspond to 71,299 km^2 or 1.42% of the Legal Amazon (PREVFOGO, 2015a). In the rest of the region, approximately 4.75 million km^2, fire prevention and firefighting is responsibility of state and municipal governments.

At least four of the nine Legal Amazon states seem to have limited capacity to act (PREVFOGO, 2015a). The state committee, a permanent forum for discussion on fire

prevention and control, involving governmental and non-governmental state institutions (PREVFOGO, 2015d), is present in five of the nine states of the Legal Amazon. And only four of them have a situation room for real-time monitoring of fire activity (PREVFOGO, 2015a). These rooms function primarily in the dry season of the year, guiding the on-field action of firefighters.

It should be added that only Tocantins state have a state-level brigade specifically trained for forest fires. The remaining Amazon states have fire brigades, which, despite being legally responsible at state level, do not always have specific qualification for fighting forest fires. Also, the availability of these brigades depends on a wide range of occurrences, including urban fires (PREVFOGO, 2015a, 2015b).

Barriers to the licencing and monitoring of agricultural fires

Licencing and monitoring of fires was instituted by Decree 2,661 of July 8, 1998, and also by state legislations. The two actions work as a command and control instrument against agricultural fires that would never be authorized due to their high probability of turning into accidental fires. The economic return of such class of agricultural fire is reduced by a magnitude equivalent to the product of the probability of being caught and the value of the fine.

However, in practice, license request is scanty (CARMENTA et al., 2013, CAMMELLI, 2014, p.13, COSTA, 2006, p.184), Ibama rarely conduct surveillance operations that target agricultural fires (IBAMA-PA, 2015) and most state and municipal governments do not conduct any of the two actions.

The decentralization of the licensing and monitoring functions, instituted in 2011, led to an institutional "void" in which Ibama's withdrawal occurred without state and municipal governments taking over. Such governments are constrained by insufficiency of trained personnel, lack of funding and effective capacity of reaching people. Regarding this last point, decentralization overestimated the capacity of local authorities to serve the target public, ignoring that in the Amazon, remoteness imposes prohibitive costs.

There are also barriers to licensing faced by farmers, especially high transaction costs due to (i) submission of documents proving land ownership and licence to deforest, and (ii) displacement to municipal environment departments generally located in urban areas. Collective licenses ("autorização de queima solidária") granted to groups of small farmers seem to be requested only with the support from the government and the third sector (PREVFOGO, 2015b, 2015c, SEMA-STM, 2015).

In addition, license is a document that attests that the holder burned his/her land. Such evidence can be used to track down those responsible for accidental fires that caused damage to third parties and the environment. This discourages license requesting, given the punishments instituted by law.

Limited support to communities

Since its inception, Prevfogo has been supporting communities of small producers through actions targeting the dissemination of fire control and fire-free-farming practices

(PREVFOGO, 2015a, PREVFOGO, 2015b). This path was also pursued by multiple programs carried out in partnership by the government and the third sector, deployed mainly in response to the great Roraima fire in 1998 (COSTA, 2006).

Such actions could not yet be consolidated as a permanent support base. The transformation of farmers' attitudes regarding land management and fire control practices, requires the creation of institutions of collective governance that are absent in most of the communities investigated by the literature (COSTA, 2006; CAMMELLI, 2014). The main limiting factor for the duration, reach, and effectiveness of government support to communities is the amount of funding available, which has proved insufficient (PREVFOGO, 2015a). This is due to the priority in allocation that firefighting has.

In addition, most of the programs developed by the government and the third sector were mainly focused on providing information (COSTA, 2006), but it is to implement recommendations that communities need help. This requires complementary public policies that expand access to technical assistance, credit, inputs and machinery.

3.2 Research, development and diffusion of fire free farming

3.2.1 *Actions targeting the transition to capital-intensive farming*

With the expansion of soybean growing and intensification of livestock production, a larger number of small farmers now have access to fertilizers and tractors (BROWN et al., 2004; BÖRNER et al., 2007). In parallel, some municipal governments provide tractors to communities of small farmers (usually located in agricultural settlements) which may or may not be accompanied by financial support for the purchase of fertilizers and the transportation of these inputs to the community (BÖRNER et al., 2007; EMATER, 2015b).

Nevertheless, the diffusion of mechanized land preparation is obstructed by constraints that small farmers are exposed to, mainly limited access to credit, technical assistance and rural extension, complementary inputs (fertilizers and herbicides) and consumer market. These barriers have also hampered the diffusion of the system of mechanized chopping of fallow vegetation (BÖRNER et al., 2007), developed by the Tipitamba program of the Brazilian Agricultural Research Corporation (Embrapa).

Another drawback of land preparation with tractors is that it requires complete suppression of vegetation, including tree stumps, while in slash-and-burn and mechanized chopping, suppression is always partial with stumps being kept. Stump removal impacts the roots of secondary vegetation, delaying regeneration (KATO, 2015; DENICH et al., 2005).

3.2.2 *Actions targeting the transition to agroforestry*

Slash without burning

Embrapa, together with non-governmental organizations (NGOs), is diffusing agricultural practices that do not require fire but require secondary vegetation as the main source of nutrients.

Considering only the practices for which a minimally informative description and some evidence of practical implementation could be found in the technical and scientific literature, it is possible to recognize two categories of slashing without burning practices.

The first aims to contain secondary vegetation growth with the introduction of fast-growing species, such as the *Mucuna aterrimum* (Piper & Tracy), banana and castor bean (SERRA, 2005, section 3.4.1; SILVA et al., 2006). One of the disadvantages of this practice is the impossibility of generating income in the first year of cultivation given the need to wait for the plants to grow. In addition, efforts must be made to manage fast growing species in order to minimize competition with agricultural crops (EMATER, 2015b). The second category is focused on soil fertilization and consists of manual chopping of secondary and understory vegetation (ALVES; MODESTO JR., 2011, SERRA, 2005, section 3.4.1).

The unavailability of labor, one of the consequences of the low population density, is an obstacle to the diffusion of the two categories of slashing without burning. Alves and Modesto Jr. (2009) estimated the manpower required by the second modality in 70 man-days per hectare and in 20 man-days per hectare for slash-and-burn. Of the 35 producers interviewed by Silva et al., (2013), 33 (94%) stated that the first category requires more labor than slash-and-burn.

Agroforestry and ecological pasture

Agroforestry systems (AFSs) consist of the integrated cultivation of crops and trees in the same plot. Several institutions have promoted the diffusion of AFSs in the Brazilian Amazon, including research and development agencies such as Embrapa, technical assistance agencies such as the Pará State Technical Assistance and Extension Company (Emater-PA) and NGOs which carry out rural development and conservation projects with local communities. The AFSs recorded in the literature are considerably heterogeneous in the species they contain (see, for example, the systems analysed by Arco-verde, 2008 and Bentes-Gama, 2005).

One of the fire-free alternatives for pasture management that has received large support from the Brazilian government and from NGOs is the Voisin silvopastoral system (MELADO, 2015). It is about raising livestock in environments that combine forage and tree species, i.e. pasture and forest. The method was developed by André Voisin in the 1970s and has been adapted for Brazilian biomes, such as Cerrado (savannah), Pantanal and Amazon (MELADO, 2002).

The Italian-Brazilian program "Amazon without fire" (MELADO, 2011) installed multiple demonstration units (DUs) of the Voisin system in farms located in the Amazonian states of Pará, Acre and Mato Grosso in 1999-2008. Currently, DUs are active in farms located in the Amazon, within the scope of multiple government and third sector projects, such as the "Cerrado Jalapão" project, co-undertaken by Prevfogo and carried out in Tocantins. In addition, training courses are being offered with the support of NGOs such as the Amazon Environmental Research Institute (IPAM, 2014).

3.2.3 Barriers to the transition to agroforestry

There are four main barriers that prevent the diffusion of agroforestry systems among small farmers, what would replace fallow and pasture fires.

The first is insufficient access to technical assistance, a service that works to reduce the cost of learning new practices. The most appropriate measure of this cost is the total economic loss resulting from a trial and error learning process (experimentation) targeted at discovering the combinations of factors of production (labor and inputs) that achieves, with a tolerable cost, a satisfactory level of productivity. Technical assistance can mitigate the losses imposed by this process, as it transfers existing knowledge to farmers.

Currently, Emater-PA has a contingent of field technicians sufficient to serve only 1/8 of the state's small-scale farmers (EMATER, 2015a). The technical deficit also occurs in the sub-state scale (EMATER, 2015b). In addition, the available technicians have their geographical reach limited by the low availability of roads of minimum quality (EMATER, 2015b).

Notwithstanding, it should be noted that technical assistance can reduce losses considerably, but not to zero, as the knowledge on agroforestry is still being built (EMATER, 2015a).

The second barrier is the larger number of labor hours that must be devoted to each hectare of agroforestry. BÖRNER et al., (2007) estimate that the cultivation of black pepper, a recurrent perennial species in the Amazon AFSs, requires 175 man-days-a-year, almost six times higher than the 31 man-days/ha-year required for the cultivation of cassava and corn based with slash-and-burn. The number of man-days/year demanded by the 20-year AFSs assessed by Arco-Verde (2008, p.93) varies in stages as follows: 86-112 in the first three years, 35-40 from the fourth to the seventh year, 25-26 from the eighth to the nineteenth and 41 in the last year. Therefore, the first seven years require more labor than slash-and-burn. The evidence provided by Börner et al., (2007) and Arco-Verde (2008) add up to suggest that the diffusion of AFSs may be hampered by the labor scarcity generally faced by small producers located in low density regions (BÖRNER et al., 2007).

The third barrier is the low investment in research and development of agroforestry (Table 2), which perpetuates the lower profitability of the latter in relation to slash-and-burn and capital-intensive systems.

Table 2.Count of R&D production of Embrapa by agricultural system, 2000-2014, ratios in relation to "soybean system" in parenthesis

Agricultural system	Research and Development Bulletin accumulated count, 2000-2014 a	Scientific articles, 2000-2014 b
Agroforestry [c]	19 (19%)	878 (27%)
Soybean [d]	98 (100%)	3240 (100%)
Silvipastoral e	6 (6%)	270 (8%)

Source: Agricultural Research Database (BDP@, Embrapa), http://www.bdpa.cnptia.embrapa.br/consulta/

a "'Research and Development Bulletin Online' is a serial, written in technical-scientific language, including the report of a R&D project or sub-project already finished." (fonte: http://www.cnpt.embrapa.br/biblio/p_bp.htm);

b It was considered only publications that fall into the following categories: (i) papers from conference proceedings, (ii) articles in peer-reviewed journals, (iii) technical-scientific book chapters;

c Agroforestry was searched with the following code: ((agrofloresta) OR (agroflorestal) OR (agroflorestais))

d Searched with keyword "soja"

e ((silvipastoril) OR (silvipastoral) OR (voisin) OR (pastagem ecológica))

Insufficient R&D investment is both cause and consequence of the fact that the curricula of agronomy and forestry courses of public universities are dominated by Green Revolution practices with scanty space to agroecology and silvipastoral systems (EMATER, 2015a).

Difficulties in raising credit for AFS constitute the fourth barrier. Although there are specific credit lines provided by the National Bank for Economic and Social Development (BNDES), public and private banks do not have a standardized methodology to calculate with tolerable level of uncertainty, the profitability of AFS. Such institutions fund only AFS whose composition can be expressed in function of technical coefficients (physical yields) issued by Embrapa, the official reference (EMATER, 2015a, KATO, 2015). But given the wide range of possible AFS compositions, it is expected that, for most of them, the technical coefficients of Embrapa do not apply directly. But there is an ongoing effort of Embrapa Roraima to diffuse across lenders and farmers, a standardized methodology for economic valuation of AFS (ARCO VERDE; AMARO, 2012).

4 Discussion

The underlying causes of Amazon fires are the social relations that constitute an economy in which fire plays a crucial role as a mean of production. It is incorrect to understand the limitations of existing policies as underlying causes, since such limitations do not perpetuate fires, but prevent the full realization of the potential of policies to halt such perpetuation. Table 3 summarizes section 3, classifying the public policy instruments

according to aspects of its performance, in line with the conceptual basis (section 2). It is necessary to distinguish insufficiencies of institutions to implement policies (fourth column) and bottlenecks imposed by socioeconomic conditions whose mitigation is the objective of complementary policies (fifth column).

Table 3.Classification of policy instruments

Policy	Instrument	Entry point explored	Institutional insufficiencies	Bottlenecks
Prevention and control of forest fires	Fire brigades	Externalities: damages of accidental fires	Lack of committees and situation rooms in some states, geographical limitations of Prevfogo, ICMBio, INCRA and FUNAI	Insufficient budget to hire personnel
	Licensing and monitoring of fires	Underlying causes: economic return	State and municipal lack of capacity to licence and monitor	Transaction costs and strategic unattractiveness of licences
	Support to communities in fire control: government and third-sector	Externalities: risk of accidental fires	Insufficient funding and focus on information dissemination	Limited access to labor* and credit
	Support to communities in fire-free agriculture: government and third-sector	Underlying causes: economic return		Limited access to rural extension, labor* and credit, remoteness*
Prevention and control of deforestation	Licencing and monitoring of deforestation	Underlying causes: economic return of deforestation fires	Not investigated	Remoteness*
Research, development and diffusion of fire-free agriculture	Promotion of fire-free agriculture: agroforestry (EMBRAPA, EMATER and private/third sectors)	Underlying causes: economic return	Limited investment in R&D and absence of methodology for AFS funding	Learning cost, limited access to rural extension, labor* and credit, remoteness*
	Promotion of fire-free agriculture: mechanization	Underlying causes: economic return	Insufficient supply of tractors, lack of mechanization subsidy in some states and municipalities	Limited access to rural extension, inputs*, remoteness*, low investment capacity*

Source: section 3; Note: The asterisk "*" indicates factors related with low economic density.

The policy of prevention and control of forest fires exerts influence both in the externalities of agricultural fires and one of the causes that act to perpetuate such practices. It is necessary, however, to remember that the budget is primarily allocated for fire brigades and therefore to mitigate externalities. What finds a parallel in other countries such as Botswana (DUBE, 2013), Chile (HALTENHOFF, 2011) and Greece (KALABOKIDIS et al., 2008). In the US, 70% of the budget of the "National Fire Plan" was directed, according to Stephens et al., (2005), to fire suppression. This fraction takes the value of 60% in Mediterranean Europe (MONTIEL-MOLINA, 2013).

Command and control instruments against high risk fires were also employed in other countries. According Pezzati et al., (2013) one of the accidental fire prevention measures that have proven most effective over the twentieth century Switzerland was a ban on the burning of garden waste in the open. Botswana, South Africa and the US state of Florida also resort to burning licensing (MOORE et al., 2002; MYERS, 2006). In the first country, as well as in the Brazilian Amazon, transaction costs operate to keep licensed fires at a low level (DUBE, 2013). In some European and African countries fires are strictly prohibited (MONTIEL-MOLINA, 2013). Nevertheless, there is a recent trend in Europe to allow, upon licensing, controlled fire use, especially when the purpose is to eliminate combustible material that can spread fires (MONTIEL-MOLINA, 2013).

Support for the adoption of fire-free farming practices directly affects the economic return of agricultural fires. That even with government support the dissemination of these practices prove unsatisfactory, due to the multiple economic constraints smallholders are subjected to, it is something also observed in other developing countries, for example, Nepal (NEUPANE et al., 2002) and Indonesia (SUYANTO et al., 2005). It should be added that the research and development stage of agroforestry contrasts with the consolidated stage of slash-and-burn and green revolution methods. This contrast operates to contain the ample diffusion of agroforestry.

Asian, Latin and African countries have also sought to include communities of smallholders and traditional people in fire management (FAO, 2011; DUBE, 2013; MOORE et al., 2002). Indeed, the potential of these actions, seminally established by the international conference "Community Involvement in Fire Management" held in 2001 by the United Nations Food and Agriculture Organisation (FAO), gave rise to the term "community-based fire management" (CBFiM, MOORE et al., 2002).

In what regards to the diffusion of mechanization as an alternative to agricultural fires, the barriers detected for Amazon are also prevalent in some African countries. Low capitalization, combined with the insufficiency of consumer market resulting from remoteness, limit the mechanization of East African countries (FAO, 2013). Taking this into account, the cited study (FAO, 2013) recommends expanding the private supply of mechanized services, a solution that has been adopted in the Amazon by smallholders (SIMÕES AND SCHIMTZ, 2000). The need for rural development policies that can change pre-conditions for mechanization, such as transport infrastructure and access to markets, was also attested in southern and West Africa (FAO, 2013).

Both in Brazil and in other developed countries, community-based approach has had its implementation limited by the lack of capacity of communities to organize themselves, lack of incentives for both public servants (bad remuneration) and for communities (lack of clarity about the benefits and uncertainty regarding their appropriation), insufficient funding, ill definition of land property rights, and lack of complementary policies (FAO, 2011, DUBE, 2013).

5 Recommendations

Decisions on fire prevention and control would generate more effective and efficient results if it was grounded on a systematization of knowledge about the cost and benefit of multiple actions that have been or are implemented (NEPSTAD et al., 1999, p. 114-115). Currently, this knowledge is dispersed and stored tacitly in the minds of many agents who took or take part in the execution of actions. To make progress, effective collaboration channels between researchers and policy makers (DRISCOLL et al., 2010) have to be created, developing a shared representation of the processes through which intervention can affect fires.

In addition, the design of interventions should involve fire-dependent communities, since they hold crucial information on the feasibility of fire-free practices and the economic, social and environmental assets at stake. In addition, they are the first-degree victims of accidental fires.

It should also be noted that the policies analysed in this article will not be able to achieve full success in reducing fires whether not accompanied by complementary policies that increase access to technical assistance and rural extension, credit and consumer markets.

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FIRES IN BRAZILIAN AMAZON: WHY DOES POLICY HAVE A LIMITED IMPACT?

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***Abstract*:** The paper identifies the key factors limiting the effectiveness of current public policies to reduce Brazilian Amazon fires. Among them, (i) the dominant allocation of budget to fire suppression in detriment of prevention, (ii) the geographical limitation of the federal action and the reduced policy making capacity of states and municipalities, (iii) institutional insufficiencies and transaction costs related with fire use licensing, (iv) limited access to credit, market, labor and rural extension, constraints that block the diffusion of fire-free agriculture. It is recommended that policies be restructured to account for their cost and benefit and to include fire-dependent communities in their design and implementation. Progress in complementary socioeconomic policies is also needed.

***Keywords*:** public policy, Amazon, fire

***Resumo*:** O artigo identifica os principais fatores que limitam a eficácia de políticas públicas vigentes para reduzir queimadas e incêndios florestais na Amazônia brasileira. Entre eles, destacam-se (i) a alocação majoritária do orçamento para combate de incêndios em detrimento da prevenção, (ii) a circunscrição geográfica da atuação federal e a reduzida estrutura pública estadual, (iii) insuficiências institucionais e custos de transação referentes ao licenciamento de queimadas e, (iv) o acesso limitado a crédito, mercado consumidor, mão-de-obra e assistência técnica, restrições estas que impedem a difusão de práticas agropecuárias substitutas às queimadas. Recomenda-se que as políticas públicas sejam reestruturadas para levar em conta o custo-benefício das ações e incluir, em seu desenho e implementação, as comunidades dependentes de queimadas. É igualmente necessário o avanço em políticas socioeconômicas complementares.

***Palavras-chave*:** políticas públicas, Amazônia, fogo

***Resumen*:** El artículo identifica los factores clave que limitan la eficacia de las políticas públicas actuales para reducir la quema y los incendios forestales en la Amazonia brasileña. Entre ellos, se destacan (i) la asignación dominante del presupuesto para la lucha contra incendios en detrimento de la prevención, (ii) la jurisdicción geográfica de la actuación federal y la capacidad insuficiente de los departamentos y municipalidades, (iii) las deficiencias institucionales y los costos de transacción relacionados con la concesión de licencias, (iv) el acceso limitado al crédito, mercado de consumo, mano de obra y asistencia técnica, restricciones que impiden la difusión de las prácticas agrícolas sustitutivas al fuego. Se recomienda que las políticas públicas sean reestructuradas para tener en cuenta la relación costo beneficio de las acciones e incluir en su diseño y ejecución las comunidades dependientes de las quemadas. También hay necesidad de avances en las políticas socioeconómicas complementarias.

***Palabras clave*:** políticas públicas, Amazonia, fuego