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# Agrobiodiversity and Public Food Procurement Programs in Brazil: Influence of Local Stakeholders in Configuring Green Mediated Markets

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**Abstract:** The last few years have seen the emergence of different initiatives designed to promote the biodiversification of agroecosystems as a counterpoint to the global expansion of homogenized industrial agriculture. In Brazil, two food procurement programs demonstrate the potential to promote discussions related to this agroecological transition: the National School Meal Program (Programa Nacional de Alimentação Escolar, PNAE) and the Food Procurement Program (Programa de Aquisição de Alimentos, PAA). The objectives of this paper are to analyze: (a) how these procurement programs currently integrate agrobiodiversity (crops and cropping systems) according to the local context; (b) the main challenges that key stakeholders perceive for the adoption of biodiverse systems; and (c) the extent to which the key stakeholders involved in these programs associate agrobiodiversity with the provision of ecosystem services. We carried out this research in 2017 in two contrasting municipalities in the eastern part of the Brazilian Amazon, Paragominas and Irituia. Our research shows that these programs have included up to 42 species in Irituia and 32 species in Paragominas. Perennial crop species are the most common type of culture in Irituia (up to 50%), while vegetables are the most common in Paragominas (up to 47%). Although in both municipalities stakeholders identify a large number of ecosystem services (up to 17), services mentioned in Irituia were more closely related to agrobiodiversity. Stakeholders indirectly associated with the programs have a broader view of ecosystem services. We conclude that these procurement programs can be useful tools to promote the biodiversification of local production systems, but their potential may depend on involving institutions not directly associated with their administration. Additionally, despite the observed differences in production context, providing more ecosystem services appears to be a compelling motivation for promoting changes in agroecosystems.

**Keywords:** agroecological transition; agrobiodiversity; ecosystem services; public food procurement programs; mediated markets

## 1. Introduction

Agricultural ecosystems, or agroecosystems, are ecosystems transformed through human intervention to produce food, fibers, and other raw materials [1], along with a number of ecosystem services [2]. The expansion of monoculture cropping has jeopardized many of these ecosystem services, putting the production of food itself at risk [2,3]. There is no doubt today that the only way for these agroecosystems to continue to sustainably supply food to the world's growing population is by conserving or producing higher levels of ecosystem services [4,5]. Agroecology, defined as the science of natural resource management [6], promotes agrobiodiversity, among other practices, as one way to increase the level of ecosystem services [7–9].

Agrobiodiversity refers to the "variety and variability of animals, plants and micro-organisms that are used directly or indirectly for food and agriculture, encompassing the diversity of species, genetic diversity and diversity of cropping systems" [10]. It has evolved over time in various local contexts, depending on the relationship between traditional knowledge and technical and scientific interventions [11], and thus reveals the existence of a process of co-production of ecosystem services based on human interactions with agroecosystems [12,13].

Agrobiodiversity has been neglected in the international biodiversity debate for many years, with resulting disregard for the complexity of its preservation [14]. Agrobiodiversity conservation policies are still incipient and require better coordination among relevant institutions. Although the legal recognition of agrobiodiversity has progressively improved, leading to the protection of traditional knowledge, these protections are still limited to very specific situations [15,16]. It is crucial to protect people's rights, but policies need to address the root of the productive agriculture problem [17] and encourage a strategy of on-farm conservation that has value for farmers [14,18]. The maintenance/improvement of existing biodiversity-based agricultures [4,19] cannot be just technical and technological, but must also be social, economic, and institutional [3,20]. Many studies show that biodiversified agroecosystems are designed through the synergistic effect of different stakeholders operating at different levels [21–23].

In some Amazonian communities, traditional agricultural practices based on the management of natural resources to enhance ecosystem services still prevail [24,25]. It is critical to promote these practices before they disappear, although this form of biodiversity-based agriculture [26] is not free of risks, such as the conversion of forests to croplands [27] and the introduction of external inputs [25].

In 2012, the Brazilian government defined and implemented a National Policy for Agroecology and Organic Production (Política Nacional de Agroecologia e Produção Orgânica, PNAPO) to improve coordination among institutions, centralizing different existing programs to promote agroecosystem sustainability [28]. This groundbreaking policy was the first in the world to promote agroecological transition at the state level, bringing together technical support and price and market support [29].

Two programs that were integrated into PNAPO have drawn scholars' attention due to their potential to drive agroecological transition [30,31]: the National School Meal Program (Programa Nacional de Alimentação Escolar, PNAE) and the Food Procurement Program (Programa de Aquisição de Alimentos, PAA). Both programs purchase products from local smallholders and make them available to social and educational institutions. These programs incorporate numerous principles related to agroecological transition and biodiversity, such as: "to promote and value biodiversity and the organic and agroecological production of food"; "to support sustainable development, with incentives for the acquisition of diversified foodstuffs produced locally"; and "articulation among the social stakeholders involved in the process of purchasing products" [32].

The PNAE and PAA programs established public mediated markets [33], characterized by a particular structure of exchanges governed by rules and conventions negotiated by a group of stakeholders and organizations, with a fundamental role for the state [34]. These procurement programs have been expanding in many countries, often spearheaded by local governments or civil society [35]. Assessment of these programs generally focuses on benefits for consumers, and significantly less on their influence on farmers [35,36]. Recently, some studies have highlighted the combined benefits of

these mediated markets for food security and rural development goals [35–37]. Some studies mention the potential of these programs in favoring agrobiodiversity and associated ecosystem services, but few studies to date document this link [35,38,39]. Wittman and Blesh (2017), for example, showed that agrobiodiversity purchased by PNAE in a specific region of Brazil (Mato Grosso state) was still very limited compared to the agrobiodiversity available on farms.

As a contribution to this growing debate, the objectives of this paper are to analyze: (a) how these procurement programs currently integrate agrobiodiversity (crops and cropping systems) according to the local context; (b) the main challenges that key stakeholders perceive for the adoption of biodiverse systems; and (c) the extent to which the key stakeholders involved in these programs associate agrobiodiversity with the provision of ecosystem services.

Our study is set in a post-deforestation frontier in the eastern Amazon, where traditional farming systems still exist, but are strongly affected by the expansion of cattle ranching and soybean production. We compare two municipalities with different environmental policy approaches: Paragominas, an agribusiness municipality that implemented a Green Municipality Pact to halt deforestation and initiate the transition to sustainable land use [40]; and Irituia, a family farm municipality that was the stage of several environmental programs, such as Proambiente, the first Brazilian policy to support environmental services [41]. This study intends to show the strengths and limitations of the mediated programs in each of these contexts for supporting agrobiodiversity a decade after their implementation. We do not analyze how they have affected the biodiversification process, but how they currently value the existing agrobiodiversity.

## 2. Study Area and Methodology

### *2.1. The National School Meal Program (PNAE) and the Food Procurement Program (PAA)*

The choice of PAA and PNAE as the focus of our analysis stems from the observation that these programs play a key role in mobilizing many local stakeholders and bringing together numerous actions developed by these stakeholders in each municipality.

The school meal program was created in the 1930s in Brazil and in 1979, after restructuring, it became known as the National School Meal Program (Programa Nacional de Alimentação Escolar, PNAE), with the goal of improving nutritional conditions for children and their performance at school [42]. Throughout this period, the program was managed by the federal government and products were purchased from the food industry [43]. A decentralization process began in 1994 with the publication of Law No. 8.913, when states and municipalities became involved in the administration of this program. This law also made the first references to favoring the consumption of local products based on the agricultural vocation of each region [32]. This process culminated in the enactment of Law No. 11.947/2009, which created real conditions for family farmers to participate in the process. The law established that at least 30% of the products destined for school meals had to be acquired from local family farmers. In this period, discussions on agroecology, organic agriculture, and sustainable development began to gain importance within the program [44].

The Food Procurement Program (Programa de Aquisição de Alimentos, PAA) was created in 2003 by Law No. 10 696 in the context of the Fome Zero (Zero Hunger) program, conceived as a possible tool to improve rural conditions. This was the first Brazilian mediated market with an exclusive focus on family farming. Generally speaking, the program buys food and seeds from family farmers to send to social welfare entities and to create public food stocks [45].

In order to participate in the programs, farmers must have a document certifying that they are family farmers (Declaration of Aptitude to Pronaf—DAP) and it is also desirable that they participate in a cooperative. The inclination to participate in the programs is usually associated with guaranteeing a market for the products produced by the farmer.

### 2.2. Study Area

Two municipalities located in the eastern part of the Brazilian Amazon, Paragominas and Irituia, were selected for empirical field research (Figure 1). Although these municipalities have similar conditions for agricultural production, they differ in the socio-productive (Table 1), cultural, and institutional dimensions. Moreover, despite their proximity, few exchange and commercial relationships exist between the two municipalities, allowing an analysis of distinct dynamics.

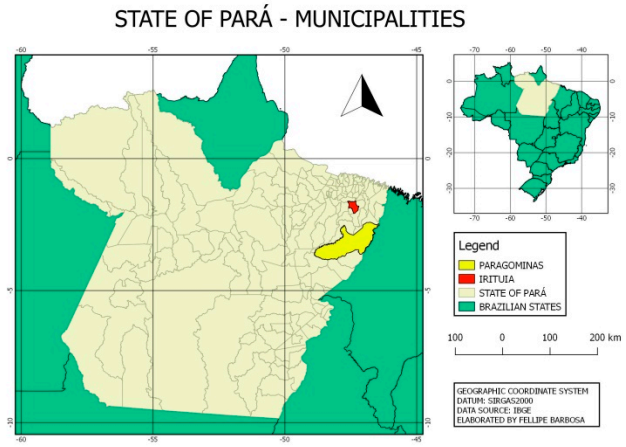


**Figure 1.** Study area.

**Table 1.** Demographic and socio-productive aspects of the municipalities.

| Characteristic | Paragominas | Irituia |
|---|---|---|
| Population (n) | 111,764 | 32,504 |
| Area (km$^2$) | 19,342 | 1379 |
| Human Development Index (HDI) | 0.645 | 0.559 |
| Percentage of the population living in rural areas (%) | 22% | 76% |
| Number of rural properties (n) | 1446 | 2356 |
| Percentage of family farmers (%) | 80% | 98% |
| Agricultural land (km$^2$) | 8560 | 776 |
| Percentage of agricultural land occupied by family farms (%) | 5% | 56% |

Source: Review of literature [46].

Both municipalities have a warm and humid climate; in Paragominas, the climate is Aw according to the Köppen and Geiger classification, while in Irituia, it is Am. Average temperatures fluctuate around 26 °C and annual precipitation is high, concentrated between the months of December and May. However, average annual precipitation is lower in Paragominas (1805 mm) than in Irituia (2268 mm), with a more well-defined dry season. Dystrophic yellow ferralsols (oxisols), which are typical of the Amazon region, are prevalent in both places [47,48]. Irituia is 168 km from the capital of Amazon state, Belém (2.5 h by car), and Paragominas is 277 km from Belém (4 h by car).

Paragominas is known for having been included in a deforestation blacklist within the framework of the Action Plan for the Prevention and Control of Deforestation in the Legal Amazon (Plano de Ação para Prevenção e Controle do Desmatamento na Amazônia Legal, PPCDAm) in 2008, but also for being the first to leave the list after establishing a "Green Municipality Pact" [40] with social stakeholders to stop deforestation. Today, new practices have been introduced and promoted, such as forest and environmental management, the intensification of livestock and plant production, and the restoration of permanent protection areas [49].

Large-scale grain and livestock farms, which practice industrial agriculture based on the intensive use of chemical inputs, represent the predominant land use in the municipality. Family farming, comprising rural communities and agrarian reform areas, represent approximately 80% of the total

number of rural properties, but only 5% of the agricultural land. These farms are threatened by environmental problems, primarily those related to fire and deforestation [50,51].

In Irituia, family farms are prevalent, representing 98% of all properties and 56% of the agricultural land. Deforestation related to family agriculture also occurs here, as in other townships in the region, driven mainly by slash-and-burn practices coupled with a high population density and long-term colonization [52,53]. Nonetheless, interesting processes of plant and animal diversity management, mostly related to the cultivation of agroforestry systems, can be observed [54,55].

### *2.3. The Stakeholders Involved in the Research*

For this study, we identified the key stakeholders representing institutions directly and indirectly related to the programs in both locations. The set of stakeholders responsible for the administration of the programs at the local level includes: institutions directly in charge of executing the programs, such as the local government; product suppliers, which are either individual or collectively organized farmers; and beneficiaries, which are the entities that receive food—schools, in the case of the PNAE, and social assistance entities, in the case of the PAA. In addition, many other stakeholders may be indirectly involved in the implementation of these programs: rural extension, sanitary surveillance, etc.

We conducted an exhaustive survey of all institutions involved in the programs using purposive sampling [56]. First, we made a list of institutions involved in the implementation of the programs, derived from our knowledge of the study area. Based on interviews and field observations, we examined other important institutions that had not been included in the initial sample. Indeed, both our observations of the local implementation, especially of meetings related to these programs, and the first interviews with key stakeholders, revealed that these mediated markets involve many more than the stakeholders directly linked to their implementation and are influenced by a broad network of stakeholders. As a result, we gradually added institutions and interviewed at least one key stakeholder per institution, for a total of 30 interviewees, comprising 15 in Paragominas and 15 in Irituia. We selected stakeholders whose responsibilities included aspects of production (e.g., selection of trade products and influence over the adoption of inputs). Stakeholders in other positions (e.g., administrative functions) were not considered. Although interviews were conducted in 2017–2018, many of the stakeholders interviewed had been in their positions from the beginning of the programs. Thus, they were able to provide accurate information on the history of the programs. According to their roles in the programs, they were classified as stakeholders directly in charge, product suppliers, or indirectly involved stakeholders. Since we aimed to analyze production-related aspects, we did not include the beneficiaries (food consumers).

The stakeholders included in the research embodied different types of knowledge, such as: (a) institutional: stakeholders responsible for the implementation of public policies; (b) technical: stakeholders associated with the extension process; (c) scientific: stakeholders involved in research and education; and (d) empirical: farmer representatives [57] (Table 2).

**Table 2.** Stakeholders interviewed and their role in the programs.

| Municipality | Role | Stakeholder (Number of Interviews) |
|---|---|---|
| Paragominas | Directly in charge | **Institutional:** *Municipal Department of Education* (1); *Municipal Department of Agriculture* (2) |
| | Product supplier | **Empirical:** Cooperuraim (1) |
| | Indirect role | **Institutional:** *Municipal Department of Environment* (1); **Technical:** EMATER (1), SENAR (1), IDEFLOR (1); **Scientific:** EMBRAPA (1); UFRA (1); IMAZON (1); **Empirical:** STTR (4) |
| Irituia | Directly in charge | **Institutional:** *Municipal Department of Education* (2); *Municipal Department of Social Development* (2); *Municipal Department of Agriculture* (1) |
| | Product supplier | **Empirical:** D'Irituia (1); COAPEMI (1) |
| | Indirect role | **Institutional:** *Municipal Department of Environment* (1); **Technical:** EMATER (1), SENAR (1), IDEFLOR (1), CODERSUS (1); **Scientific:** EMBRAPA (1); UFRA (1); **Empirical:** STTR (1) |

Further qualitative information was collected through constant observation of the involvement of different stakeholders in the two programs and by participating in 22 events and field activities concerning the execution of the programs and other issues within the rural context.

Sixty family farmers (30 in Paragominas and 30 in Irituia) received field visits to observe agrobiodiversity (frequency and diversity of cropping systems). Farmer selection was designed to include the full range of participation level in the procurement programs and other local programs (e.g., Tijolo Verde, Pará Florestal), including no participation in any program. Both in Paragominas and in Irituia, the farmers who participated in the programs were in different regions of the municipalities.

We asked the institutions involved in the implementation of the programs to create a random sample of these farmers and asked other institutions to refer farmers involved in other programs. Although we aimed to have 10 PAA/PNAE participants, 10 participants of other programs, and 10 non-participants, we were only able to interview nine participants of the Paragominas PAA/PNAE, as many of the farmers contacted did not return our calls, and 17 participants were interviewed in Irituia, as many farmers involved in other programs were also involved in PAA/PNAE. Because almost all sampled farmers in Irituia participated in both programs, and because in Paragominas, the products marketed to the two programs were almost the same, we did not differentiate between farmers participating in PAA and PNAE.

We selected non-participant farmers in the same vicinity of participants to assess farms exposed to similar conditions (i.e., distance from the city center, neighborhood relationships). Although we recognize that there is a variable set of factors that can affect the performance of these farms, we tried to control for factors such as property size and labor force availability as much as possible. The sample of non-participants cannot be considered representative of all non-participants in each municipality; it is representative of non-participants in the same environment as the program participants. Our intention was not to compare farmers participating and not participating in the programs, but to analyze the way that the farmers participating in the program implemented their crops.

### *2.4. Data Collection and Analysis*

The semi-directive interview guide used for interviews with stakeholders was structured around personal and institutional issues, the relationship between biodiversity and agriculture, and the stakeholder's knowledge about ecosystem services. Questions about ecosystem services were intentionally placed at the end of the interview to explore if this concept emerged spontaneously during the interview. The interviews were transcribed and a thematic analysis was carried out based on the transcripts [58] to organize the qualitative information according to the different topics included in the guide. The diversity of ecosystem services mentioned in the interviews and the challenges of adopting biodiversified systems were also quantified. The structured interview guide used for field visits to farmers focused on quantitative information related to production aspects, such as the frequency and diversity of cropping systems.

Based on the survey data, we created a diagram of the set of stakeholders associated with the execution of the programs in each municipality, including the relationships among different institutions and the role of each institution in implementing the programs. We also analyzed the relevant legislation and documents provided by the executive branches of the programs. This document analysis was used to gather supplementary information—mainly quantitative data— on the diversity of products purchased by the programs in 2017 and the number of farmers registered in each of the two municipalities, and to refine some of the information obtained from informants.

To quantify the agrobiodiversity currently integrated in the different procurement programs, we made a list of crops purchased by each program in 2017 based on documents presented by institutional representatives. The most common cropping systems were described in another table, based on interviews, observation of events and field activities involving the stakeholders, field observations of farmers, and a review of the literature. Based on these two types of information,

we propose a description of the agrobiodiversity related to the programs, both in terms of crops and cropping systems, in 2017.

It is important to note as a limit of the study that we are not measuring the area of each cropping system on a farm, but the diversity of cropping systems. The difficulty in measuring the size of each cropping system is due to the complex mosaic of systems found in many of the properties, which prevents the analysis of the real size of each one. However, since we are analyzing family farmers without major size dissimilarities, there are no major dissimilarities between cropping system sizes.

Lastly, we determined the level of knowledge of local stakeholders with regards to ecosystem services, with the goal of understanding whether biodiversity associated with mediated markets may be influenced by environmental concerns or whether it is largely driven by consumption issues and product availability. First, we focused on the knowledge of the conceptual framework of ecosystem services. Services mentioned by stakeholders during the interviews were listed, even if they were not explicitly referred to as ecosystem services. In addition, we identified the main challenges perceived by local stakeholders regarding the adoption of more biodiversified systems. For this analysis, we considered the number and diversity of services/challenges mentioned per interview. We sought to verify the extent to which this theme is debated among stakeholders to analyze how the knowledge of ecosystem services is being explicitly or implicitly mobilized for the execution of the programs and how these programs could reinforce actions related to the provisioning of ecosystem services.

We were unable to evaluate: (a) data on products purchased by institutions since the beginning of the programs (mostly due to the lack of organized administrative records); (b) more quantitative information on the area of cropping systems cultivated by farmers and the evolution of farmer practices (e.g. adoption of inputs, increase on biodiversification); and (c) the isolated effect of each initiative in promoting biodiversification. This prevented us from analyzing the evolution of the agrobiodiversification process, the extent of each cropping system, and the contribution of other specific initiatives to this process.

## 3. Results

### *3.1. Configuration of Mediated Markets and the Role of Different Stakeholders*

#### 3.1.1. Stakeholders Directly or Indirectly Involved in Mediated Markets

The PAA and the PNAE must be implemented by the municipal government. However, the configuration of these mediated markets and the roles of the different stakeholders are defined locally. The programs bring together different stakeholders to outline common objectives through several activities throughout the year, such as: meetings scheduled specifically to discuss the programs; other meetings where the programs are included in the agenda (primarily monthly cooperative meetings); and product deliveries (once a week), where both farmers and program managers are present.

In Irituia, the programs became operational in 2006; the PAA started first, followed by the PNAE. Currently, there are a number of institutions involved in the implementation of these programs in this municipality (Figure 2). The Municipal Department of Education (Secretaria Municipal de Educação, SEMED) and the Municipal Department of Social Development (Secretaria Municipal de Promoção Social, SEPROS) are the direct managers of the PNAE and PAA programs, respectively, and are responsible for purchasing products from cooperatives (PNAE) or individual farmers (PAA) and distributing them to the final beneficiaries. The Municipal Department of Agriculture (Secretaria Municipal de Agricultura, SEMAGRI) plays a direct role in administering the process as a whole. Other institutions have an indirect role in the implementation of the programs. Rural extension institutions, such as the public Technical Assistance and Rural Extension Agency (Empresa de Assistência Técnica e Extensão Rural, EMATER) and the private Cooperative for Sustainable Rural Development Services (Cooperativa de Prestação de Serviço em Desenvolvimento Rural Sustentável, COODERSUS), as well as the National Service for Rural Apprenticeship (Serviço Nacional de Aprendizagem Rural, SENAR) and the Forestry Development Institute of the state of Pará (Instituto de

Desenvolvimento Florestal e da Biodiversidade do Estado do Pará, IDEFLOR), provide training and technical assistance. The Union of Rural Workers (Sindicato dos Trabalhadores e Trabalhadores Rurais, STTR) helps organize farmers, and universities and research institutions, such as the Federal Rural University of the Amazon (Universidade Federal Rural da Amazônia, UFRA) and the Brazilian Agricultural Research Corporation (Empresa Brasileira de Pesquisa Agropecuária, EMBRAPA), which are very active and influential in the municipality, have enduring relationships with farmers and other institutions.

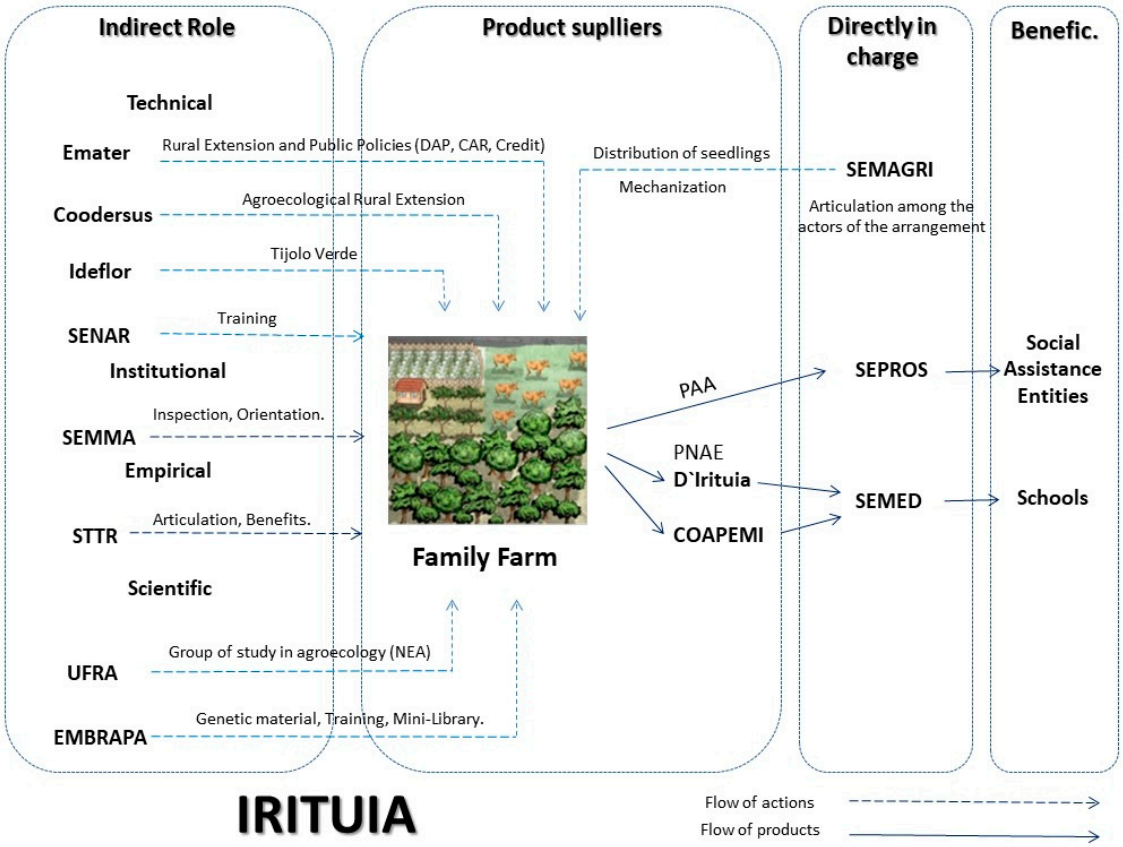


**Figure 2.** Stakeholders involved in mediated markets in Irituia.

In Irituia, the stakeholders we interviewed underscored the influence of previous programs in encouraging biodiversity and promoting environmental services, such as the Decentralized Execution Project (Projeto de Execução Descentralizada, PED), which was operational in the 1990s and was one of the first to discuss agroforestry systems at the institutional level in this municipality, and PROAMBIENTE, implemented in the following decade. In the mid-2000s, the municipality also experienced an important "movement" of visibility and valorization of Quintais through participatory action research [54] supported by research institutions, such as EMBRAPA and Federal University of Pará (Universidade Federal do Pará, UFPA). The quintal agroforestry system refers to the diversity of animal and plant species around a farmer's house, whose primary purpose is feeding the family. This movement initiated knowledge exchanges with other municipalities that were already developing agroforestry systems, such as Tomé-Açú. Several initiatives linked to the promotion of biodiverse systems are currently being implemented in Irituia, such as Tijolo verde, an initiative of IDEFLOR employed to build seedling nurseries in the municipality to stimulate the adoption of agroforestry systems for food and firewood, and an agroecological rural extension project managed by COODERSUS. Therefore, many of these initiatives promoted activities directly linked to the improvement of local agroecosystems, such as the exchange of genetic materials and production practices, promotion of agroforestry systems, cultivation of organic vegetable gardens,

and production of organic fertilizers. Discussions about reducing chemical inputs have also become quite common within these initiatives. Hence, PAA and PNAE were implemented in a context that already promoted agrobiodiversification.

In Paragominas, the PNAE worked with individual or informally organized farmers until 2009. After the promulgation of Law No. 11.947/2009, the program started working with formal groups of farmers (associations and cooperatives). The PAA began operations in 2015. Both programs also depend on a number of institutions to operate (Figure 3). The farmer cooperative COOPERURAIM serves both programs, interacting with the Municipal Department of Education (Secretaria Municipal de Educação, SEMED) for the PNAE and interacting directly with the National Supply Company (Companhia Nacional de Abastecimento, CONAB), a federal agency, for the PAA. As in Irituia, SEMAGRI plays a central role in organizing this process. Other partner institutions, such as rural extension, the Union of Rural Workers (STTR), and research institutions, have a less important role in the implementation of the programs compared to Irituia.

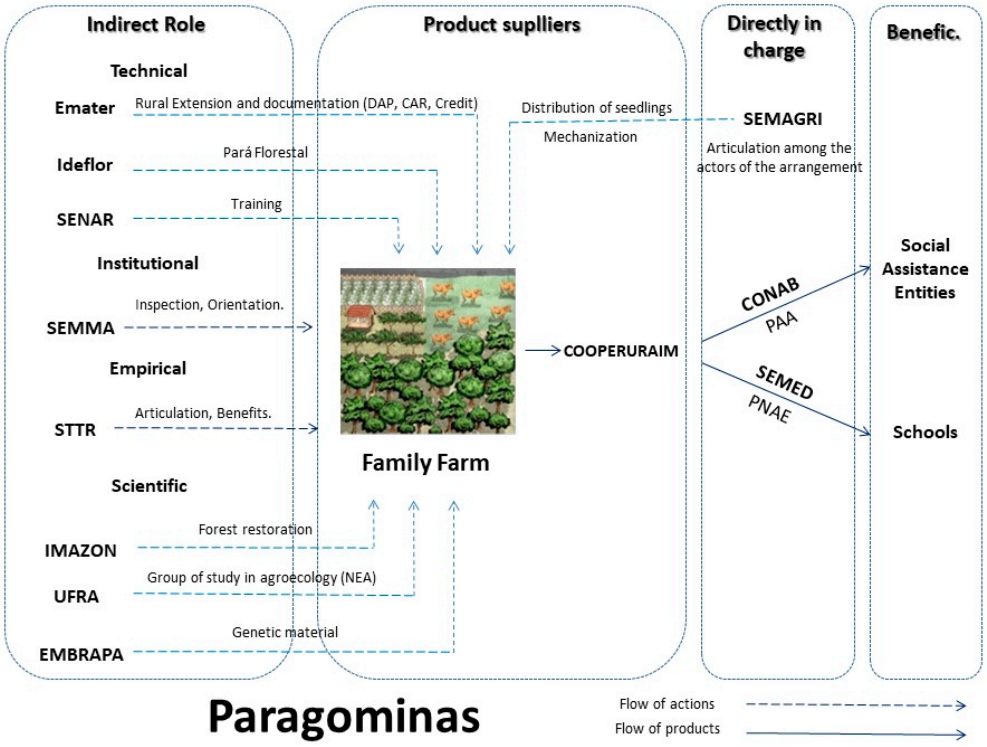


**Figure 3.** Stakeholders involved in the mediated markets in Paragominas.

There have been fewer initiatives directly promoting the biodiversification of production units in Paragominas. The environmental public policies of the municipality, such as the Green municipality pact, are largely directed towards large-scale agriculture. Even the IDEFLOR project Pará Florestal, which is similar to the Tijolo verde initiative in Irituia, but replaces firewood with timber, currently includes a very limited number of producers (less than 10). Most of the activities related to the biodiversification of family farming in Paragominas are carried out by specific university and research institution projects. Moreover, the representatives of the farmer union report that they do not believe their position is considered in the decision-making process in Paragominas.

Regarding the product suppliers (farmers), in 2017, there were 51 farmers participating in the PAA and 52 participating in the PNAE in Irituia (out of 2300 family farmers). In general, the same farmers participated in both programs. In Paragominas, about 78 farmers (out of 1150 family farmers) had access to both programs. The low level of farmer participation in the programs is largely related to the low availability of resources from the programs. Although the programs reached only a limited number of individuals compared to the total number of farmers in the municipalities, they encouraged

the creation or revival of cooperatives, which have become important local stakeholders. This was the case of COAPEMI and D´Irituia cooperatives in Irituia, and of COOPERURAIM in Paragominas. In Irituia, the PNAE operates through cooperatives and the PAA purchases from individual farmers. The reason usually given by the farmers for not selling to the PAA through cooperatives, despite the fact that it would strengthen these cooperatives, is that they have greater autonomy as individuals, both in terms of choosing the products to be sold and in terms of getting paid for them; the payment goes directly to the producer, without a deduction for the cooperative's share. In Paragominas, both programs operate through the cooperative.

Apart from the cooperatives that were created, new relationships have been established, both formal—commercial agreements between producers and the local government—and informal—exchanges between producers on the day of product delivery.

#### 3.1.2. Influence of Local Context on the Management of the Mediated Markets

Because the programs were conceived at the federal level, their operating rules were the same in both municipalities. However, we observed the establishment of a "local management", aimed at facilitating the operationalization of the program based on the local context. In both municipalities, the selection of products to be purchased is a participatory process that takes into consideration both the farmers' ability to supply products (e.g., availability of production, harvest) and the products of interest requested by the local government, defining both quantitative objectives (kilos of products to be delivered) and qualitative objectives (practices to be encouraged). The definition of these objectives depends on the stakeholders involved in the process. For example, in Irituia, the list of products that could be purchased was expanded; normally the inclusion of regional diversity is limited by federal rules, especially for products from the Amazon region:

> "*Regarding the list of products, they are even discussing its regionalization, because it is developed at the national level and it normally includes many products that are not produced or consumed locally. Important Amazon products are absent.*" (SEPROS representative in Irituia)

In order to expand the number of traded species, the PAA administration (mainly in Irituia) chose to purchase products that are part of the local food culture, even though they were not included in the official list. On this topic, the federal government recently enacted the Interministerial Ordinance Nº 284, which aims to increase product diversity and focuses on sociobiodiverse products. In addition, an informal rule has been followed in this municipality, where the products purchased by the programs were organic. Even if the federal program guidelines allow for 30% higher payments for organic products, the program managers in both municipalities are unaware of this possibility. However, the local stakeholders in Irituia have a tacit agreement and have enforced a tacit rule themselves, buying almost exclusively organic products and formally verifying the organic origin from time to time through laboratory analyses of produce samples. Some cooperatives also offer a participatory certification attesting that the farmers are organic producers, making this standard official. This is the case of the D'Irituia cooperative:

> "*Here we require products that do not use chemical pesticides. They have this concept of not delivering products with agrochemicals. No one needs to say anything. There was a year when some cassava flours were tested because some farmers would use poison to kill the weeds. One of the samples contained traces of agrochemicals. We no longer bought from that farmer.*" (SEMED representative in Irituia).

This informal rule does not exist in Paragominas. The main obstacle raised by local administrators and representatives of family farmers is their proximity to large-scale farms that, as mentioned above, intensively use chemical inputs—pesticides, fungicides, and herbicides. This proximity results in direct contamination of family farms by these products, carried by the wind or by rivers, and even in the displacement of pests, such as the silverleaf whitefly. As a result, some family farmers also use chemical inputs to combat these pests:

> "*We also had some courses on organic farming that some farmers took, but it is difficult to implement it in the municipality because there are many conventional fields surrounding the municipality properties—mainly grains—with an intensive usage of chemical inputs that is ultimately detrimental to the small properties that follow organic practices.*" (Cooperuraim representative in Paragominas).

Thus, although some elements are independent of local management, such as the availability of federal resources and operating rules, local stakeholders have a certain level of autonomy to influence the choices made by the programs.

### *3.2. What Agrobiodiversity is Directly Associated with the Programs?*

#### 3.2.1. Species Diversity

The choices made by the stakeholders involved in the programs largely impact the species that can be marketed. These may be classified as perennials, annuals, vegetables, and others (Table 3). According to annual purchase reports, the PAA program in Irituia had the largest number of traded species (42 species), followed by the same program in Paragominas (32 species). Compared to PAA, PNAE included a smaller number of different products, with greater diversity in Paragominas (30 species) than in Irituia (22 species). These species were cultivated in a variety of cropping systems, such as agroforestry, monoculture, slash-and-burn/mechanized annuals, vegetable gardens, and cattle breeding, as described below.

**Table 3.** Number of species traded by the programs in 2017.

| Type of Culture | Irituia | | Paragominas | |
|---|---|---|---|---|
| | **PAA** | **PNAE** | **PAA** | **PNAE** |
| Perennial crops | 21 | 10 | 10 | 10 |
| Annual crops | 6 | 5 | 5 | 5 |
| Vegetables | 15 | 7 | 15 | 13 |
| Others | 0 | 0 | 2 | 2 |
| **Total** | **42** | **22** | **32** | **30** |

- Perennial crops

Perennial crop species were the most common type of culture in Irituia, both for PAA (50%) and PNAE (45%). In Paragominas, perennial crops were the second largest category for PAA (31%) and PNAE (33%), after vegetables. Some of these crops were traded in both municipalities, such as acerola (*Malpighia emarginata*), banana (*Musa* spp.), guava (*Psidium guajava*), orange (*Citrus sinensis*), lemon (*Citrus limonum*), papaya (*Carica papaya*), passion fruit (*Passiflora edulis*), and yellow mombin (*Spondias mombin*). Others were consumed specifically in one municipality. In Irituia, these products were bacuri (*Platonia insignis*), cashew nut (*Anacardium occidentale*), carambola (*Averrhoa carambola*), cupuaçu (*Theobroma grandiflorum*), soursop (*Annona muricata*), jackfruit (*Artocarpus heterophyllus*), muruci (*Byrsonima crassifolia*), peach palm (*Bactris gasipaes*), and tangerine (*Citrus reticulate*). The açaí berry (*Euterpe oleracea*) and the malay apple (*Syzygium malaccense*) were only recorded in Paragominas. Although açaí is the most common perennial produce present in the local diet [59], it is no longer marketed in Irituia through the programs due to difficulties in complying with sanitary regulations.

In Irituia, our field work showed that perennial cultures were mostly cultivated as agroforestry systems. In most cases, these systems result from the progressive introduction of a diverse set of perennial species within slash-and-burn systems. This process is called the expansion of *quintais* [54]. Another form of implementing agroforestry systems is through the enrichment of forest areas (primary or secondary) with species of agronomic interest. In Paragominas, in contrast, perennial species are predominantly monocultures, often established following slash-and-burn.

- Annual crops

Compared to perennial crops and vegetables, species from annual crops had the lowest diversity in both programs in the two municipalities. In Irituia, they corresponded to 14% of the total number of species for PAA and 23% for PNAE. In Paragominas, annual crops represented 16% and 17% of the species purchased by PAA and PNAE, respectively. In addition to cassava (*Manihot esculenta*), the main annual crop, other annual cultures were beans (*Vigna unguiculata*), maize (*Zea mays*), pineapple (*Ananas comosus*), and yam (*Dioscorea alata*). Of these, only yam is commercialized in just one of the municipalities (Irituia).

Annual crops are usually planted using the slash-and-burn system, but in some cases, mechanization or herbicides may also be used. This cropping system is locally known as roça. Despite the small number of species associated with this system, they also have an important level of intraspecific diversity, especially in the case of cassava (farmers commonly plant three to eight varieties of cassava). Slash-and-burn is the most widespread farming system in the Amazon region and the main cultural food staple. It is often associated with deforestation and may lead to a cycle of soil impoverishment, but when the rotation is well-managed, it creates landscape mosaics that can promote biodiversity [60].

- *Vegetables*

This category included many species traded in both programs and municipalities, since they are the most common in the modern diet. In Paragominas, they corresponded to 47% and 43% of the species for PAA and PNAE, respectively, and had the greatest diversity compared to other categories. In Irituia, 36% and 32% of the species acquired by PAA and PNAE were vegetables, respectively, making this the second most diverse category.

Many of these cultures were commercialized in both municipalities, such as pumpkin (*Cucurbita* spp.), lettuce (*Lactuca sativa*), paracress (*Acmella oleracea*), cilantro (*Coriandrum sativum*), waterleaf (*Talinum fruticosum*), culantro (*Eryngium foetidum*), wild cabbage (*Brassica oleracea*), welsh onion (*Allium fistulosum*), maroon cucumber (*Cucumis anguria*), watermelon (*Citrullus lanatus*), and green pepper (*Capsicum* spp.). Basil (*Ocimum basilicum*), okra (*Abelmoschus esculentus*), melon (*Cucumis melo*), and bell pepper (*Capsicum annum*) were sold exclusively in Irituia. The vegetables only found in Paragominas were cucumber (*Cucumis sativus*), cabbage (*Brassica oleracea*), spinach (*Spinacia oleracea*), and sweet potato (*Ipomoea batatas*). Most of these products were cultivated in vegetable gardens, but some were planted intermingled with the slash-and-burn system planted at the beginning of the rainy season, usually more diversified, and specifically known as roças de inverno. These vegetable gardens have been largely encouraged by the programs. However, these systems represent very small areas within the rural properties and mostly consist of exotic species.

- Others

In Paragominas, the programs also purchased dairy products, such as milk and yogurt. These products were processed in partnership with a local private dairy unit. The inclusion of only a limited number of processed products stems from the difficulty of producers complying with current sanitary regulations. As already noted in the case of the açai berry, the norms applied to processing units are very strict and individual producers have not been able to make the investment.

#### 3.2.2. Cropping System Diversity

According to the diversity of species listed by local stakeholders, the programs are related to different cropping systems (Table 4). These normally coexist at the agroecosystem level. Slash-and-burn and mechanized annual cropping are traditional systems that are extremely common and independent of the programs. Other systems, such as vegetable gardens and perennial plantations (either as agroforestry systems or monocultures), were supported by the programs. Often, these are not new

cropping systems, but activities that used to be marginalized and gained greater visibility and validation with the creation of these mediated markets:

> "*Before the existence of the programs we used the products only for household consumption. We couldn't sell them. Today you can sell everything. [...] The main advantage [of the programs] is being able to sell the products you have. Last year we delivered a lot of tangerine and orange. The peach palm [Bactris gasipaes], for example, we'd never imagined before making money with it and today it has a lot of sales.*" (Family farmer in Irituia).

New crops were also planted specifically to address the programs:

> "*The participation in the programs is really good because the person will plant and know to whom they will sell. Before, I used to plant mainly beans, pumpkins. There was a variety of plants that I did not plant because there was no market, like spinach [Spinacia oleracea], waterleaf [Talinum fruticosum]. Today there is a market for these crops.*"
>
> (Family farmer in Paragominas).

**Table 4.** Diversity of cropping systems and relation to agrobiodiversity and nature.

| System | Objective | Description | Agrobiodiversity | Relation with Nature |
|---|---|---|---|---|
| Slash-and-burn/ Mechanized annual cropping | Household consumption and trading | Cassava as the main crop, usually combined with other annual crops | 1 to 11 different species and significant intraspecific diversity | Transient production system, generally associated with the use of fire and secondary forest suppression |
| Agroforestry | Household consumption, but also trading | Combination of perennials (fruit, firewood, timber) with annual crops and/or livestock | Ranging from simplified systems with three or four species to more complex systems with about 100 species; there is also significant intraspecific diversity | Perennial production system, normally associated with forest regeneration |
| Vegetable garden | Mainly trading, but also household consumption | Mixture of fast-growing food species | Between 3 and 20 plant varieties, normally with low intraspecific diversity | Input-intensive system, but usually implemented in small areas |
| Fruit crops (monoculture) | Mainly trading, but also household consumption | Production system based on a single plant species | One species, normally with low intraspecific diversity | Perennial production system, normally requires inputs |
| Cattle breeding | Mainly trading, but also household consumption | Dairy cattle breeding | Low animal diversity in a pasture that is also not diversified | Transient production system, generally associated with the use of fire and secondary forest suppression |

Source: Interviews, field observations, and review of the literature [27,41,60–62].

These various cropping systems may promote the production of organic materials—litter, manure, and cassava peels—that can be reused by the system itself or in a different system, increasing the likelihood of implementing biodiversity-based agriculture. Thus, in addition to the diversity of cultures, it is important to note how these cultures are implemented. Table 5 provides a broader view of the diversity of cropping systems present on the farms, complementing the information provided by key stakeholders.

**Table 5.** Frequency of cropping systems among farmers in Paragominas and Irituia.

| Cropping Systems | Paragominas | | Irituia | |
|---|---|---|---|---|
| | Participants ($n$ = 9) | Non-Participants ($n$ = 21) | Participants ($n$ = 17) | Non-Participants ($n$ = 13) |
| Slash-and-burn/Mechanized annual cropping | 78% | 95% | 94% | 100% |
| Agroforestry | 11% | 38% | 88% | 38% |
| Fruit crops (monoculture) | 55% | 57% | 17% | 38% |
| Vegetable garden | 88% | 28% | 35% | 23% |
| Cattle breeding | 22% | 28% | 11% | 8% |

Note: Among sampled farmers, the mean value and standard deviation (SD) of size and labor force were, respectively: **(a) Irituia**—26 Ha (SD 16.70) and 3.4 persons (SD 1.54) for participants; and 22.5 Ha (SD 12.66) and 4.8 persons (SD 2.4) for non-participants; **(b) Paragominas**—23 Ha (SD 13.31) and 3.8 persons (SD 1.90) for participants; and 24 Ha (SD 12.47) and 3.5 persons (SD 1.74) for non-participants. These values demonstrate that the sample is relatively homogenous regarding these indicators between and within the municipalities.

The field visits confirm that the differences in the orientation of the procurement markets between municipalities are linked to different cropping systems. In Paragominas, the dominant cropping system among participants is vegetable gardens (88% of participants), which are indeed the main products purchased (Table 3). In Irituia, the main cropping system, apart from annual crops which are widespread among all farmers, is agroforestry (88% of participants). Moreover, in both cases, it is suggested that there is a difference between participants and non-participants (in Paragominas, only 28% of non-participants have vegetable gardens, and in Irituia, only 38% of non-participants have agroforestry systems). Another interesting difference is that in Paragominas, fruit crops are mainly from monoculture systems (55% of participants have monoculture fruit crops, but only 11% have agroforestry systems).

Our method and the data acquired do not enable us to conclude whether the programs determined differences between participants and non-participants. Additionally, we cannot measure either the extent to which the cropping systems have been influenced by the programs or whether the choice of the key stakeholders in orienting the programs was influenced by the available cropping systems. However, interviews with key stakeholders tend to show that both processes reinforce one another. Thus, this information generates valuable insight for future research on the biodiversification process influenced by the programs.

### *3.3. What Are the Main Challenges for the Adoption of Biodiverse Systems?*

To identify whether the programs can contribute to supporting more biodiversification, we interviewed the key stakeholders regarding general challenges related to the biodiversification of cropping systems (Figure 4). In total, 20 different challenges were identified by local stakeholders, including 13 in Paragominas and 14 in Irituia. There was a great dissimilarity in the perceived challenges for each municipality, and 60% of the challenges were mentioned in only one of them.

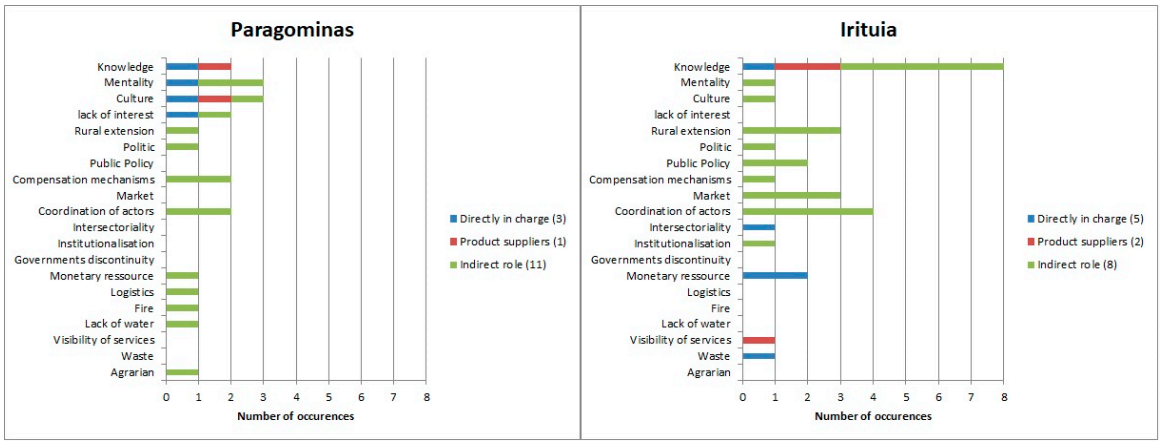


**Figure 4.** Main challenges identified by local stakeholders for the adoption of biodiversified agroecosystems.

In Paragominas, the most frequently listed challenges were related to the production paradigm, such as mentality (3) and culture (3), followed by a lack of interest (2), the coordination of actors (2), compensation mechanisms (2), and knowledge (2). In Irituia, the challenges were more closely related to elements supporting production, with a predominance of knowledge (8), followed by the coordination of actors (4), market (3), rural extension (3), public policies (2), and monetary resources (2). Mediated markets may be relevant to meet these challenges.

Of the challenges identified in Paragominas, 69% were mentioned by a single type of stakeholder. Despite this, there was a balance among the three types of stakeholders in this municipality regarding the most mentioned challenges. In Irituia, 93% of the challenges were mentioned by a single type of stakeholder. In this municipality, apart from knowledge, the three most cited challenges were only brought up by stakeholders who were indirectly associated with the programs. This reveals how

important it can be for stakeholders who are indirectly involved in the programs to participate in their delineation, as they have a broader view of the challenges to be met.

### *3.4. Which Ecosystem Services Are Mentioned by Local Key Stakeholders?*

The concept of ecosystem services is not explicitly used by the different stakeholders, except those who are close to the scientific and institutional community. Forty-seven percent of the stakeholders in Paragominas and 60% of stakeholders in Irituia had never heard of this concept or did not know exactly what it meant. Almost all the stakeholders interviewed stated that it was not a normal topic of discussion in their circles. Nonetheless, many stakeholders referred to different types of services (Figure 5) and mentioned that they were frequently discussed in events they attended.

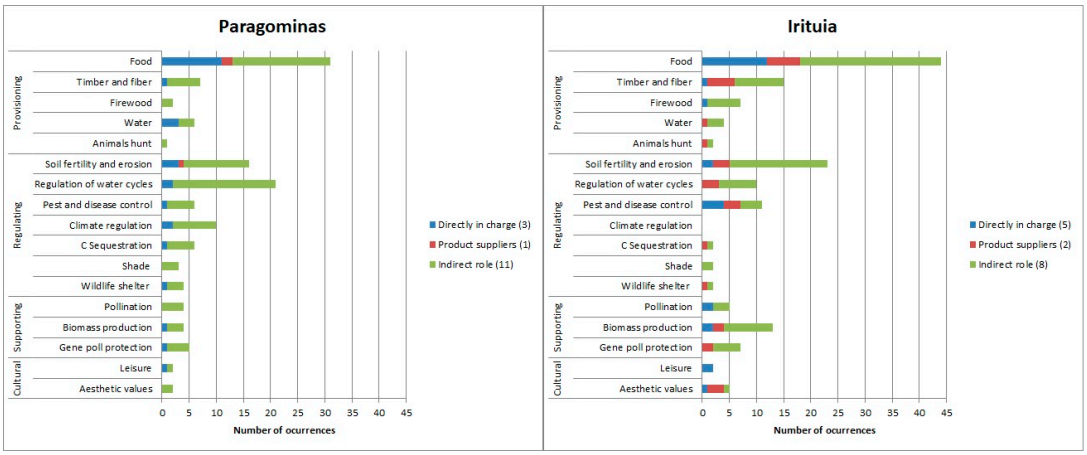


**Figure 5.** Number of citations made to the different services by the stakeholders. (Classified as [6]: (a) provisioning services, products obtained from nature; (b) regulating services, services provided by nature that regulate our environment; (c) cultural services, non-material benefits provided by nature that enrich lives; and (d) supporting services, which are necessary to produce the other three categories).

Seventeen different types of ecosystem services were mentioned during the semi-directive interviews, including 17 in Paragominas and 16 in Irituia. In both municipalities, the highest number corresponded to regulating services (41% and 43% in Paragominas and Irituia, respectively), followed by provisioning (29% and 31%), supporting (17% and 18%), and cultural services (11% and 12%).

Food was the predominant service in both municipalities, mentioned by all stakeholders in Paragominas and Irituia. In Paragominas, stakeholders frequently cited the regulation of the water cycle and the regulation of climate. In Irituia, stakeholders predominantly mentioned soil fertility and erosion, pest and disease control, biomass production, and maintenance of the gene pool. These services have a strong relation with agrobiodiversity. This seems to confirm that the key stakeholders in Irituia recognize the environmental importance of agrobiodiversity.

In Paragominas, only 19% of the services were mentioned by the three types of stakeholders, but this figure was higher in Irituia (40%), especially because the stakeholders representing the product suppliers mentioned many ecosystem services. Stakeholders indirectly associated with the programs bring a broad view related to the provision of ecosystem services. This highlights the importance of involving these stakeholders to devise better ways to promote these services through the programs.

## 4. Discussion

### *4.1. Mediated Markets as a Way to Ensure the Sale of Agrobiodiversity Products*

Our results show that procurement programs have created markets capable of absorbing a high diversity of products. Highly biodiverse systems often experience difficulties in marketing their products, which can discourage their expansion and even their existence. For instance, “quintais” are

usually underused, because many of the products exceed the food demands of the family and are not consumed, and there are few market alternatives for these products [63]. In this context, a very positive outcome of mediated markets is the creation of a fair mechanism to absorb the surplus of these systems [64], and therefore stimulate the maintenance of this diversity [65]. This greatly differs from the usual market logic based on a reduced number of products, leading to the homogenization of agricultural production systems [66] or dominance of highly marketable species [67].

Despite the observed potential of these programs to absorb a high diversity of products, they did not sponsor actions directly linked to production. The mediated markets formed to implement the programs, the institutions indirectly associated with their implementation, and the local production context are of the utmost importance to define the level of biodiversity that may be promoted. In our case studies, while the programs were associated with significant agrobiodiversity in both municipalities, the number of different species, especially perennial crops, traded by the programs was higher in Irituia.

The interviews show that current and past actions and programs—public policies and other activities—carried out by the key stakeholders reflect the predominant production paradigm of each municipality. These actions shape intrinsic aspects of these institutions, such as objectives, mentality, and power of influence, that continue being present even after they end [68,69]. Thus, although the benefits associated with biodiversified systems may be acknowledged by local stakeholders in both municipalities, in Paragominas, there is skepticism about the feasibility of effectively applying this agricultural model in rural areas, even in the case of family farming. In Irituia, a favorable atmosphere was created by past initiatives and ongoing projects. The cooperatives had a very important role in this process. This type of mobilization is less common in Paragominas. Moreover, the very attitude of the institutions that manage the programs towards agroecological approaches is fundamental to stimulating a transition process. Conscious of this role, managers in Irituia have required all farmers to produce according to organic principals (although produce is not certificated).

These factors reflect current differences related to the programs, mainly in terms of agrobiodiversity. In terms of the diversity of crops acquired by the programs in 2017, we found that PAA in Irituia was the most diversified program, followed by PAA and PNAE in Paragominas and PNAE in Irituia. Considering the type of culture, perennial crops were prevalent in Irituia, while vegetables were the most common culture in Paragominas. This is valuable information, because the type of culture reflects the type of cropping system. As we have shown, perennial crops in Irituia were planted preferably as agroforestry systems (unlike in Paragominas, where they were primarily monocultures). In contrast, vegetables were planted mainly as vegetable gardens in both places. By encouraging agrobiodiversity, the key stakeholders in Irituia recognized agroforestry as a low-input cropping system that promoted the provision of ecosystem services.

### *4.2. Ways Forward to Strengthen the Biodiversification Process*

How can the programs contribute to overcoming the main challenges faced by local stakeholders at each locality for the adoption of biodiversified systems? In Paragominas, the main challenges were more closely linked to paradigmatic issues, such as mentality and culture. This can be explained by the difficulty in suggesting "alternative" ways of production to replace production-based agriculture, which is widely disseminated in the municipality. This paradigm, as we have extensively discussed, was strongly adopted by large-scale farms and, in part, by family farmers. The procurement programs do not have any specific actions to solve these problems. On the contrary, the functioning of the programs is influenced by this production paradigm. Programs must be useful to overcome the challenges of coordinating actors and implementing compensation mechanisms.

In Irituia, in contrast, the main challenges were related to production issues, such as knowledge, market, coordination between stakeholders, and rural extension. Despite the efforts of some stakeholders to fill the gap in knowledge and rural extension, the dissemination of technical knowledge is still limited. Regarding markets, apart from mediated markets, they are either non-existent for

many of the local products, such as those derived from agroforestry systems, or the products are commercialized through a middleman, with unattractive prices. Only a few farmers are included in mediated markets, and the markets are susceptible to disruption, especially given the current political instability in Brazil. Finally, coordination among actors was also perceived as a challenge, because even if many institutions operate in the municipality, there are weaknesses related to political incompatibilities and the termination of people occupying administrative positions.

Unlike in Paragominas, programs in Irituia could help overcome some of these challenges. In the case of markets, one logical step would be to increase the number of farmers who have access to procurement programs. Another good strategy would be to take advantage of frameworks created by farmers to access the programs (e.g., cooperatives) to secure additional agroecological markets. The programs could also improve coordination among actors. Despite the absence of a formal arena including the various institutions linked to the programs, which prevents better coordination among actors, some progress has been made in creating new structures and establishing formal contracts between the government and farmers' organizations. Nonetheless, in both municipalities, the discussion about the contribution of ecosystem services related to the biodiversification may bring an interesting perspective to overcome the potential paradigmatic conflict regarding agroecology and the possible role of biodiversification and to generate new relevant knowledge to support this biodiversification.

### *4.3. Agrobiodiversity and Ecosystem Services*

Although several "services" are recognized by stakeholders, the conceptualization of ecosystem services is only disseminated in academic and institutional settings and rarely discussed in other circles. A negative aspect of this lack of knowledge is the difficulty in operationalizing anticipated elements of the programs and other associated public policies that aim to directly or indirectly improve the production of these services. More knowledge about the concepts could spur the demand for new public policy instruments. In Brazil, for example, the concepts of family farming and agroecology have been a major tool used to fight for new public policies related to these issues in recent years [28,70]. Naturally, this process involved many stakeholders linked to these issues. In the case of environmental services, different agendas surrounding this issue have emerged in Brazil in the past few years, including water, forestry, socio-environmental, and agricultural issues, especially regarding PES programs. However, despite the involvement of various stakeholders in this debate [71], most often, this subject is not included in federal public policies.

Regarding the perception of service diversity by local stakeholders, we observed that food provisioning is the most important perceived service in both places. This is coherent, since as a rule, the main objective of the production system is the production of goods, mostly food. Here, it is important to recognize that the type of cropping system, as well as the technological model adopted, are fundamental to determining whether the production of provisioning services, notably food, will improve or decrease the provisioning of other services [2]. For instance, agroforestry systems are normally associated with the production of ecosystem services, such as provisioning (e.g., food, timber), regulating (e.g., soil fertility and erosion, regulation of water cycles, climate regulation), and supporting services (e.g., biomass production) [55,72,73]. However, other systems are also important. For instance, slash-and-burn systems, despite their potential to cause deforestation and soil impoverishment [27,74], play an important role in protecting the gene pool in situ [60].

Both in Paragominas and Irituia, stakeholders identified a set of other services that may be used to increase the productivity of cropping systems. In Paragominas, they are related to the regulation of the water cycle and soil fertility and erosion. The frequent mention of water cycle management in Paragominas may be explained by the fact that this municipality has a more well-defined dry season compared to Irituia, or by problems related to river conservation. Soil fertility and erosion were also frequently mentioned in Irituia. This suggests that this is a well-recognized and important service in

both localities. In Irituia, biomass production, which is related to soil fertility, was also frequently cited as an important service, along with pest and disease control.

The perception of some services differed between the two localities. For example, climate change and carbon sequestration were mentioned more often in Paragominas, which may be related to the substantial extent of large-scale agriculture in Paragominas. Indeed, studies have shown that climate change is more severe in soybean expansion regions [75]. Moreover, in this Green Municipality, many discussions have been promoted to establish green business opportunities, such as Reduction of Emissions from Deforestation and Forest Degradation (REDD+), linked to carbon sequestration.

This result suggests that the perception of ecosystem services may be related to local issues and, for this reason, they could be a possible incentive for farmers and local communities to change their systems to improve production. However, we also observed that the perception of ecosystem services is not always reflected in stakeholder actions. This suggests that the perception by itself does not determine the actions of the stakeholders.

Promoting increased dialogue between stakeholders could enable them to share their perceptions of ecosystem services related to cropping systems, and thus steer the programs toward stimulating the adoption of cropping systems that have a greater potential for delivering services. For example, discussing how an agroforestry system could improve climate regulation in Paragominas may motivate farmers to adopt this cropping system, because climate regulation was an important service mentioned by stakeholders of this municipality. Another important discussion topic would be to analyze the extent to which the production of these services could be used to improve the agricultural production process and reduce the use of external inputs [6].

Although we did not have suitable data to assess the biodiversification process, empirical evidence about the current agrobiodiversity purchased by the programs in the two municipalities suggests that mediated markets are related to significant agrobiodiversity. Such markets could improve biodiversification as long as the key stakeholders involved in rural development at a given locality are interested in promoting this agroecological transition. We emphasize the importance of the synergistic contribution of all the other initiatives that take place in each municipality, especially because the PAA and PNAE do not act directly on productive aspects. As a result, they become a driver of support/reward of biodiversified agroecosystems as they create markets for products that might otherwise have little value. However, the persistence of this process will depend on keeping these public policies active and reinforcing the involvement of different institutions.

## 5. Conclusions

Both programs have the potential to promote the biodiversity of local production systems, as they can buy a diversity of products, but their impact depends on the local administration of each program, the key stakeholders associated with their implementation, and the local socio-productive context. Various elements could improve the programs: (a) strengthening cooperatives as intermediaries between executors and farmers; (b) including more farmers; and (c) formally establishing an organization to coordinate institutions directly and indirectly linked to the implementation of the programs. The stakeholders that are not directly involved have an important role to play, as they have the broadest view of the challenges to improving biodiversification and important ecosystem services. Thus, encouraging multi-actor discussions about the benefits and ecosystem services associated with agrobiodiversity as part of the programs would certainly promote the biodiversification process. However, the situation of these procurement programs is currently very fragile due to the political instability at the national level. As a result, despite the demonstrated potential of these programs to support local rural development, much uncertainty remains about their scope of operation, and even their continuity. Therefore, this article presents novel and valuable data showing the importance of such programs regarding agrobiodiversity. It also generates insight for future studies that might aim at effectively assessing the influence of programs on the adoption of cropping systems/inputs.

**Supplementary Materials:** The following are available online at http://www.mdpi.com/2071-1050/11/5/1425/s1.

**Author Contributions:** A.G.L.R. designed and performed the research and collected and analyzed the data used in this article. E.C., M.-G.P. and C.L.P. advised him on research design and data analysis. E.C. and M.-G.P. contributed to writing and revising the manuscript. N.C., M.P., T.S. and W.A. contributed to improving the analysis through their knowledge and suggestions on specific topics of the manuscript.

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