An institutional framework for Bioinputs in Brazilian agriculture based on Ecological Economics

Um marco institucional para os Bioinsumos na agricultura brasileira baseado na Economia Ecológica

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ABSTRACT

In search of sustainability, new patterns for production or consumption have been created in opposition to conventional products, such as biological inputs or "bioinputs". They are products, processes or technologies of animal, plant or microbial origin which can positively affect agricultural production. The adherence of rural producers to sustainable and economic agricultural practices, which use bioinputs, is growing in Brazil. They have been encouraged to adopt these products because of the existence of the National Bioinputs Program, created in 2020. The results show that several benefits have been associated with their use. However, inadequate handling can bring negative externalities that could be avoided. It requires an institutional framework to guide the country's production and use of bioinputs. This article proposes a new institutional framework based on ecological economics and institutionalism, considering Brazil's sociopolitical and environmental situation.

Keywords: Bioinputs. National Bioinputs Program. Ecological economics. Institutional framework.

RESUMO

Em busca da sustentabilidade, novos padrões de produção agropecuária têm sido criados e, em oposição aos insumos convencionais, surgiram os insumos biológicos, ou "bioinsumos". Eles são produtos, processos ou tecnologias de origem animal, vegetal ou microbiana que podem interferir positivamente na produção agrícola. A adesão dos produtores rurais a práticas agrícolas sustentáveis e econômicas, que utilizam bioinsumos, é crescente no Brasil. Os produtores rurais têm sido encorajados a adotar essas inovações por meio da existência do Programa Nacional de Bioinsumos, criado em 2020. Os resultados apontam diversos benefícios relacionados ao uso desses produtos, no entanto, o manejo incorreto pode trazer externalidades negativas que poderiam ser evitadas. Isso requer um marco institucional que oriente a produção e a utilização dos bioinsumos no país. Este artigo propõe um novo marco institucional, baseado nos pressupostos da economia ecológica e no institucionalismo, considerando a conjuntura sociopolítica e ambiental brasileira.

Keywords: *Bioinsumos. Programa Nacional de Bioinsumos. Economia ecológica. Marco institucional.*

1 INTRODUCTION

The term "sustainability" gained space in the search for production strategies that are adequate to the environmental, economic, ecological and social conditions existing on the planet. Thus, researchers, rural producers, entrepreneurs, traders, and other social actors, driven to meet the current demands of production and consumption, have increasingly considered the limitations in using biosphere resources.

Currently, the planet is home to about 7.8 billion people. Future estimates of population increase are disparate, but some suggest that the planetary population may exceed 11 billion inhabitants by the end of this century (REICHARDT; TIMM, 2016). Therefore, the prospects for global consumption and its possible environmental consequences present great uncertainty and have led experts to investigate the relationships established between the economic growth of societies and the carrying capacity of the biosphere. Furthermore, these threats or challenges to human survival have led scholars to rethink consumption patterns and economic growth in the capitalist system.

Considering the historical events since the emergence of the human species, it is common sense that the means of production are in the period of most significant potential destruction and alteration of terrestrial ecosystems, the Anthropocene. Several approaches have been proposed to define when the Anthropocene began. For example, events such as the discovery of fire, pre-industrial agriculture, the beginning of colonialism, advances with nuclear energy and the development of industrial technologies would mark its beginning. However, there are still disagreements about the precise scientific data, requiring further studies (LEWIS; MASLIN, 2015).

Despite this, it is evident that the planetary concern with environmental issues has increased more and more, causing representatives from various countries to meet to discuss action plans to minimize emerging problems. Thus, regarding the productive systems, the most significant changes to support strategies of global interest for sustainability are observed from changes that bring environmental benefits and consider ecological principles in large areas of agricultural, livestock or extractive production.

The studies favouring the construction of ecologically-based agriculture started in the 1920s, but the interest in using production methods that consider ecological principles is recent. These were initiated after the 1970s, following the consequences of the "Green Revolution" headed in the United States and Europe and followed by Latin American and Asian countries (GLIESSMAN, 2005; LOPES, P. R.; LOPES, K. C. S. A., 2011; MARCHESE; FILIPPONE, 2018).

In summary, the socio-environmental problems engendered by agricultural modernization have made it counterproductive under several conditions. The depletion of water sources and soils, the reduction

of genetic diversity, and the increased dependence on external inputs to the production unit and non-renewable fossil fuels have highlighted the need to rethink the conventional model of agricultural production (GLIESSMAN, 2005).

Nevertheless, in recent years the configuration of intensive agriculture in Brazil has increasingly recognized ecological principles in production. Such changes have converged to the growing adherence (voluntarily, as a response to the problems cited, by economic advantages or due to the growing demands of the international market) of production technologies that have a more rigorous and responsible environmental conduct, as in the case of the use of precision agriculture, integrated pest management and socio-environmental certification processes (KITAMURA, 2003).

One of Brazil's most expressive actions to encourage the implementation of environmentally friendly technologies in large-scale agriculture is the National Bioinput Program, Decree No. 10.375, instituted on May 26, 2020. Generically, the decree cited refers to bioinputs as products, processes or technologies of plant, animal or microbial origin that "positively interfere in the growth, development and response mechanism of animals, plants, microorganisms and substances derived from and interacting with products and physicochemical and biological processes" (BRASIL, 2020, p. 105).

Therefore, while the demand for many products has fallen due to the current economic and health crises, the use of bio-inputs has shown significant growth in recent years. Besides governmental incentives, this phenomenon is possibly due to the competitive advantages these innovations offer with conventional inputs since many of them present superior efficacy compared to those applied today in agricultural crops. These processes, however, present significant challenges in Brazil, mainly due to the need for a regulatory framework that guides the handling of bioinputs (FINKLER, 2012).

Therefore, it becomes increasingly necessary to discuss the safety, efficiency and regulation of the production of biological inputs in rural areas. Thus, in light of the principles of ecological economics and institutional theory, this article proposes to constitute understandings that can contribute to the establishment of a new institutional framework for the National Bioinput Program underway in Brazil. To this end, it uses a theoretical discussion on the subject, considering the economic, environmental, and social characteristics of biofuels. Accordingly, the paper is divided into three sections. The first describes the methodological procedures of the research the steps for its elaboration. The second one deals with the analytical discussion of obtained results, composed from (i) evaluation of the uses and means applied to processes and products from an economic, ecological and institutional viewpoint and (ii) elaboration of a synthesis of notes that highlight the weaknesses of the current legal framework that supports the National Bioinput Program. Finally, the last section covers the final considerations, i.e., it issues the conclusive comments concerning the exposed throughout the article.

2 METHODOLOGICAL PROCEDURES

The present study used a case study analysis of the Federal Decree 10,375/2020, which instituted the National Bioinput Program, proposing to understand it with emphasis on an economic, environmental, and social approach.

According to Yin (2001, p. 32), "a case study is an empirical investigation investigating a contemporary phenomenon within its real-life context, especially when the boundary between the phenomenon and context is not clearly defined.

The case study seeks the interpretation and deeper understanding of specific phenomena and facts, not the generalization of its results. In this sense, although they cannot be generalized, the results obtained should enable the dissemination of knowledge through possible theoretical propositions (YIN, 2001).

Therefore, this research is qualitative and exploratory in nature, as it aims to understand a social problem that has been little studied and specific aspects of a broad theory.

Initially, bibliographic research was developed, constituted, according to Gil (2002), of delimiting information and data contained in the material to establish a relation between this information and the data of the proposed problem and, finally, to analyze the consistency of the information and the data presented by the authors.

Based on the data obtained through literature review, this paper evaluated the use of bioinputs, highlighting the ecological relations of their processes and functions and the possible impacts of their use in crops from an economic-ecological point of view. Finally, the weaknesses of the current legal and political framework were evaluated, through an institutionalist analytical approach of the National Bioinput Program, highlighting the challenges encountered for its regulation.

In short, the research sought to emphasize incorporating ecological and social dimensions in constructing a new institutional framework for the ongoing Bioinput Program in Brazil, performing an ecological-economic approach and highlighting notes about the initiatives of a legal institution in the country on the subject.

3 RESULTS

3.1 BIOINPUTS FROM AN ECOLOGICAL AND INSTITUTIONAL ECONOMIC PERSPECTIVE

3.1.1 BIOINPUTS: PROCESSES, PRODUCTS AND ECOLOGICAL ECONOMICS

The alteration of agroecosystems for large-scale production has made these environments highly dependent on external and non-renewable inputs and thus vulnerable to low sustainability. At the same time, in monocultures, the genetic and environmental simplification or homogenization, associated with the disturbances inherent in the production process (such as the use of non-selective pesticides), directly interfere in the susceptibility of the environment to attack by phytophagous individuals ("pests" of the crop), reducing the population of natural enemies (ALTIERI; NICHOLLS, 2004; FEIDEN, 2005).

In other words, the homogeneous environment facilitates the multiplication of organisms that feed on the abundant resource (the crop of interest) and hinders the control of these "pests" by their respective natural enemies, which can be further eliminated through the application of non-selective insecticides (AGUIAR-MENESES; SILVA, 2011).

However, when the diversity of plant species is increased in an agroecosystem, it is possible to favour the natural existence of "pest" enemies that will act in biological control, without the need for the application of chemical inputs or introduced bioinputs. Thus, the environment is changed to induce the control of the phytophagous population as it occurs in the natural system, aiming to reduce the exaggerated population of undesirable individuals from the economic point of view to reach an acceptable level of profitability. This type of control is not performed through exogenous products that are strange to the system (AGUIAR-MENESES; SILVA, 2011).

In this sense, it is understood that bioinputs, if properly managed, can bring advantages to the productive efficiency of agroecosystems. Thus, it is recommended that these environments produce their bioinputs for biological control by only increasing the diversity of plant species to avoid dependence on external inputs. This type of management is considered natural biological control (GALLO *et al.*, 2002; GLIESSMAN, 2005).

Besides this type of control, classical and applied biological controls refer to the importation and colonization of natural enemies, aiming to control exotic or native "pests". In the first, the releases are inoculated in small numbers of individuals, one or more times in the same place. In contrast, the second type of control is performed by flooding releases with a more significant number of individuals after mass rearing in the laboratory, aiming to rapidly reduce the pest population to the desired level (PARRA *et al.*, 2002).

In these cases, the introduction of an exotic species, whether genetically modified or not, may compete with the native fauna, causing population imbalances and displacing certain native species to other habitats or even their extinction. It is, therefore, a strategy that involves risks. Thus, to minimize these dangers, basic procedures regulated by laboratories must be obeyed (SCOPEL; ROZA-GOMES, 2011).

Thus, it is possible to establish sustainability indexes from the concepts of input of external resources, the output of the production result and the waste generated, considering the possible negative impacts within the production unit (on-farm) (GLIESSMAN, 2005; ODUM, 2004).

Understanding the ecological and economic relationships established in natural systems and in agrosystems that use bioinputs produced on-farm makes it possible to propose three schemes that differentiate these environments (figures 1, 2 and 3).

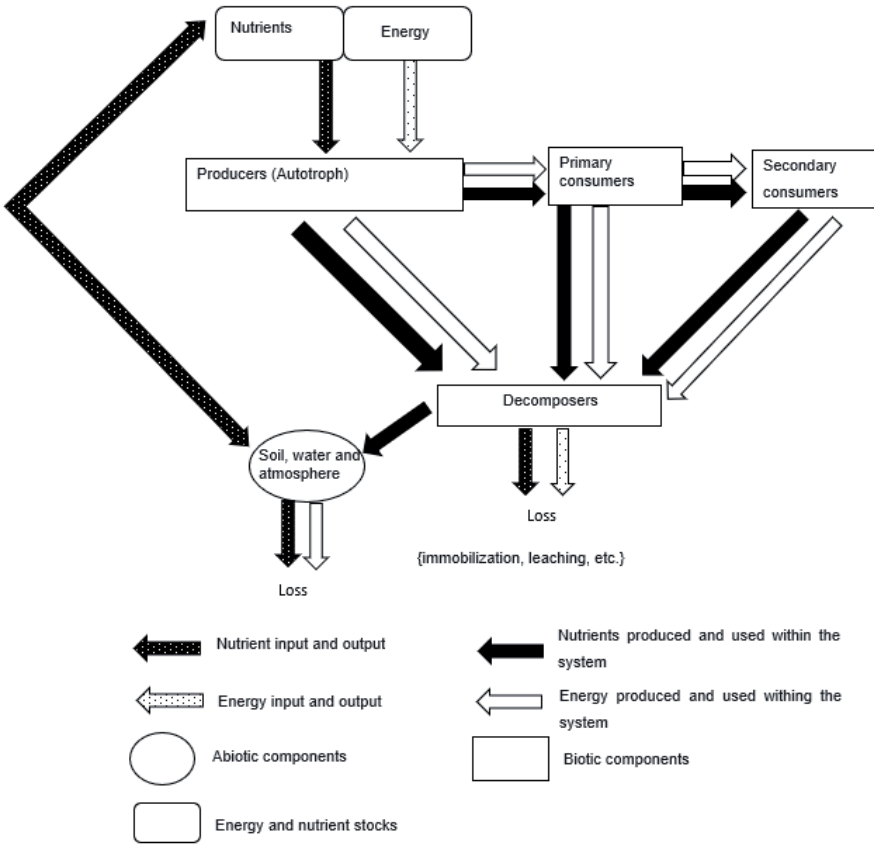

Figure 1 | Nutrient and energy cycling within a natural ecosystem

Source: Adapted from GLIESSMAN (2005).

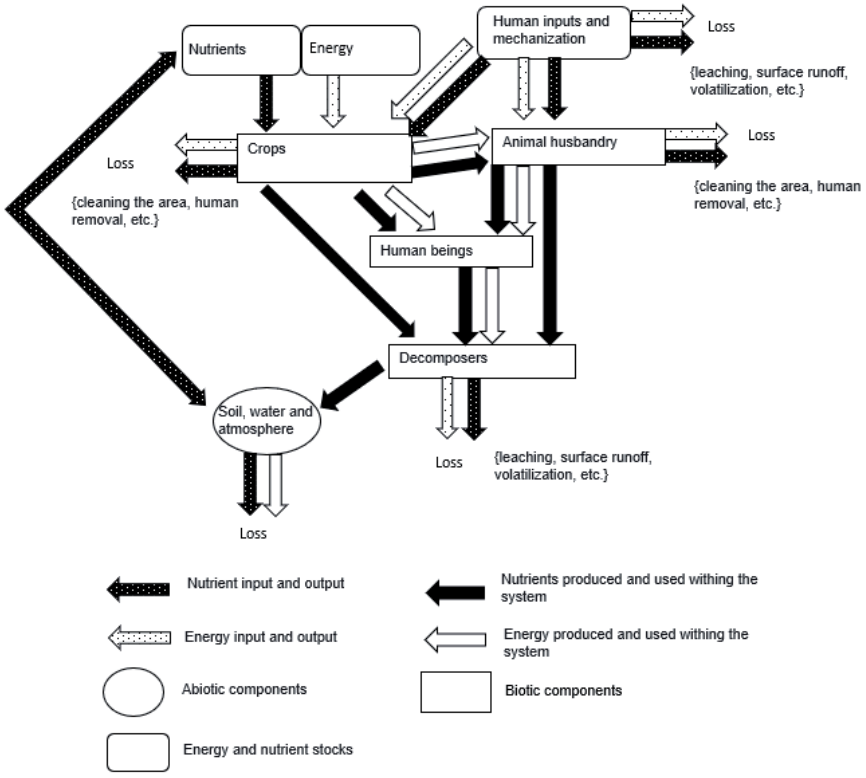

Figure 2 | Cycling of nutrients and energy within an agroecosystem

Source: Adapted from GLIESSMAN (2005).

Observing the diagrams makes it possible to identify that agroecosystems have more arrows in and out of the system. At the same time, the number of arrows that indicate the energy and nutrients produced and used within these environments is smaller than in natural environments. This indicates that they are more "open" systems than natural ecosystems, have a greater number and volume (or energy equivalent) of inputs and outputs, and also have higher entropy (ODUM, 2004).

Therefore, to achieve greater efficiency, these anthropic systems need to become less "open", seeking the supply of resources from the internal capacity of the production unit (on-farm), increasing production efficiency and decreasing the entropy produced by the system, as shown in figure 3. This understanding is consistent with the definition proposed by Feiden (2005, p. 53) about sustainability that aims "to have minimal effects on the environment and not release toxic or harmful substances into the atmosphere, surface water or groundwater."

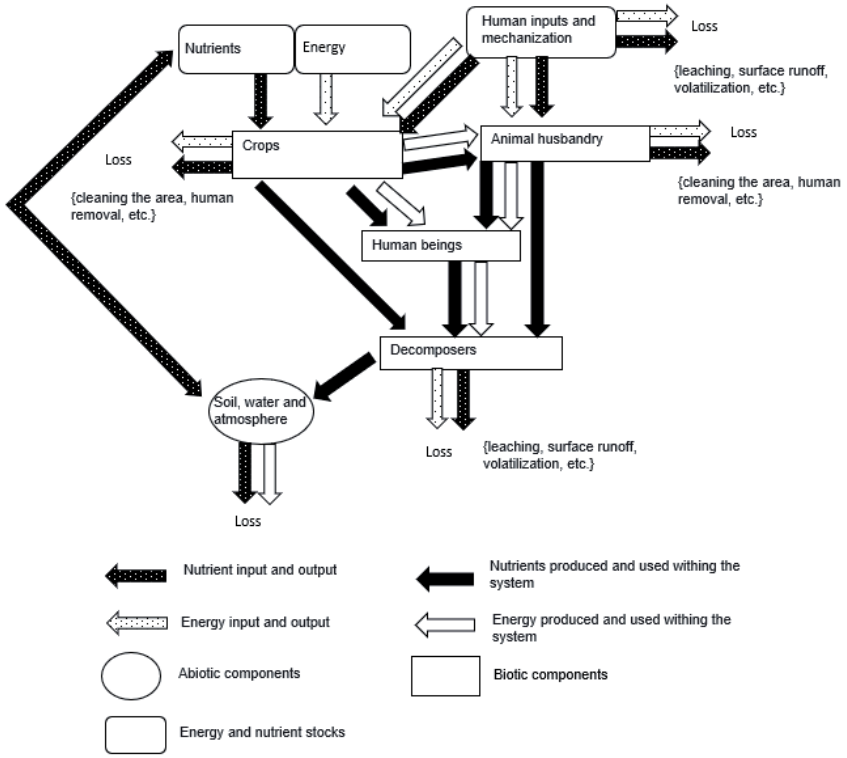

Figure 2 | Nutrient and energy cycling within an agroecosystem using on-farm produced bioinputs

Source: The authors.

Along the same line of thought, Daly (1974) proposes that efficient steady-state systems have a high capacity to convert nature's resources into services. Nevertheless, the transfer flow must first be accumulated within short-lived stocks to generate the services. The stocks, therefore, are intermediate variables that the produced services require to maintain and reproduce themselves. In this sense, the stationary level is determined as a function of the laws of thermodynamics.

Thus, the equation proposed by Daly (1974) is used to measure the level of efficiency:

$$Ultimate\ efficiency = Service \div Throughput = Service \div Stock \times Stock \div Throughput$$

Up to this point, sustainability has been analyzed from the efficiency level of natural and anthropic systems, not from the ability of a larger ecosystem to maintain them. In this sense, Daly also proposes that the steady-state economy can only be achieved under conditions of low transfer rates. The use of external resources needs to be less than the regenerative capacity of the environment and the production of waste with the assimilation capacity of the receiving ecosystems (DALY, 1974).

This understanding leads to the need to establish legal and political parameters for bioinputs that consider the ecosystemic reality and, more than that, the hegemonic production model. As Bettiol and Morandi (2009, p. 8) point out: "this approach changes the priorities of conventional agricultural systems in relation to the use of non-renewable sources, especially energy, and changes the view on the appropriate levels of balance between food production and impacts on the environment."

3.1.2 BIOINPUTS AND THE CONCEPTS OF THE INSTITUTIONAL THEORY

According to the institutionalist view of economics, institutions play a major role in directing economic actions. Consequently, they are responsible for charting society's economic "course". Thus,

Douglass North (1991) researched the behaviour of different societies concerning their institutional performance to understand the reasons that led to the stagnation of some economies and the growth of others.

Based on this premise, one must consider that for long periods, the agricultural production processes were based on conventional production systems, with the use of insecticides, chemical fertilizers, and the implementation of monocultures in larger rural areas. Therefore, the production unit was conceived from a segmented view that identifies with neoclassical assumptions by not considering the systemic characteristics of rural properties.

However, as Caporal (2009, p. 27-28) points out, due to the growing negative externalities, "society has been seeking to establish styles of agriculture that are less aggressive to the environment [...], trying to escape from the conventional style of agriculture that has become hegemonic."

Based on the understanding of this reality, it is understood that the use of alternative management, therefore, contributes nationally as a great political-institutional challenge. Creating sustainable productive systems means breaking away from traditional patterns searching for more appropriate production strategies. This implies the challenge of rethinking paradigms society follows from a network of complex relationships influencing the rules and norms of the market.

In this aspect, the word sustainability, for example, has become increasingly ambiguous because the contexts and discourses in which it has been used need to be reviewed so that it does not become a worn-out or meaningless term. Moreover, as Diegues (2003) points out, the term's application varies according to the political interest of each group or social class. Thus, the researcher exemplifies that businessmen may conceive sustainability from its eminently economic perspective or from the ability to achieve "sustainable profits". On the other hand, certain environmental groups may refer to sustainability regarding only the use of natural resources, regardless of its relationship with society.

Thus, it is understood that sustainability, as the principle governing productive systems, lacks concrete actions. However, as Sawyer (2011, p. 36-37) points out, the effects of public policies and initiatives related to sustainability cannot become ineffective or even superficial, to the point of not being perceived as effective actions, i.e., "without keeping the various ecosystems working and without meeting current and future human needs".

In developing countries, the main challenge focuses on sustainability from the social point of view. However, as Diegues (2003, p. 1) points out, society's ills are seen "by the same governments that have sustainable development as an ideological platform as natural factors resulting from technological advances and not from decisions made by powerful economic groups.

From this observation, it can be seen that more and more certification bodies have emerged that base their analyses on ecological aspects and forget about social factors. For example, one can cite the "regenerative agriculture" seal of the Regenagri Program, created by the global organization Control Union, active in several countries, including Brazil. "Regenerative agriculture" is defined from four aspects: the increase of organic matter in the soil, the preservation of local biodiversity, carbon sequestration and management of water resources (GOTTEMS, 2021).

In this context, one can mention the observation highlighted by North about the reasons that lead to unequal access to resources in less developed countries. The researcher points out that "the large gap observed even today between poor and rich countries lies much more in differences between institutional matrices than in problems of access to technologies" (GALA, 2003, p. 93). Therefore, the cause of the failures of some economies would be due to the lack of a base of rules, laws and customs capable of stimulating economically productive activities, precisely the accumulation of capital and knowledge.

The use of or even access to new biofuel technology alone cannot offer advantages beyond environmental and economic perspectives. Therefore, it cannot be recognized as a sustainable alternative in the complete sense of the term if it does not also recognize social aspects. This suggests the need to elaborate a legal framework compatible with the internal conflicts that society has been facing.

Within the Brazilian political aspects, social conflicts translate into problems that hinder even the growth of the country's economy. For, as Abramovay (2001, p. 12) points out: "a society that concentrates income generating opportunities and assets can hardly transmit to its citizens the confidence to form cooperative structures".

As a result, chronic problems are observed, such as regional asymmetries, marked by social inequality and unequal access to resources, the country's lack of articulation among social agents, and the stagnation of political agents. Natural laws alone cannot explain these factors (thermodynamics); an institutional approach is also required.

In this prism, North considers the existence of uncertainties or asymmetries of information among economic agents. This, according to the researcher, makes economic transactions between social actors impossible or difficult. Thus, institutions are essential to creating the rules of the economy that are responsible for determining the matrix of incentives (costs and benefits) for the exercise of economic activity (NORTH, 1991).

North also argues that institutions themselves, in many cases, lack accurate information, and this makes it difficult for them to make decisions based on rationality. Therefore, they base themselves much more on socially accepted conventions, given the poverty of information, making it challenging to adequate the normative frameworks to the constant process of transformations in social reality (GALA, 2003).

However, for a society with wide dissemination of information (as is the case today), the result of technological advances stemming from the Third Industrial Revolution, these arguments are not processed correctly. Thus, Toyoshima (1999, p. 104), precisely, asks, "Since the costs in obtaining information have fallen, why is there no convergence among economies?"

The answer centres on self-reinforcing mechanisms; that is, existing institutions turn out not to be efficient in generating economic development. The institutional matrix by strengthening prevailing beliefs may become sedimented over time. Thus, a network of interdependent relationships is created, in which it becomes challenging to reformulate the established institutional matrix (lock-in), and a dependency environment is created (path dependence). This hinders the emergence of institutional changes from the already solidified power arrangements (ABRAMOVAY, 2001; TOYOSHIMA, 1999).

In turn, the process of social structuring is historically delimited by the evolution of institutions. Therefore, implementing institutional transformations based on exogenous models without the proper adaptation and transmutation to local conditions almost always fails. North, therefore, proposes the gradual character of this overcoming so that social groups adopt organizational modalities derived from open, participatory and democratic governance structures, based on the independent legal system "the rule of law" (ABRAMOVAY, 2001).

3.1.3 IN SEARCH OF RESPONSES TO INSTITUTIONAL CHALLENGES

Faced with the maintenance of the productive *modus operandi* in agriculture, based on institutional arrangements solidified in a system of behaviour, specific values and beliefs.[1] The need to rethink alternatives in search of institutional efficiency and more sustainable agriculture is considered. In this context, and based on what institutionalism advocates, three works by Douglass North can be cited whose contributions are synergistic to the focus of this analysis:

1. Structure and change in economic history (1981);

2. Institutions, institutional change and economic performance (1990);

3. Understanding the process of economic change (2005).

In the first work, "Structure and change in economic history", North uses the neoclassical theory as a basis, but focuses mainly on property rights. Thus, the researcher argues that economic efficiency is based on the guarantee of property rights as an instrument to maximize the generation of wealth attributed to it. In this point, the flaw would be the search for the maximization of production in society considering the generation of rents to the rulers and not the economic growth and income distribution.

In this sense, North proposes that the structure of an efficient property minimizes transaction costs and amplifies both the current income and the production growth rate. Ultimately, North emphasizes the importance of institutions as a tool to overcome the incentive dilemma between paying taxes and economic growth.

In *"Institutions, institutional change and economic performance"*, North demonstrates that weak institutions can be maintained or strengthened, depending on social actors' incentive and power structure. The argument is developed in three parts.

In the first, institutions provide stability and guidelines for action given the lack of information and the inability of agents to make rational choices. Institutions, therefore, create formal rules, informal rules, and enforcement procedures.

In the second, North states that there is a dependence on institutional trajectories for institutional efficiency. The initial structures of institutions that allow changes in contracts, changes in property rights, and economic rules are decisive in this process. The outcome depends, among other things, on price differentials, bargaining power among organizations, informal constraints, and enforcement procedures.

In the third, North emphasizes the importance of incremental change in path dependence because tangential changes can produce structural changes. Some countries have proven better at this than others, and North cites the example of Japanese economic modernization.

The last work, "Understanding the Process of Economic Change," analyses the importance of evolving beliefs for institutional change to occur. When accepted by society, the belief system can be a major factor in increasing the economic system's productivity. The dominant beliefs, for example, related to the fulfilment of contracts and the smoothness of government transactions, can result in the addition of an elaborate structure of institutions, formal and informal, which will determine economic growth. In other words, they constitute the emergence of a behavioural matrix that induces procedural innovations that induce the expansion of systemic productivity.

In this way, North conceives of an open circular flow, in which initial perceptions of what constitute productive incentives lead to the construction of a set of beliefs and convergent behavioural conventions to capitalist modernization. However, the path-dependence rarely changes direction abruptly since the effect of beliefs and institutions constrains the emergence of transformations rapidly. However, democratic social systems that privilege autonomy, decentralization, and social participation are more efficient in generating institutional transformations, as they reward cooperation and collaborative interaction, inducing a higher degree of economic efficiency. Therefore, they signal an innovative concept concerning other systems, as they suggest participation through socially rooted mechanisms as a strategy to overcome the challenges of stagnation in political-institutional development.

Based on the works of Douglass North, it is possible to make some notes about how his theoretical contribution could be processed in the context of the establishment of an institutional framework for biofuels in Brazil. In a first analysis, we highlight the importance of social conventions in the institutional trajectory of the country. In this aspect, it is worth emphasizing the formative character of institutions in the dissemination and consolidation of ideas and moral values. Furthermore, it is worth pointing out the social heterogeneity in the country, given its constitutive diversity. On the other hand, the dominant beliefs and values are preponderant in determining the historical-institutional course, given the construction of legal and social restriction mechanisms. In this case, we should also highlight Brazilian society's clear segregationist and concentrated character, characterized by a high land concentration and income inequality in rural areas (FERNANDES, 2015; FURTADO, 2020). Therefore, it is assumed that this course will hardly be abruptly changed, and the flexibility for institutional changes depends on the mobilizing capacity of the social actors involved.

On the other hand, incremental changes can be the key in the decision-making processes of institutional changes. The path proposed by North, and reinforced by the current of neoinstitutionalist researchers (EVANS, 1996; OSTROM, 1990; SCHARPF, 1997), is the creation of shared governance mechanisms, such as the creation of a structure of incentives and autonomy via decentralization and social participation rewarding cooperation. From these conjectures, it is possible to glimpse the conceptual scheme of how institutional influences are processed and how social participation, through incentive rules for cooperation, can stimulate institutional efficiency (figures 4 and 5).

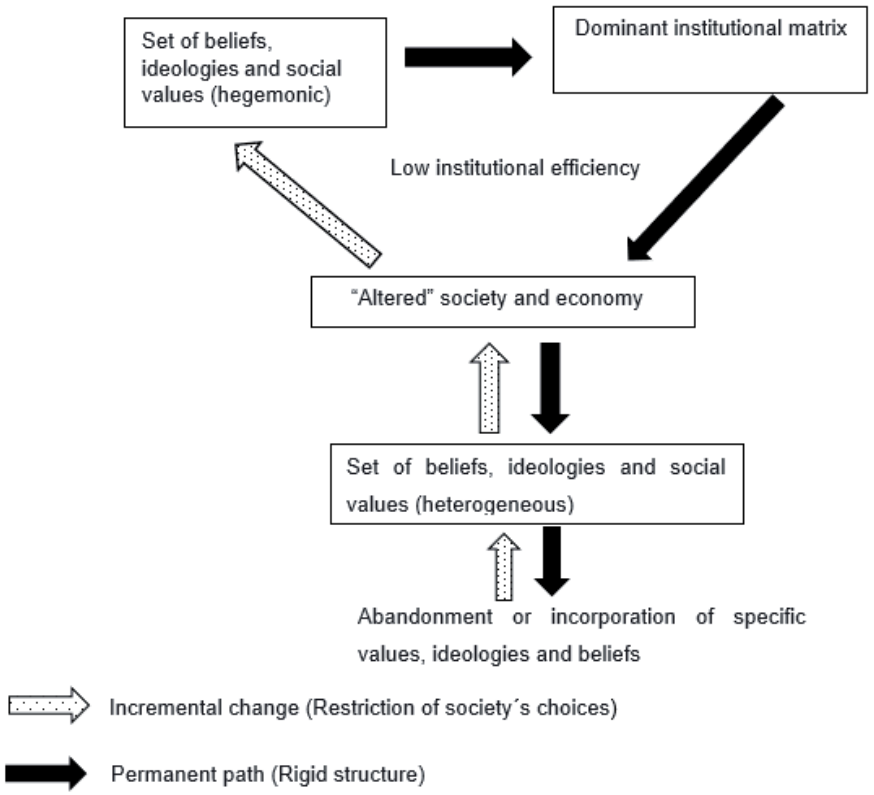

Figure 4 | Open circular flow of institutional changes in society and economy, marked by low institutional efficiency.

Source: The authors, based on North (2005).

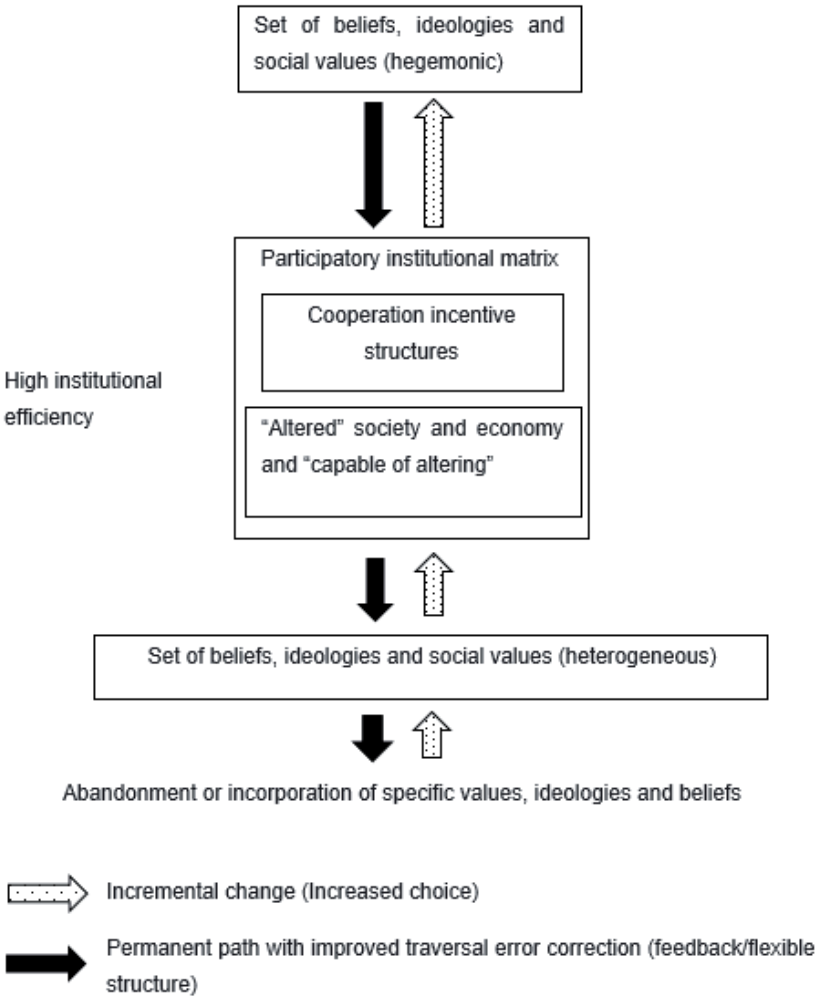

Figure 5 | Circular flow of institutional change in society and the economy with the insertion of participation and cooperation incentive structures marked by high institutional efficiency.

Source: The authors, based on North (2005).

Unlike figure 04, which presents a circular flow of change without effective participation structures, figure 05 illustrates more outstanding communication between agents through the arrows that indicate the path of institutional change, with the possibility of error correction and the decentralization of decision-making power. Thus, the Brazilian reality demands the creation of other mechanisms besides the insertion of new technologies. In constructing a legal framework, it should consider bio-inputs and the evident political, economic and social asymmetries in Brazil and all the complexity that large rural properties, research and technical assistance institutions require for the implementation of sustainable transition agriculture.

3.2 NATIONAL BIOINPUTS PROGRAM: CHALLENGES FOR ITS REGULATION

The National Bioinputs Program developed in Brazil has been thought of as an instrument to "expand and strengthen the use of bioinputs in the country to benefit the agricultural sector" (BRASIL, 2020, p. 105). However, as seen, because it is a recent legal instrument, it needs more studies and adequate parameters and legal provisions. Furthermore, due to the growing adherence to ecological principles in primary production, especially in large rural properties, coherent bases must be established to guide the production chain in the search for transition models.

The technical explanations proposed by ecological economics present themselves as an essential step in reviewing the productive models. Along these lines, on-farm production of biofuels can bring countless environmental, economic, and even social benefits. However, to regulate it, it is also necessary to consider the entire Brazilian socio-political context to establish guidelines that are coherent with the country's reality.

Thus, as a governmental action within the National BioInputs Program with an institutional focus, the National Institute of Science and Technology created the "Microorganisms that Promote Plant Growth for Agricultural Sustainability and Environmental Responsibility" (INCT-MPCPAgro). Coordinated by Embrapa to develop and promote scientific and technological research on the use of bioinputs in the country, IT consistS of more than 20 research or educational institutions and more than 20 private sector companies.

In addition to this crucial institutional representation, the government has also established, through Decree 10.375/2020, the Strategic Council of the National Bioinputs Program, composed of members of the federal government and representatives of civil society, which aims to: support the strategic planning and management of the National Bioinputs Program and propose federal public initiatives for the development of bioinputs.

The creation of the representative bodies is an essential initiative in discussing a legal framework for the Program, but it is not enough to ensure success in its political construction. The effectiveness of the collaborative and consultative process of drafting legal and guidance instruments for the Program also depends on ensuring broad popular participation, including those who have fewer material resources and who could be affected by policy changes in agricultural production, such as family farmers, peasants, and small and medium-sized rural producers. As Abramovay (2012, p. 23) points out: "A new economy has the mission of broadening the participation of individuals and various types of communities in innovation and wealth creation.

In this way, the inclusion of agents can figure as a possibility to rediscover new points of view because collaborative management expands creativity and innovation. On this subject, Abramovay also highlights (2012, p. 24): "The consequences of this new reality are decisive not only in defining conventional property rights over innovations but also by opening unprecedented perspectives of social interaction in corporate management".

Citizen participation in the construction of public policies and the creation of innovation mechanisms are essential for the enrichment of ideas and effective strategies. On the other hand, especially in actions involving biotechnology, care in the registration of technical responsibility is essential to ensure safety and accountability for any effects resulting from the use of products.

The INCT-MPCPAgro highlights some challenges facing the implementation of the National Bioinputs Program in Brazil. In its technical report, it is possible to identify the government's concern regarding the production and use of on-farm bioinsuments, indicating that the improper handling of bioinputs can bring severe health and environmental problems (BRASIL, 2020).

Thus, considering the need for regulation of the Program, the Bill of Law No. 658 of March 2021, which provides for the classification, treatment, and production of biofuels through on-farm biological management and ratifies some items of the National Bioinputs Program, is being discussed in the House of Representatives. Among the main proposals presented by the Bill, there is the classification of bio-inputs according to their potential biological risk and the detailing of rules for the production of on-farm biological inputs, where the Ministry of Agriculture should prepare a Manual of Good Practices for on-farm biological management to guide rural producers (BRASIL, 2021).

From the analysis of the INCT-MPCPAgro's Technical Note and PL 658/2021, it is noticeable that the main regulatory difficulty lies in the possible biological risks associated with the production, distribution

and use of on-farm bioinputs, as well as on the registration and improper possession of these products (property rights and biopiracy).

In this sense, it is possible to recognize that although harmless to the environment and public health, bioinputs, if improperly managed, can bring harmful effects. For example, Capalbo and Nardo (2000) point out the possible harms resulting from the improper use of bioinputs, among them: unexpected properties through interaction with other organisms (harmful or beneficial); disturbances in the balance of an ecosystem (where a beneficial organism could become a "pest"); and finally, the possibility of unintentional transfer of genetic information between organisms (so that non-pathogenic beings could become pathogenic, or those already pathogenic could have their range of hosts increased).

However, there are many examples of success with applying these products, especially in agriculture, which presumes that their use correctly and with proper government support can bring health, environmental and social benefits (MORANDI; BETTIOL, 2009). In this sense, bio-inputs can present themselves as an alternative to replace conventional pesticides whose indiscriminate and habitual use in agriculture has promoted several environmental and health problems (PIGNATI, 2007).

Therefore, among the actions necessary for implementing the Program in Brazil, there is an urgent need for investment in research to understand the mechanisms of action involved in ecological interactions between bioinputs, the environment, their target and non-target compartments. Thus, studies involving environmental risk analysis, environmental impact studies and reports on the behaviour of biocontrol agents are necessary for their safe adoption.

These studies should be conducted in an interdisciplinary way, involving experts in different areas of knowledge, along with the productive sector (small, medium and large producers) and the government. After validating the research and its production, appropriate mechanisms should be created to transfer knowledge and products to those who need them most: the socioeconomically vulnerable rural producers.

It can be seen that the lack of interaction between agents of society has been the cause of many failures concerning efficiency in the creation and development of public programs. As Morin (2004, p. 21) warns, "the absence of complexity in scientific, political and mythological theories is linked to a certain lack of complexity in the social organization itself." The researcher highlights a tendency to simplify the fragmentation of knowledge and that inter, and multidisciplinary considerations are essential to think from an ecological and systemic approach.

There are already some actions to improve the interaction mechanisms between social agents. One of them is the Bioinputs application (APP). This APP is an advance concerning access to information for small, medium, and large rural producers. The on-farm Good Biological Management Practices Manual can also offer advantages, but all this information still lacks adequate monitoring by a duly qualified professional who can guide the actions.

Therefore, it is necessary to invest in rural extension activities to avoid the problems related to the biosecurity of these products, especially concerning the genetic manipulation of living organisms. An example is seeds, whose genetic manipulation has caused irreversible social and environmental problems, such as increased dependence on external inputs and "genetic erosion" (disappearance of numerous plant species), due to the progressive replacement of native seeds by the massive use of genetically improved and patented species (FERNANDES, 2017).

As an alternative, the state needs to foster access to and the sustainable use of native microorganism species in biological control and thus encourage the use of disease and pest control methods through management strategies, recomposition, and conservation of natural resources, stimulating the autonomy of production units.

If there is concern about the misappropriation of living resources, access to this diversity cannot be denied, nor can the fair and equitable sharing of the benefits derived from its use, as stated in the Convention on Biological Diversity signed in 1992 (MMA, 2000). In this case, a new legal framework for the Program must pay attention to this obligation, considering the dependence on biological resources that many local communities have.

Brazil has enormous biodiversity, and when companies use this biodiversity to make several bioproducts to be commercialized, they must also incur the burden resulting from the socio-environmental damage caused by their introduction into the environment and the consequences of these factors.

As asserted by Cavalcanti (2004) and Cechin (2010), an economic system that considers ecological principles must recognize that in conventional economic activities, the costs usually considered in the calculation of economic benefits are those internal to these activities (so-called private costs), such as environmental contamination or the extinction of a species, are externalities that are excluded from the economic calculation.

In this sense, the authors emphasize the need to consider ecological effects when calculating the economic benefits of activities. As Cechin (2010, p. 86) points out, if the ecological costs "are greater than the benefits generated by growth, then growth is uneconomical. To this factor must be considered the sharing of benefits gained with traditional populations that are holders of knowledge and have contributed with numerous researches, which result in the manufacture of various bioproducts.

A legal framework anchored in ecological, social, and ethical principles should respect and reward those who hold the knowledge accumulated over generations. On this subject, Brito and Pozzetti (2018, p. 61) comment that "Brazilian legislation is weak and that a more efficient mechanism is needed that can guarantee a fair distribution of benefits and ensure the protection of traditional knowledge from misappropriations."

Besides the issue of property rights and fair distribution of benefits, biopiracy is another crucial factor that needs to be better regulated. The great national biodiversity attracts international interest, and many take advantage of the country's vulnerabilities to collect and send materials abroad to manufacture products illegally and without paying royalties to Brazil. In addition, the knowledge associated with the use of these materials by its inhabitants is also usurped (GOMES, 2007).

Cunha (2020) highlights the chronic problems existing in the country that favour the illegal appropriation of genetic resources and the knowledge associated with them: the disorganization and lack of an efficient inspection system, the existence of soft laws, the ease of access by foreigners to places with high biodiversity and a large number of researchers in the Amazon region, without adequate control or registration of their activities.

As observed, the lack of effective normative instruments focuses on, basically, three aspects, namely: the need for more studies regarding the impacts of the use and management of bioinputs, the security of the Brazilian genetic heritage, and finally, aspects related to the appropriate sharing of benefits and accountability for damages resulting from products and processes that involve them.

To resolve these bottlenecks in constructing a new regulatory framework, institutions should not focus on "developing" the economy and society but rather on building sustainable communities and societies. In this aspect, Diegues (2003, p. 3) points out that "(...) the construction of sustainable communities and societies must start from the reaffirmation of their cultural and historical elements, from the development of new solidarities, from the respect for nature, not from the commodification of biodiversity." These are preponderant factors in the establishment of any public policy.

4 FINAL CONSIDERATIONS

The predictions of increasing world population, and in contrast, the search for sustainable production patterns, have greatly influenced the tendency to adhere to innovative technologies. In this scenario, there are great expectations about the use of biofuels, mainly because of the possibility of providing production increments and, at the same time, bringing the slogan of sustainability with it.

In this scenario, large-scale production has caused significant changes in agroecosystems, making them highly vulnerable and dependent on non-renewable inputs, which opens the way to rethink the conventional model of productivity and encourages adherence to alternative production systems.

There are several advantages in applying these products, such as their use as inoculants and for the biological control of plant diseases. Bioinputs can also be manufactured through relatively simple, low-cost processes, even on-farm.

However, even if this technology is innovative and presents itself as an alternative for replacing conventional pesticides, which have caused countless environmental problems, it can also bring harm if mishandled. The risks range from problems with residues and the introduction of pathogens to the possibility of unpredictable reactions due to interaction with other organisms.

In this sense, an important step was taken with the passage of bill No. 658/2021 in the House of Representatives, which provides for the classification, treatment and production of biofuels through on-farm biological management, including defining guidelines for use and marketing, as well as risk classification of biofuels, and facilitating production mechanisms by family farmers.

However, more profound changes are needed, and this study demonstrates that the contributions of ecological economics to the construction of a legal framework for bioinputs public policy (and of transitional agriculture) occur through research that demonstrates the advantages of increasing ecological diversity in agroecosystems, emphasizing the value of on-farm bioinput production in order to increase energy and material efficiency in production units.

In turn, approaches based on institutional theory indicate the need to create structural changes capable of incorporating even more efficient mechanisms of social participation through the insertion of benefits to encourage cooperation and participatory formulation of public policies and institutional rules.

Even if there is no applicable model capable of bringing efficiency and development in different contexts, this approach precepts the need to carry out holistic considerations that can direct the production and use of bioinputs in the country. The construction of any public policy that involves productive and economic aspects requires the recognition of all the ecological and social complexity present in the Brazilian scenario.

NOTE

1 | Although evidence based on scientific rationality is capable of demonstrating the inefficiency of hegemonic agricultural production processes and the socio-environmental crises associated with them, according to research carried out by Altieri (2004); Caporal (2009); Gliessmam (2005); Primavesi (2002) and by other researchers.

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