TECHNOLOGY ACTION PLANS FOR THE ENERGY SYSTEM, AGRICULTURE, FORESTRY AND OTHER LAND USE SECTORS

EXECUTIVE SUMMARY

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Secretariat for International Economic Affairs
Ministry of Economy
BRAZIL
MINISTRY OF SCIENCE, TECHNOLOGY AND INNOVATIONS
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TECHNOLOGY ACTION PLANS FOR THE ENERGY SYSTEM, AGRICULTURE, FORESTRY AND OTHER LAND USE SECTORS

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Ministry of Science, Technology and Innovations

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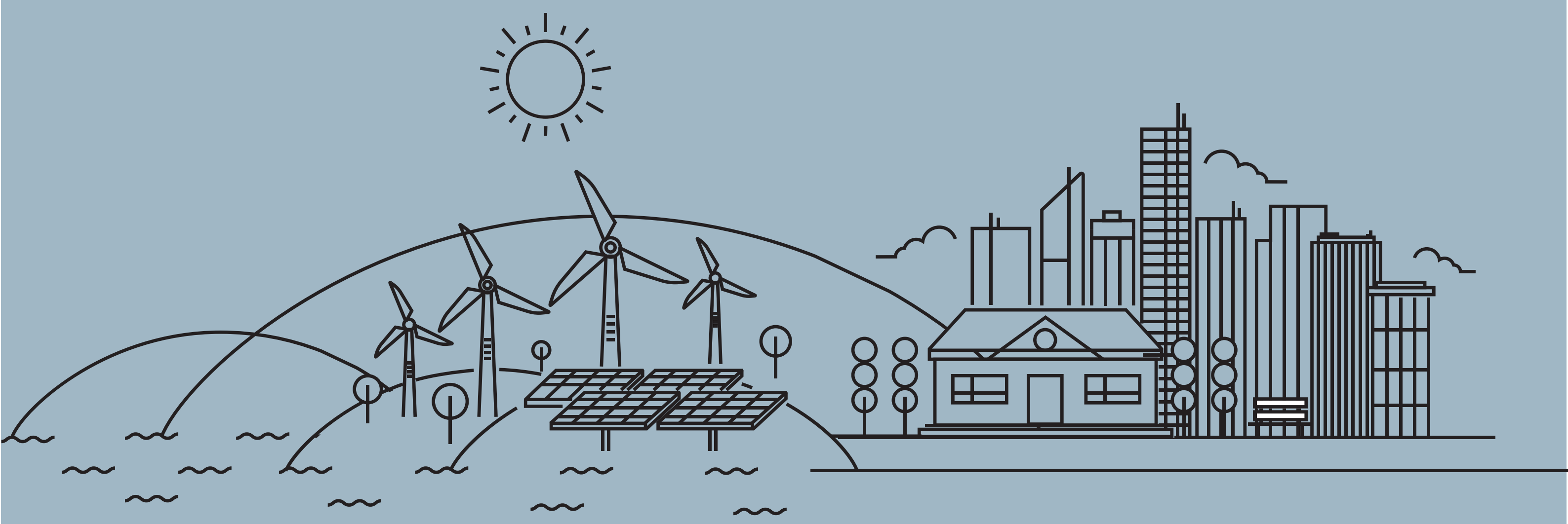

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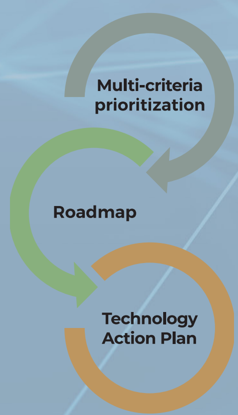


Introduction

The "Technology Needs Assessment for the Implementation of Climate Action Plans in Brazil (TNA_BRAZIL)" project aims to strengthen the technical capacity of the Brazilian government through the development of a comprehensive assessment of technology needs for the implementation of climate action plans in Brazil aimed at providing subsidies for decision making to meet GHG emission mitigation goals under Brazil's Nationally Determined Contribution (NDC) and Brazil's strategy for the Green Climate Fund (GCF).

The TNA_BRAZIL project preparation process has three phases: i) identification and prioritization of technologies for the selected sectors; ii) identification and analysis of value chains, co-benefits and the main barriers to the development and diffusion of the prioritized technologies; and iii) the proposition of Technology Action Plans (TAPs), based on previous results, to foster the development and diffusion of the prioritized technologies in each evaluated sector.

Each TAP consists of an action plan to address technology, training or diffusion, among other considerations, which translates into concrete actions aimed at the development and/or diffusion of the technologies in the prioritized sectors. The actions, in turn, can be subdivided into activities and indicate the necessary resources for their application, including schedules, cost estimates and potential stakeholders to mobilize throughout the process. Furthermore, actions should take into account implementation risks so that measures may be proposed to limit these risks.

It should be noted that there was a comprehensive breakdown of costs related to the actions and activities in the plans in the following areas: human resources; permanent materials; consumables; and third-party services and travel and hotel expenses, among others. All information was systematized in MS-Excel spreadsheets, which the National Directorate of the TNA_BRAZIL project will make available to stakeholders interested in preparing project proposals.[1]

In the energy, agriculture, forestry and other land use sectors, the following technology packages were prioritized (the action plans are summarized below): floating solar power plants; flex hybrid vehicles; ethanol fuel cell electric vehicles; energy generation from agricultural and agro-industrial waste; solar photovoltaic induction stoves; innovative materials for cement; industry 4.0; precision agriculture (PA); genetic improvement (GI) of beef cattle; silviculture and genetic improvement of native species; silviculture with mixed planting for restoration; and satellite monitoring.

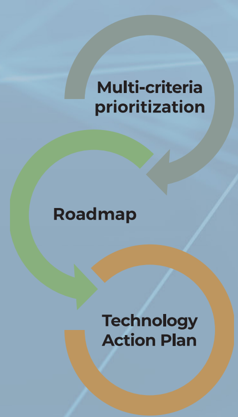
Meetings to validate the TAPs were conducted between March and November of 2020 with members of the project's Technical Advisory Committee (TAC) and the Sectoral Chambers (SCs). They were systematized using matrices, leading to improvements in the plans (MCTI, 2020a; 2020b). The participation of key stakeholders was fundamental for the robustness of the Plans, which were widely publicized on official MCTI channels (MCTI, 2020c) and through seven webinars held between October and December of 2020 (MCTI, 2020c-2020i).

In what follows, we present the TAPs, organized by the technologies to be implemented. This is followed by project ideas that aggregate plans according to scope and goals. Finally, we present our conclusions at the end of this document.

[1] Send requests for access to the spreadsheets, specifying the Action Plan, to tna@mctic.gov.br.

1.

Technology Needs Assessment **for Floating Solar Power Plants**

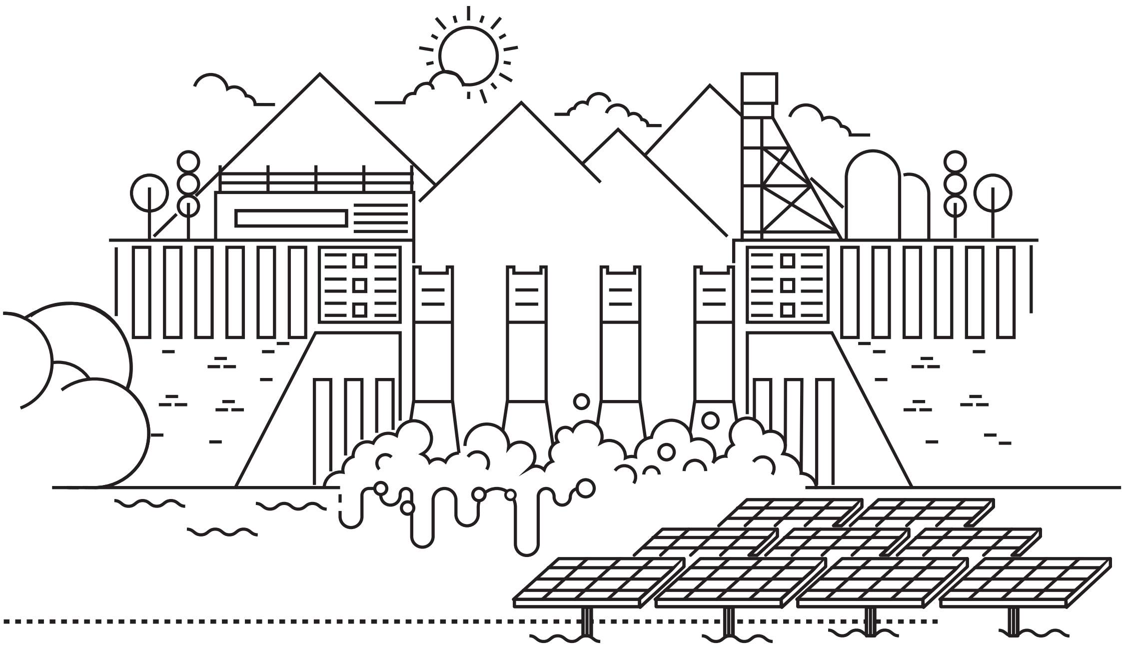


1. TAP FOR FLOATING SOLAR POWER PLANTS

Floating solar systems differ from conventional photovoltaic systems in that the support structure of the panels involves floats and an anchoring system that must ensure the stability of the photovoltaic panels in winds, waves and currents. They can be installed in lakes, ponds, reservoirs, channels and dams, among other bodies of water.

It is necessary to address some issues to ensure that the mapping of the energy source contributes effectively to its development. The first issue is of a technical nature and is related to the lack of mapping of the sustainable potential of floating solar. In other words, there is a need to collect specific data to map the areas available for the installation of floating solar projects in terms of sustainability, analyzing environmental and social restrictions that may conflict with the implementation, especially in view of the multiple uses of hydroelectric power plant (HPP) reservoirs in Brazil. In addition, as it is an emerging energy source in the country, little is known about the technology and its benefits. Given this barrier, it is often discarded an option for power generation to be developed, mainly due to the availability of other renewable energy sources already in use in the country. This has resulted in a lack of interest in understanding its potential. In addition, there is a degree of uncertainty about land use rights and reservoir management obligations, since, quite often, reservoirs have multiple uses that have to be guaranteed and enforced, such as navigation, water supply, tourism, leisure and fishing, as well as environmental conservation. With respect to the installation of plants, specific regulatory and administrative regulations on the use and concession of reservoir water surfaces are still being defined by the competent authorities. Thus, this barrier undermines business interest in the technology, underscoring the need to discuss these issues at the reservoir and the institutional level when considering the potential of this energy source.

By removing these barriers, a number of benefits may be obtained. In addition to being a renewable and safe energy source, which contributes to the reduction of greenhouse gas (GHG) emissions in the energy sector, floating solar power plants provide other important benefits, such as: i) improved energy production due to water cooling the panels and a reduction in the likelihood of shading from structures (improving the efficiency of the system); ii) a reduction in potential conflicts with other priority land uses; iii) a decrease in capital costs with networked connection infrastructure; iv) an increase in the availability of reservoir water for other human uses, such as water supply and navigation; and v) the generation of employment and income in the floating solar implementation and maintenance phases, among others.



Solar Power Plants

Before and after implementing the Action Plan

	Current situation	Action Plan	Impacts
MAPPING OF POTENTIAL	• Lack of mapping of the sustainable potential of the energy source • Lack of knowledge of the technology and its benefits. • Lack of clarity of reservoir management obligations. • Technology readiness level of complete, tested, qualified and demonstrated system (TRL 8).	Prepare a national inventory of floating solar energy potential, in view of the application of restrictions, to anticipate impacts and identify critical points of the technology for the different types and conditions of the country's reservoirs.	• Increase in energy efficiency compared to conventional solar farms (cooling of panels). • Increase in energy contribution from renewable sources in the electricity matrix. • Contribute to the mitigation of 5.4 $MtCO_2$ by 2030. • Technology operating in all conditions, areas and range (TRL 9). • Increase in the availability of water for human consumption and power generation. • Generation of jobs and income (installation and maintenance of panels).

Figure 1 – Before and after implementing the TAP

Source: the author.

To obtain these benefits, the TAP aims to develop a national inventory of floating solar energy potential, taking into account restrictions, in order to anticipate impacts and identify critical aspects of the technology for the different types and conditions of reservoirs in Brazil.

The TAP includes actions to achieve the goals. Aimed at addressing the vast geographical size of the country and, at the same time, the accuracy of the data, the Plan was conceived in two stages. The first stage, which encompasses Actions 1 and 2, consists of a broader analysis that involves compiling the existing data on the HPP reservoirs across the country. This data addresses the solar energy potential and climatic conditions that can affect solar photovoltaic energy generation, and basic data on the reservoirs, such as location and surface area. This is following by a preliminary mapping of the potential of floating solar technology on a national scale. Based on this mapping, a deeper analysis is obtained. To this end, the proposal is to select five promising Brazilian reservoirs, preferably with different bio-climatic conditions, to serve as sites for the pilot projects. With the reservoirs selected, the second phase consists of estimating the solar energy potential on the reservoir surface with greater precision and collecting high resolution spatial data and specific data for the precise mapping of available areas for installing the floating solar power plants. Thus, in addition to the preliminary mapping of solar energy potential on a national scale and detailed case studies on the five most promising reservoirs in the country, the Plan will indirectly provide a methodology for identifying locations for the installation of future floating solar projects. Furthermore, it will include the creation of a database of high-resolution spatial data for the analyzed reservoirs, and an analysis to support discussions on the feasibility of developing the energy source in the national or regional context.

Solar Power Plants

The TAP for floating solar energy is structured in 4 actions, with a 5-year execution period

Figure 2 – TAP macro-actions

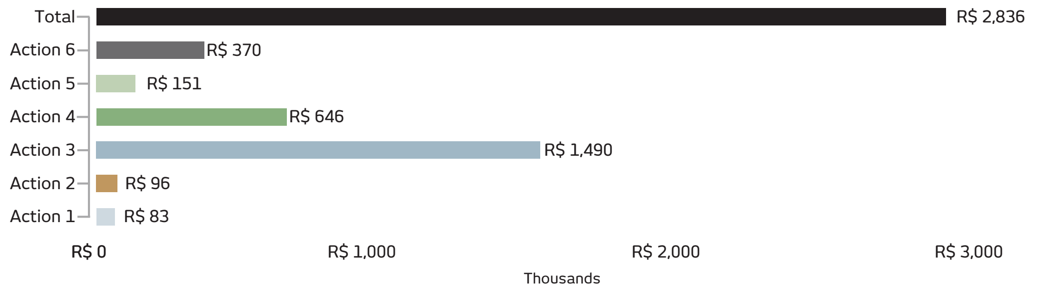
Source: the author.

The successful implementation of the Plan depends on the participation and contribution of multiple stakeholders. Thus, it should involve public sector stakeholders, regulatory and supervisory agencies, technical and scientific support institutions (including universities and research centers), the private sector and technology promotion and development institutions. It is a highly technical and multidisciplinary TAP, which involves the data gathering and production and spatial and energy analysis. Thus, the coordination and/or Results Validation Committee should be a partnership between a public institution in the energy sector, such as the Ministry of Mines and Energy (MME) and/or the Energy Research Company (EPE), and an institute or research group with expertise in climate and energy studies (with the competence to carry out all the actions), such as the National Institute for Space Research (Inpe). Especially for Action 3, which is the most specific, costly and long-term action in the Plan, it is essential that Inpe head technical coordination, given that it is the research center with the most experience and the best computational infrastructure to carry it out and is already leading the effort to map solar energy potential in Brazilian waters. Some activities, such as Action 4, which involve specific technical studies, should be carried out by contracted specialized companies, under the supervision of the TAP coordination institution.

The time frame for implementing the action plan is five years, with an estimated total cost of approximately BRL 2.8 million. Actions 3 and 4, which concern the production of solar resource data on bodies of water and specific high-resolution data for reservoirs, respectively, are the most significant in terms of costs. The cost estimates for all actions include the contracting of staff, materials, possible third-party services and travel and hotel expenses. Action 3, for example, already includes the costs for installing and maintaining solarimeter buoys (sub-activity 3.1), as well as data storage and processing on site and in the cloud for sub-activity 3.2.

Solar Power Plants

Implementation costs



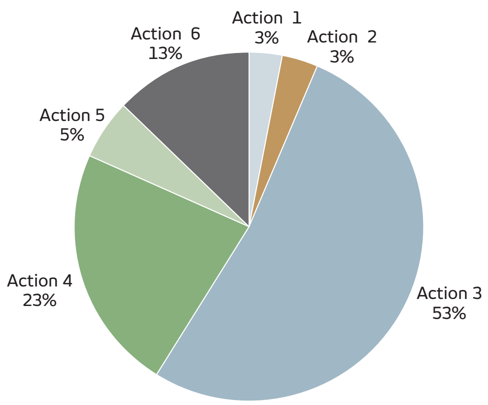


Figure 3 – TAP implementation costs

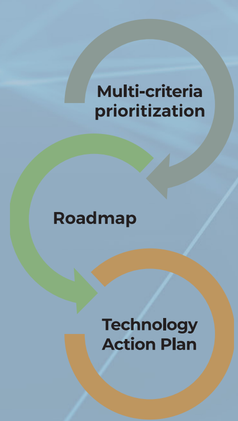
Source: the author.

With respect to potential sources of financing for the activities, and with a view to financial results and a focus on research and development aimed at the subsequent diffusion of the technology, we determined the typical means of financing would be non-repayable loans and technical assistance. Financing is accessible by state agents (federal, state and municipal), companies (public and micro companies and small, medium and large private sector companies), associations and cooperatives. The mechanisms to request resources are presented in the "Electronic guide to financing options for the technologies prioritized in the TNA_BRAZIL Project" (MCTI, 2021j).

Finally, a risk and contingency plan was proposed for the implementation of TAP actions and activities. The higher risks are associated with Action 3 and sub-activity 5.2. Sub-activity 3.1 could be hindered by potential failures or technical problems with the measuring instruments, representing a high risk with potential serious consequences for the progress of the rest of the project. The first measure to address these risks is to install redundant sensors on the solarimeter buoys. In addition, we propose a period of six months, prior to the installation of the instruments, so that technical cooperation agreements (TCAs) may be signed with the concessionaires responsible for the reservoirs, and with local science and technology institutions for monitoring and maintenance of instruments during the measurement period, combined with routine on-site visits by a project specialist. Sub-activity 3.2 runs the risk of becoming unfeasible due to the contracted party's computational limitations, which also risks undermining the progress of the rest of the project. To avoid this risk, technical capacity and computational infrastructure to support the modeling should be ensured, with a clause to this effect in the modeling consulting contract. In addition to this, a budget was projected for contracting computational resources for on-site and remote cloud modeling. Sub-activity 5.2 concerns the application of the methodology previously outlined for the determination of available areas for installing floating solar power plants in HPP reservoirs, taking into account technical, environmental and social restrictions. However, given the lack of an environmental regulatory framework and clear land use rights, there is the risk that the methodology applied in sub-activity 5.2 will not be applicable in the future, given that determinations may change on land use restrictions and the criteria for issuing licenses and concessions for projects. Thus, the participation of regulatory and environmental agencies in the validation of the methodology for determining areas is essential.

2.

Technology Needs Assessment **for Flex Hybrid Vehicles**

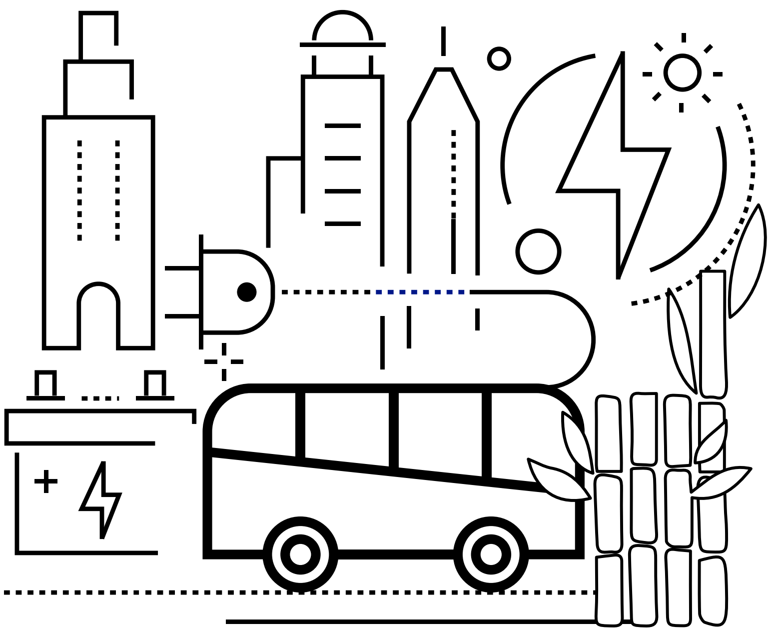


2. TAP FOR FLEX HYBRID VEHICLES

Hybrid vehicles (cars, buses or trucks) contain an internal combustion engine and an electric motor. They use these motors in series, using the combustion engine to generate electricity for the electric motor, or in parallel, used together when necessary or at low revolutions, such as in traffic. They can also vary in electrification levels and can be equipped with a simple start-stop system, which allows the engine to be turned off when the vehicle is idling, or the sole use of the electric motor to power the vehicle.

They can run on different ratios of gasoline and ethanol, or even use each fuel independently. In addition to the advantage of improved fuel consumption with the combined use of an internal combustion engine and an electric motor, there is also a reduction in GHG emissions compared to single-fuel gasoline, ethanol or diesel engines. In the case of flex hybrid buses, which is the focus of this TAP, some additional advantages are noteworthy: i) a reduction in fuel consumption per kilometer; ii) the ability to run on more than one fuel; iii) emissions reductions, compared to the conventional diesel buses used in the Brazilian fleet; and iv) a high penetration potential in urban centers.

The goal of this TAP is to develop a pilot application of a flex hybrid bus fleet for a municipal transportation line by 2030. Achieving this goal would imply the transition from technology readiness level to validate the integration of vehicle components in a laboratory environment (TRL 4) to testing the system prototype in an operational environment, with the production of components on a commercial scale (TRL 7). Moreover, it would help overcome bottlenecks, such as the lack of national technological content; the high cost of investment for automakers to produce the hybridization kit components; and the lack of technological standards.



Flex hybrid vehicles

Before and after implementing the Action Plan

	Current situation	Action Plan	Impacts
USE OF COMPONENTS IN VEHICLES	• Lack of technology standards. • Lack of vehicle components at local level. • High investment costs for the production of vehicle components. • Validation of component use in vehicles only in the laboratory environment, or basic experimental laboratory arrangements (TRL 4).	Develop pilot application of a flex hybrid bus fleet for a municipal line by 2030.	• Efficiency gains compared to internal combustion engines (lower fuel consumption per km) • Contributes to the mitigation of 400,000 tCO_2 by 2030. • System prototype testing in an operational environment, enabling the production of components on a commercial scale (TRL 7). • High penetration potential in urban centers. • Preservation of jobs and income in the sugar-energy sector.

Figure 4 – Before and after implementing the TAP

Source: the author.

The TAP is divided into seven actions, with their respective activities, which include: i) evaluation and selection of a municipality for the pilot implementation of the flex hybrid bus fleet; ii) selection and simulation testing of the characteristics and equipment for flex hybrid buses in the fleet; iii) creation of a startup for developing and installing bus retrofit kits to transform them into flex hybrid buses; iv) equipment design and elaboration of hybridization kit to convert a fleet of diesel buses into flex hybrid buses; v) pilot application of this fleet in the municipality selected in Action 1; vi) demonstration and data collection of the flex hybrid bus fleet, with the dissemination of demonstration results; and vii) training of personnel for the operation and maintenance of the pilot fleet.

Flex hybrid vehicles

The TAP for flex hybrid buses is organized in 4 actions, with a 8-year implementation period

1. SELECTION OF MUNICIPALITY AND SPECIFICATIONS

Selection of a municipality for the pilot application of a fleet of flex hybrid buses and determination of fleet specifications (2 years) .

2. CREATION OF ITS

Creation of a startup to produce and install retrofit kits in conventional buses for conversion to flex hybrid power (1 year).

3. DESIGN AND APPLICATION OF KITS

Elaboration of the hybridization kit project and pilot application in a bus fleet (2 years).

4. DEMONSTRATION, COMMUNICATION AND TRAINING

Demonstration of the fleet of hybrid flex buses and communication of results. Training for fleet operation and maintenance (3 years) .

Figure 5 – TAP macro-actions

Source: the author.

The mobilization of multiple stakeholders, from different segments, ensures greater cooperation between stakeholders and government bodies for the success of the Plan. Itaipu Binacional, a company with a significant portfolio of electric vehicle, electric plane and ethanol hybrid bus projects, could coordinate it. Governance could be carried out by key stakeholders, such as the National Transport Confederation (CNT); the National Petroleum, Natural Gas and Biofuels Agency (ANP); the National Motor Vehicle Manufacturers Association (Anfavea); the National Association of Urban Transport Companies (NTU); bus dealerships; and the Integrated Technology System (ITS).

The TAP implementation period is eight years, with a total cost of BRL 8.3 million. Action 4, involving the design and assembly of the hybridization kits, as well as the acquisition of the necessary equipment for their assembly, accounts for approximately 54% of the total cost of the project.

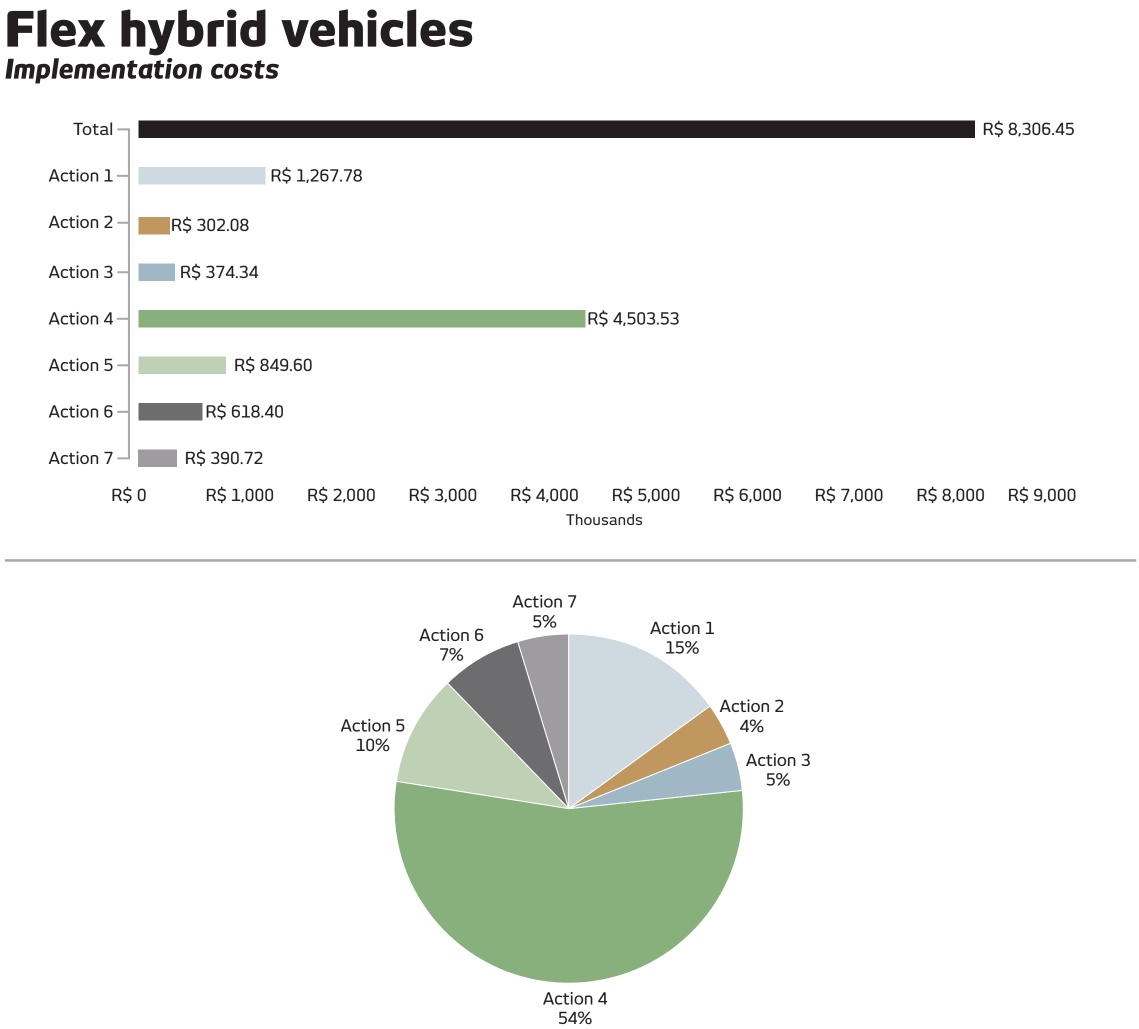


Figure 6 – TAP implementation costs

Source: the author.

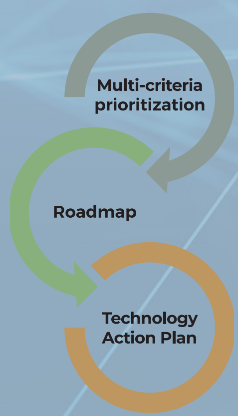
With respect to potential sources of financing for the activities, and with a view to financial results and the scope of Actions 1, 2 and 7, we determined the typical means of financing would be non-repayable loans and technical assistance. Financing is accessible by state agents (federal, state and municipal), companies (public and micro companies and small, medium and large private sector companies), associations and cooperatives. The mechanisms to request resources are presented in the "Electronic guide to financing options for the technologies prioritized in the TNA_BRAZIL Project" (MCTI, 2021j).

Finally, a risk and contingency plan was proposed for the implementation of the TAP actions and activities. The highest risks are associated with sub-activities 4.4, 4.5, 4.6 and 5.1. These risks include the potential incompatibility between the equipment purchased to create the hybridization kit and variations in the currency exchange rate, which could make it impossible to purchase these items. There are also the risks of incompatibility between the hybridization kit and the buses to be retrofitted; non-compliance with the partnership agreement signed in sub-activity 1.8; delays in the delivery of the kit assembly; and lack of technical coordination for sub-activity 5.1.

In order to limit these risks, 3D computer-aided design software could be used to determine potential equipment incompatibilities, in addition to establishing mechanisms in project contracting to ensure contingency resources in the case of equipment cost variations. In the case of sub-activity 5.1, rights and obligations should also be established in the partnership agreement to address installation costs by bus dealerships and fleet maintenance after the conclusion of the project, as well as ensure technical coordination in the permanent project team.

3.

Technology Needs Assessment **for Ethanol Fuel Cell Electric Vehicles**



3. TAP FOR ETHANOL FUEL CELL ELECTRIC VEHICLES

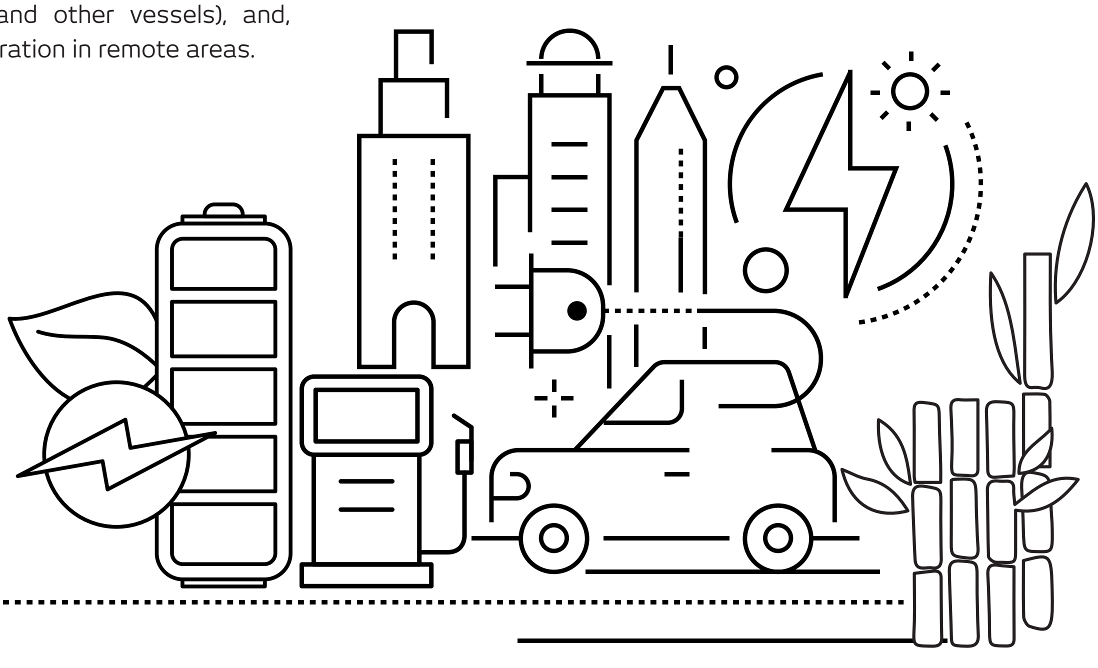
There are several types of fuel cells, depending on the conFigureion of the electrodes and electrolytes and the type of fuel to be electro-chemically oxidized. A direct ethanol fuel cell is defined as one where the anode is supplied with liquid or gaseous ethanol, anhydrous or diluted in water, and the cathode is supplied with air or oxygen. This term is mainly used to differentiate cells where the supplied fuel is hydrogen resulting from an external reform, but with a coupled ethanol unit.

Among direct ethanol fuel cells, the most promising technology is solid oxide, and, more precisely, one supported by metals, which has higher energy densities, resistance to temperature variation and longer operating times. The structure of this type of cell, which uses metallic interconnectors between the unit cells, greatly reduces the thickness of the electrolyte, since it is supported by the anode. There is no problem with fuel crossover or cathode poisoning due to the impermeability of the electrolyte.

Solid oxide fuel cell (SOFC) applications are diverse, largely due to their modularity, and range from micro-capacity applications, such as 1 W electronics, to macro applications, such as 1 MW electricity plants. This TAP focuses on vehicle electrification and stationary electricity generation. It is understood that the most viable first market for this technology is electric vehicles, followed by more challenging electric propulsion applications (trucks, ships and other vessels), and, finally, stationary power generation in remote areas.

Given this context, the Plan aims to transition from technology readiness level TRL 3 (conceptual validation) to TRL 7 (demonstration in vehicles) with the engineering and production of direct ethanol solid oxide fuel cells. Achieving this goal will result in the removal of the main barriers that hinder the maturity and diffusion of this technology on a commercial scale, including: i) lack of consensus on the optimal direct ethanol fuel cell technology with high capacity, long operation time and thermal stability; ii) low technology readiness level ; iii) technology production only at the research level; and iv) dependence on technological development that does not take into account the country's competitive advantage (hydrogen).

There are a number of benefits obtained from implementing the actions described below, among which we can highlight: i) energy efficiency gains of up to 60% (compared to internal combustion engines); ii) significant GHG emission reductions; iii) guarantee of a captive market for ethanol (mainly in Brazil) once the internal combustion engines are replaced by electric motors; and iv) reductions in particulate matter emissions (with human health benefits), among others.



Ethanol fuel cell electric vehicles

Before and after implementing the Action Plan

Current situation → **Action Plan** → **Impacts**

COMPONENT DESIGN

Current situation

- Lack of consensus on dominant component technology to use direct ethanol fuel cells.
- Lack of technology development incentives to demonstrate the effectiveness of the technology.
- Operational problems (capacity, temperature and use time).

FUEL CELL

Current situation

- Lack of local products and dependence on the international market (hydrogen fuel cells).
- No dominant technology adapted to the national reality (ethanol).
- Technology readiness level of proof of concepts of critical functions in an experimental manner (TRL 3).

Action Plan

Transition from the technology readiness level from TRL 3 (concept validation) to TRL 7 (demonstration in vehicles) through engineering and production of a solid oxide ethanol fuel cell.

Impacts

- 60% efficiency gain over internal combustion engines.
- Generation of jobs and income, while preserving the competitiveness of the sugar-energy sector (captive ethanol market).
- Mitigation potential of 2.3 $MtCO_2$ in 2030 (40,000 vehicles).
- Emission reductions of particulate matter (NO_x and SO_x), with human health benefits.
- Development of the ethanol fuel cell prototype in an operational demonstration (TRL 7).

Figure 7 – Before and after implementing the TAP

Source: the author.

The Plan is divided into two phases, comprising 21 actions. In the first phase of the Plan, the activities are aimed at building a complete system prototype for various applications, from the manufacturing of the stack components to the elaboration of balance of plant, focusing on the development of all necessary auxiliary systems for the operation of the cell in a laboratory prototype. The second phase consists of larger projects, aimed at increasing the scale from prototype to semi-industrial production, culminating in the coupling of a pilot prototype and balance of plant in a vehicle for testing and operation in real conditions. It is important to note that patents for any technology developed in the laboratory prototype and the pilot prototype should be submitted at the end of each action.

Ethanol fuel cell electric vehicles

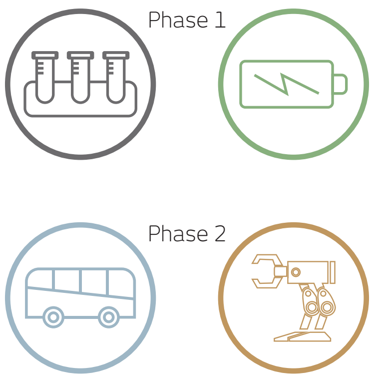
The TAP is organized in 2 phases and 4 task areas, with a 6-year implementation period

1. PARTS MANUFACTURING

Laboratory scale manufacturing of the components of the single fuel cells (1 year).

2. LABORATORY PROTOTYPE

Assembly and activation of the stacks, integrated with plant balance auxiliary systems, for building the first prototype (2 years).



3. MANUFACTURING OF PILOT PROTOTYPE SYSTEMS

Scaling up of laboratory activities to semi-industrial, in partnership with specialized companies (1 year).

4. PILOT PROTOTYPE

Assembly of stacks and auxiliary systems in vehicles for pilot testing (2 years).

Figure 8 – TAP macro-actions

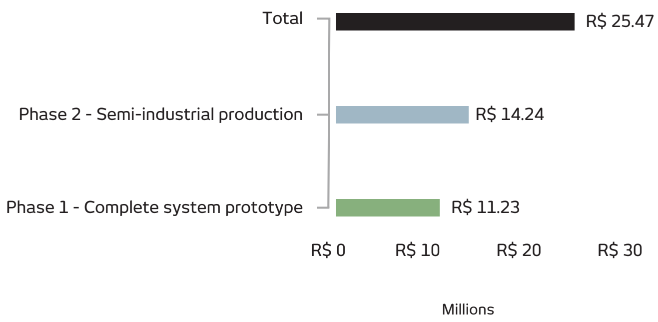
Source: the author.

Implementing the TAP requires the involvement of numerous stakeholders from academia and industry, as well as the public and private sector. The heterogeneity of the stakeholders involved is fundamental for the robustness of the decisions made during the execution of the activities to ensure the high quality of products delivered at the end of each stage. As it is a technologically ambitious Plan that can produce new technology for national and international markets, and strategic for the transport and ethanol sector in the country, the Ministry of Science, Technology and Innovation (MCTI) should be involved in coordination. The MCTI could also propose implementation arrangements for the Plan that include a Technical Committee. This Committee could be composed of the Ministry of Mines and Energy (MME), the Ministry of Regional Development (MDR) and the National Petroleum, Natural Gas and Biofuels Agency (ANP). To execute the Plan's activities, it is understood that a technical team should be created for each action, comprised of, at least in part, members of one or more leading research institutes and centers, who should act under MCTI coordination.

The time frame for implementing the action plan is six years, with an estimated cost of BRL 25.5 million. Both phases have similar total costs, with the second phase slightly higher. The second phase cost is only slightly higher due to the fact that, when increasing the scale, it can make use of the processes, methods, testing routines and infrastructure developed in Phase 1.

Ethanol fuel cell electric vehicles

Implementation costs



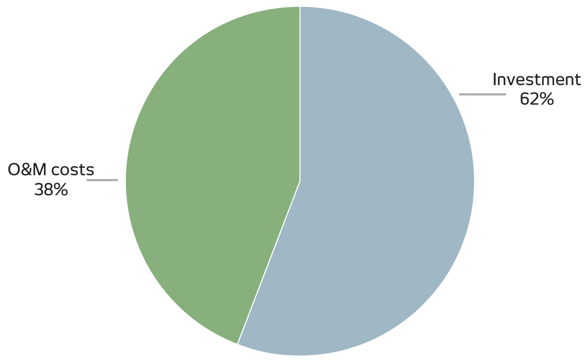


Figure 9 – TAP implementation costs

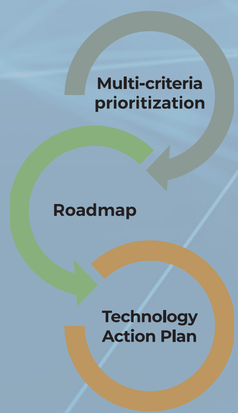
Source: the author.

With regard to potential sources of financing for activities, due to the focus on research and development to reach TRL 5 (Phase 1) and TRL 7 (Phase 2) stages, we determined the typical means of financing would be non-repayable loans and technical assistance. Financing is accessible by state agents (federal, state and municipal), companies (public and micro companies and small, medium and large private sector companies), associations and cooperatives. The mechanisms to request resources are presented in the “Electronic guide to financing options for the technologies prioritized in the TNA_BRAZIL Project” (MCTI, 2021j).

Finally, we analyzed the potential risks associated with implementing the proposed TAP activities. The highest risks are associated with sub-activities 5.3 and 6.2, which involve purchasing equipment, materials or state-of-the-art systems (with very specific requirements) that may not be easy to source; and 13.1, 13.2, 13.5 and 19.2, which include the plan to increase the scale of processes and/or the realization of new semi-industrial projects, often pioneering and using state-of-the-art technology. Sub-activity 5.3 poses risks such as execution failures, lack of maintenance and possible equipment breakdown. It is contingent on satisfactory quality control and a partnership with a company capable of assisting or supervising activities. Sub-activity 6.2 poses a high risk of not being able to obtain components and systems in national and international markets, which is contingent on the development of specific projects or the adaptation of existing equipment. The risks in sub-activity 13.1 are associated with the possible non-scalability of processes, inadequate infrastructure and execution failures resulting from lack of maintenance and/or equipment breakdown. The contingency actions include an extensive bibliographical review and comparative tests for alternative processes; satellite projects for infrastructure adaptation; and identification of a partner company to carry out and/or consult on activities, in addition to reserving contingency resources for unforeseen expenses. In sub-activity 13.2, generic design errors may occur, in addition to inadequate infrastructure and execution failures. The contingency actions are the same as previously described. In sub-activity 13.5, in addition to the same risks and contingencies as sub-activity 13.2, possible compliance false positives are also possible, which are contingent on the definition of optimal test parameters. Sub-activity 19.2 poses high risks due to a potential lack of coordination, methodological errors, the environment outside real use conditions and the lack of qualified labor. A partnership with automobile companies and companies specializing in SOFCs could reduce these risks, combined with a centralized management strategy and ensuring the contracting of sufficient manpower.

4.

Technology Needs Assessment **for the use of Agricultural and Agro-industrial Waste**



4. TAP FOR THE USE OF AGRICULTURAL AND AGRO-INDUSTRIAL WASTE

Agricultural and agro-industrial waste has great potential in Brazil for the production of electricity and fuels using renewable sources. Recent studies indicate a potential for biogas production of 23 to 40 million cubic meters per day using waste in the agriculture, livestock, industrial and urban waste sectors.

The co-digestion technology in this TAP allows for the use of different types of substrates (waste products), thus guaranteeing the continuous operation of plants and making investments in the sector feasible. The use of waste from different sources overcomes the problem of seasonal availability of agricultural waste from crops, allowing biogas plants to operate throughout the year and made use of a greater quantity of waste. In this context, integrated crop-livestock-forest systems (ICLFS) and/or crop rotation systems, for example, are potential niches for the implementation of biogas plants in the country. Waste can be used for energy production and/or fertilizer, which is produced in the digestate treatment process.

Due to the great potential for waste in energy production, the principal technology needs associated with the use of these resources relate to improving the technological process for the development of large-scale projects and the characterization and definition of suitable substrate pre-treatments, taking into account the different sources of waste that can be used in a complementary manner, depending on seasonal agricultural. To address these technology needs, the TAP aims to develop a pilot biogas plant in an ICLFS system and another plant in crop rotation systems, using important Brazilian crops for the production of electricity, biomethane and biofertilizer.

The Plan is in line with incentive programs for renewable energy sources in Brazil, such as the National Biofuel Policy (RenovaBio), established in Law No. 13.576 / 2017. The Plan is justified by benefits similar to those outlined in the policy, among which we can highlight: i) increased participation of renewable energy sources in the energy matrix; ii) significant mitigation of GHG emissions; iii) and significant potential for generating employment and income in rural areas, among others.

Use of Agricultural and Agro-industrial Waste

Before and after implementing the Action Plan

Current situation → **Action Plan** → **Impacts**

Current situation

CHARACTERIZATION OF SUBSTRATE

- Inadequate definition of pre-treatment technologies.
- Lack of gravimetric data on waste.
- Seasonality of agricultural waste.
- Laboratory scale validation level (TRL 4).

BIOGAS PLANT

- Technology for large-scale production is limited.
- Need to optimize processes, considering the use of different substrates over the year.
- High operating, maintenance and capital costs.
- Biodigestion projects with implementation problems.

Action Plan

Pilot application of 1 co-digestion plant in an Integrated crop-livestock-forestry systems (ICLFS) system and 1 plant in crop rotation systems involving leading Brazilian consortia for the production of electricity, biomethane and biofertilizer.

Impacts

- Potential production of 40 million m^3 of biogas per day (energy use and fertilizer production).
- Great potential for generating employment and income in rural areas.
- Contributes to Renovabio goals and the increase of renewable energy sources in the energy matrix.
- Mitigation potential of 8.2 $MtCO_2$eq. by 2030.
- Application of co-digestion in an operational environment (TRL 7).

Figure 10 – Before and after implementing the TAP

Source: the author.

The implementation of the TAP involves three interdependent actions. Action 1 seeks to identify and characterize potential sources of raw materials for the process, with the goal of mapping potential locations to apply the technology and define the locations for the pilot plants and available waste for biogas production. Following this, it is necessary to better understand the co-digestion process through research to determine the best substrate pre-treatment and identify optimal co-digestion process conditions (Action 2). Finally, Action 3 involves the implementation of pilot plants in ICLFS and crop rotation systems, as well as disseminating results and sharing knowledge.

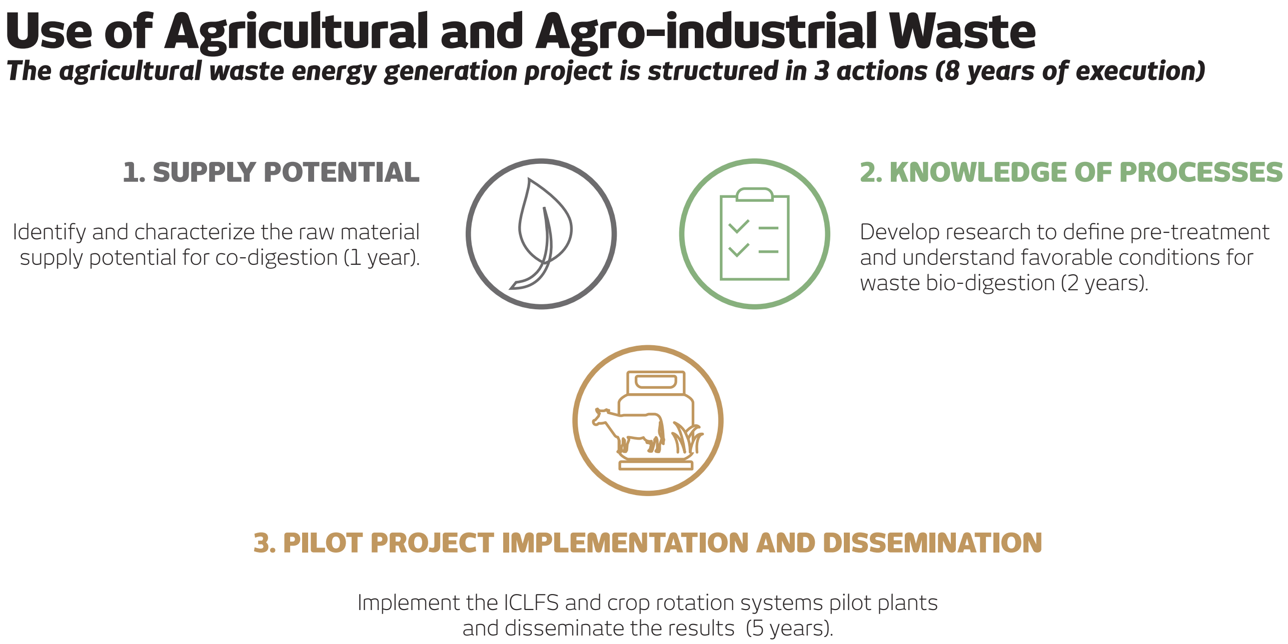


Figure 11 – TAP macro-actions

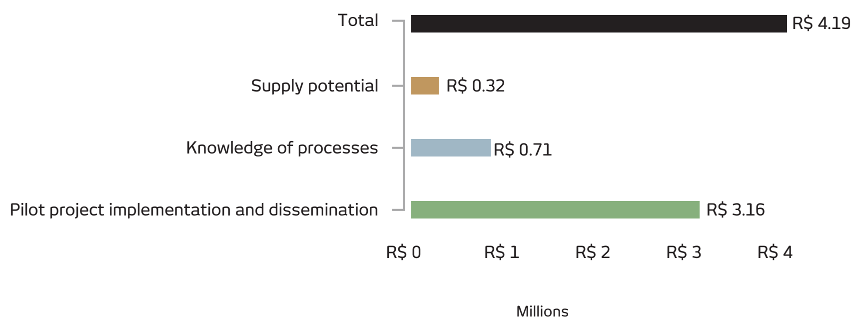
Source: the author.

To successfully implement the Plan, it is important to bring together the expertise of various stakeholders from the public and private sector, associations and representative entities. The MCTI and the Ministry of Agriculture, Livestock and Supply (MAPA) could coordinate the Plan since they have the necessary scientific and technological research competence and involvement with the agricultural sector. For all actions, technical coordination and the contracting of partners with experience in the activities is necessary. The technical coordination should count on institutions such as the International Center for Renewable Energies (CIBiogás) and the Brazilian Agricultural Research Corporation (Embrapa), in addition to universities and research centers that can contribute, especially, to the implementation of Actions 1 and 2. The Ministry of Economy (ME) could mobilize stakeholders in the financial sector. The Brazilian Funding Authority for Studies and Projects (Finep), the National Council for Scientific and Technological Development (CNPq), the Brazilian Company for Industrial Research and Innovation (Embrapii) and the National Bank for Economic and Social Development (BNDES) are potential financing agents for the TAP. Furthermore, given their extensive experience with studies on energy generation from waste, EPE and the Brazilian Biogas Association (Abiogás) could be mobilized to assist the coordinating institutions in validating the results of the Plan. Finally, it is important to involve municipal governments in the mobilization of local stakeholders to implement the pilot units.

The implementation period is nine years, with an estimated total cost of BRL 4.2 million. Action 3, for the implementation of the pilot plants and the dissemination of results, accounts for most of the budget (approximately 75%).

Use of Agricultural and Agro-industrial Waste

Implementation costs



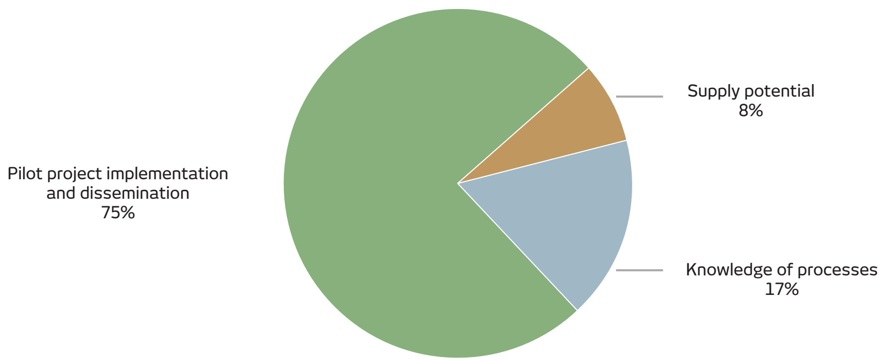


Figure 12 – TAP implementation costs

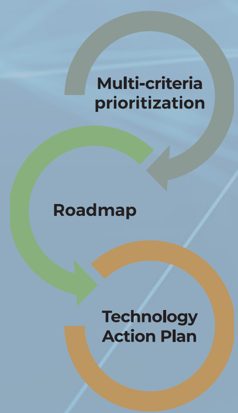
Source: the author.

With regard to potential sources of financing for the activities, and with a view to financial results and the focus on research and development in Actions 1 and 2, we determined the typical means of financing would be non-repayable loans and technical assistance. Financing is accessible by state agents (federal, state and municipal), companies (public and micro companies and small, medium and large private sector companies), associations and cooperatives. The mechanisms to request resources are presented in the "Electronic guide to financing options for the technologies prioritized in the TNA_BRAZIL Project" (MCTI, 2021j).

Finally, potential risks to the implementation of the TAP activities and their respective contingency measures were determined. The highest risks are related to sub-activities 3.4 and 3.5 for construction of the pilot plants, since there are obstacles that could delay and/or impede the continuity of the project, such as lack of financing, design errors, mistakes in economic planning and unforeseen demands. To mitigate this, it is necessary to prepare a realistic budget with a commitment to guarantee financial resources and reserve resources for project contingencies. For the risks associated with failures or delays in the delivery of material and equipment, it is important to establish an agreement with competent institutions and suppliers. In addition, agreements with institutions should be established to avoid regulatory and legislative barriers. To reduce technical errors in the execution of the project, we recommend contracting qualified technical staff, supervision of the construction of the plants by specialists and the creation of mechanisms to inspect the work.

5.

Technology Needs Assessment **for Photovoltaic Solar Induction Stoves**

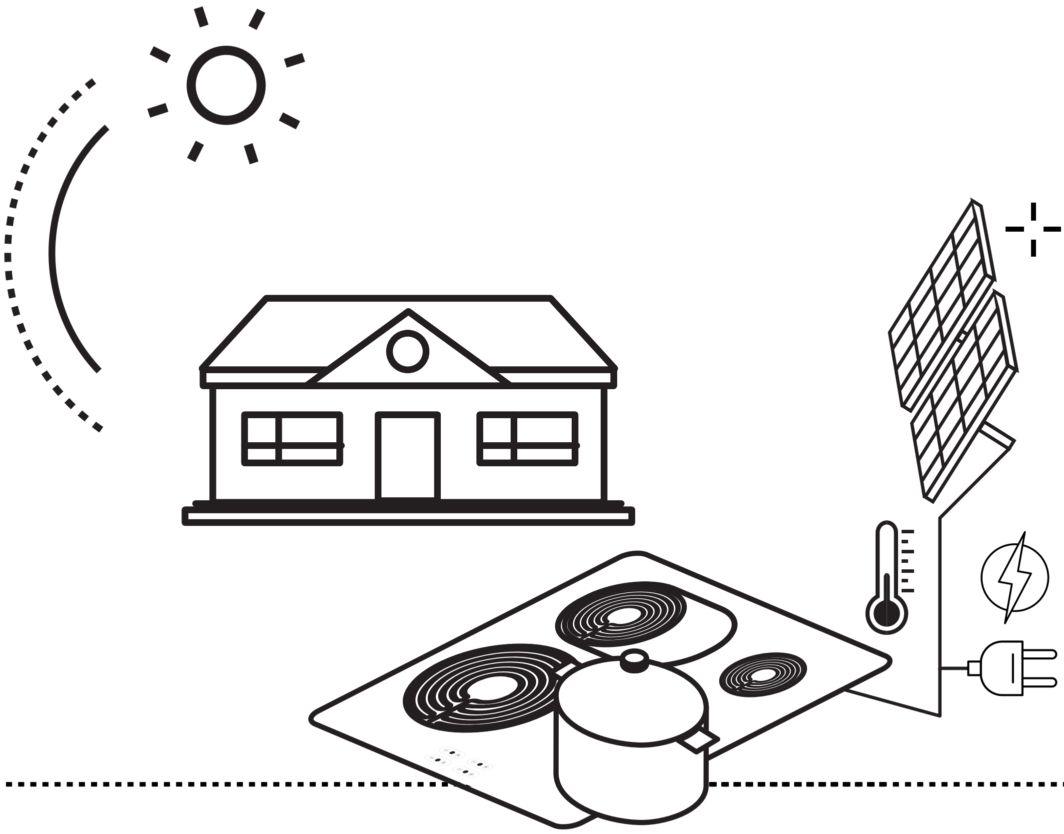


5. TAP FOR PHOTOVOLTAIC SOLAR INDUCTION STOVES

Solar stoves cook food using energy captured from sunlight. According to the scope defined in this TAP, advanced models of solar electric induction stoves, integrating components such as batteries and photovoltaic panels, solve the problems that hinder the diffusion of this technology in Brazil, ensuring greater autonomy and efficiency by storing larger quantities of energy and increasing cooking capacity.

Solar stoves have an application niche in isolated regions and rural areas, often characterized by low human development indexes (HDIs) and the lack of modern cooking alternatives, such as electric or gas stoves. In these areas, traditional biomass is the only affordable fuel for cooking, either purchased (if available commercially) or collected directly in the local environment. Some of the critical barriers to the diffusion of this technology include: i) lack of a market with established value chains; ii) cost of additional equipment for the solar electric induction stove; iii) resistance to changes in cooking habits; iv) and lack of training in the use of the technology, among others.

To overcome these barriers, The TAP proposes developing a prototype and pilot application of solar induction stoves in residential buildings in regions with a high dependency on traditional biomass for cooking fuel. The implementation of this Plan is justified by the economic, energy, environmental and social benefits. The following can be highlighted: i) opportunity to generate income by increasing free time available for remunerated activities; ii) decrease in government spending on public health; iii) increased use of renewable energy sources and energy security (due to energy generation self-sufficiency with photovoltaic panels); and iv) reductions in atmospheric pollutants, GHG emissions and deforestation, among others.



Photovoltaic Solar Induction Stoves

Before and after implementing the Action Plan

	Current situation	Action Plan	Impacts
SOLAR IRRADIANCE **AUTONOMY**	• Absence of market with value chains for the technology. • Cost of additional equipment for the induction stove (cooktop, PV panels and battery). • Technology readiness level of demonstration prototype in production environment (TRL 6).	Development of the prototype and pilot application of PV solar induction stoves in residential buildings in regions with high use of traditional biomass.	• Increased use of clean energy and greater energy generation autonomy for buildings. • Improved health and reduction in public spending on respiratory illnesses. • More free time for women to pursue remunerated activities. • Mitigation of 6,000 kg CO_2/year/residence. • Complete, tested, qualified and demonstrated system (TRL 8). • Generation of employment and income.
TRAINING	• Cultural resistance to changes in cooking practices. • Lack of knowledge of the benefits of the technology. • Lack of training in the use of PV solar induction stoves .		

Figure 13 – Before and after implementing the TAP

Source: the author.

The Plan includes three interdependent actions: design; prototype; and application and dissemination of the technology. Action 1 aims to define the photovoltaic solar induction stove design most appropriate for conditions in Brazil. To achieve this, it is necessary to study the stoves currently manufactured and available on the market, as well as to define and characterize the potential location for application in order to define a model suitable to local conditions. Action 2 aims to develop and test the solar stove prototypes. The activities in this stage include the elaboration of stove components, integration and testing. Finally, Action 3 involves the pilot application of the prototype in homes in the selected location, aimed at widely disseminating the initiative results.

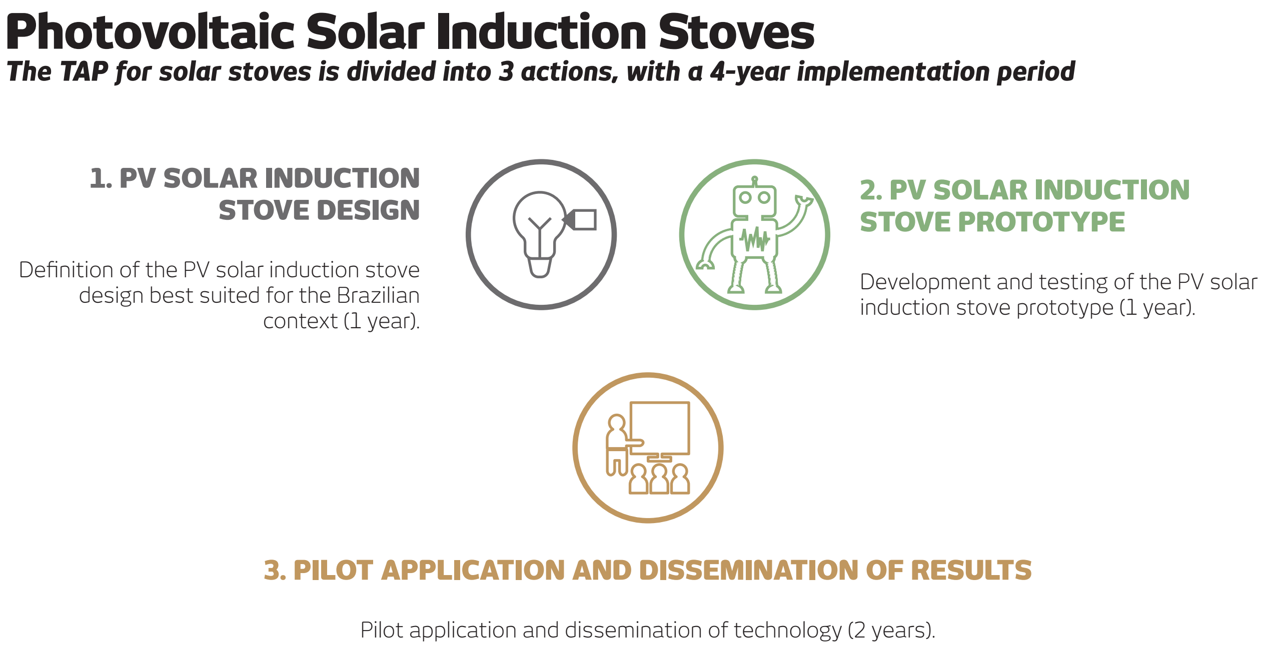


Figure 14 – TAP macro-actions

Source: the author.

To successfully implement the Plan, each of the proposed actions requires the involvement of stakeholders (public and private sectors, associations and representative entities, among others) to collaborate on the implementation. Among potential coordinating institutions, we can highlight the MDR and the MME. Among its duties, The MDR is responsible for formulating and executing regional development plans and programs and establishing strategies for the integration of regional economies. This Ministry has the challenge of integrating different public policies on urban infrastructure and promoting regional and economic development. These functions are closely aligned with the objectives of the proposed actions, especially Actions 1 and 3, aimed at determining the location for the pilot implementation of solar stoves. Similarly, the MME is a potential coordinating body, as it acts in energy development in rural areas and establishes national policies on energy resource use to promote economic, social and environmental development. Finally, companies in the solar energy sector, as well as universities and research institutes with expertise in this field, could act as coordinators or technical partners to carry out the Plan's activities.

The implementation period of the Plan is four and a half years, with an estimated cost of BRL 2.6 million. The pilot application of photovoltaic solar stoves represents more than half of the total cost (59%), totaling approximately BRL 1.5 million. In fact, this is the most costly step, as it includes the acquisition of the solar stove kit for application.

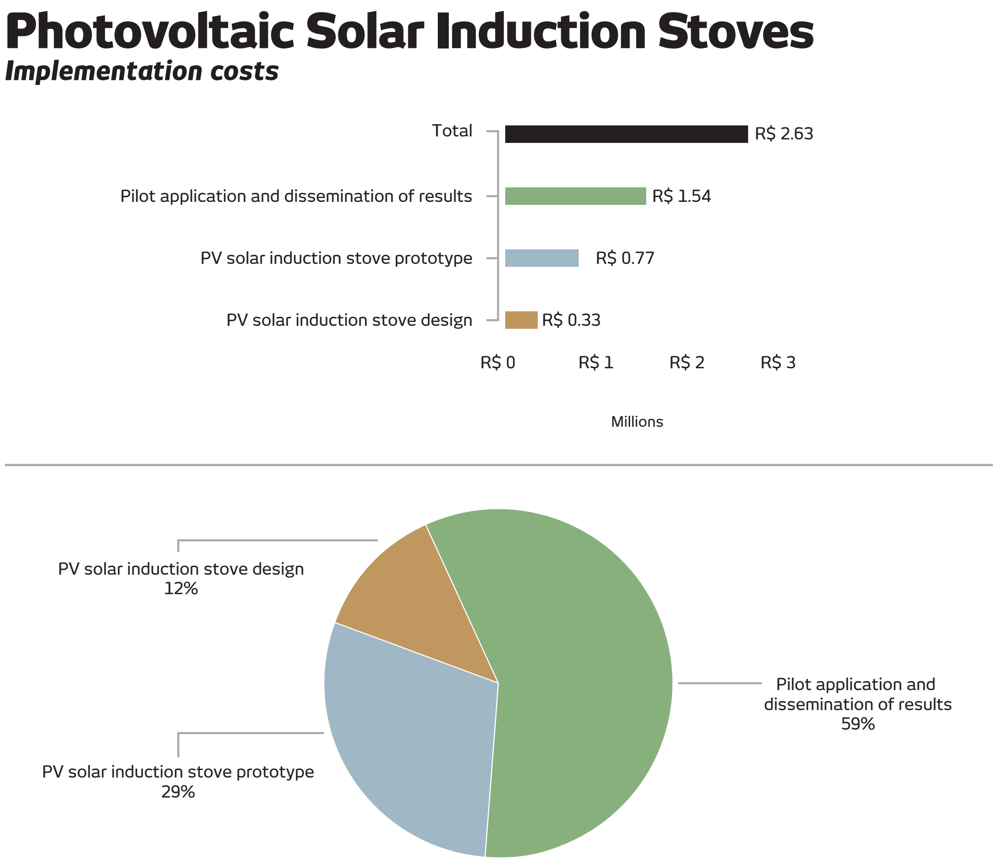


Figure 15 – TAP implementation costs

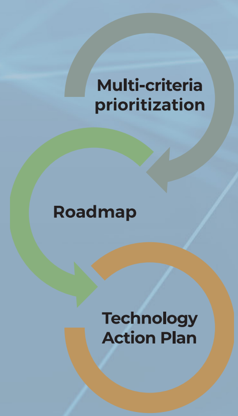
Source: the author.

With respect to potential sources of financing for the activities, and with a view to financial results and a focus on research and development aimed at the subsequent diffusion of the technology, we determined the typical means of financing would be non-repayable loans and technical assistance. Financing is accessible by state agents (federal, state and municipal), companies (public and micro companies and small, medium and large private sector companies), associations and cooperatives. The mechanisms to request resources are presented in the "Electronic guide to financing options for the technologies prioritized in the TNA_BRAZIL Project" (MCTI, 2021j).

In terms of implementation risks in the proposed actions and measures to limit them, we determined that there were higher risks in sub-activities 3.1 and 3.2, aimed at establishing institutional cooperation and applying the technology in 30 households. These risks are mainly associated with the potential lack of stakeholder involvement in the initiative; lack of knowledge and inappropriate use of the solar stove kit; low acceptance of the technology by potential beneficiaries; potential installation delays; problems with the maintenance of solar stove kits; and lack of technical coordination. In order to mitigate these risks, some contingency measures were proposed, such as establishing TCAs and contracts; obtaining authorization from the electric utility; providing training and monitoring the installation, use and maintenance of solar stoves; and the mobilization of government authorities, non-governmental organizations (NGOs), regional leaders and technical staff to facilitate dialogue with the population to overcome cultural barriers, among others.

6.

Technology Needs Assessment **for Innovative Materials for Cement**



6. TAP FOR INNOVATIVE MATERIALS FOR CEMENT

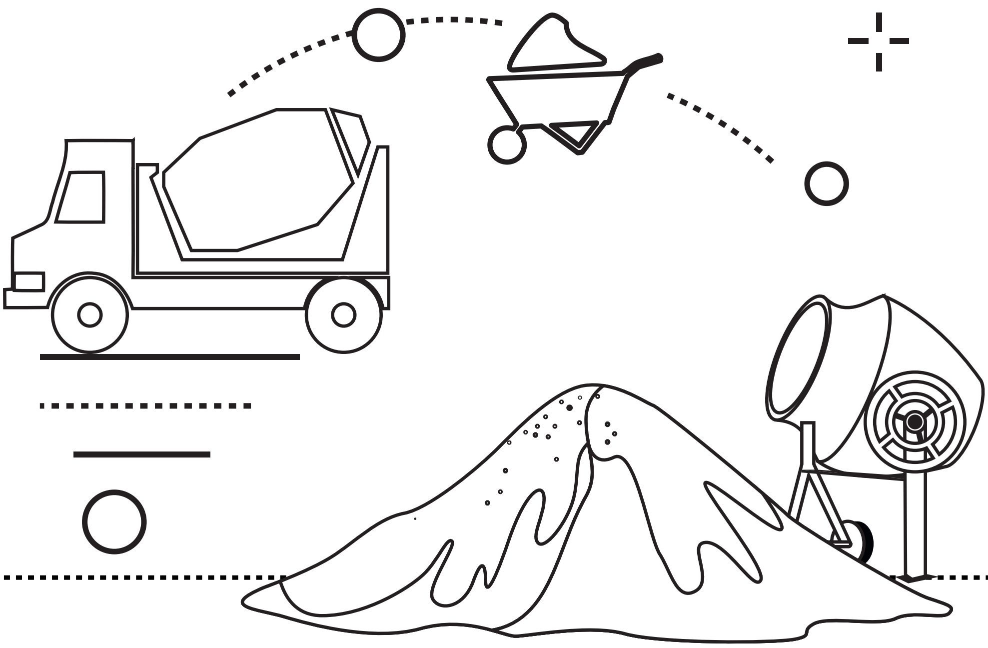
Cements can be defined as the binding element that, when mixed with water and other aggregates, produces basic materials for construction, such as concrete and mortar- the most consumed manufactured product worldwide, in terms of volume.

A considerable part of the sector's emissions, responsible for about 7% of world emissions, is directly associated with the production of clinker, the main component of traditional Portland cement. The production process consists of heating limestone to high temperatures (around 1,400ºC) to produce the calcination reaction, which is the decomposition of the CaCO3 molecule into CaO, the base of clinker, and CO_2. The process releases carbon dioxide into the atmosphere in the same molar ratio as it generates the desired product, which accounts for process emissions. Thus, much of the research in the cement production sector aimed at improving environmental performance in the industry currently focuses on reducing the proportion of clinker in the final mixture that makes up Portland cement.

In particular, one of the techniques widely adopted by the industry to improve the environmental performance of cement (among other objectives) is to incorporate other materials in the mixture to formulate cements with lower clinker content (generally residues from other industrial processes or abundant, low-cost substances). Among these materials, known as mineral additions or supplementary cementitious materials (MCS), granular blast furnace slag, coal fly ash, limestone filler and calcined clays stand out.

In this context, this TAP aims to demonstrate the technical, economic and environmental feasibility of an innovative cement with a clinker content of 50% or less, complemented with other abundant and low-cost raw materials (SCMs) by 2030.

Achieving this goal would remove obstacles, resulting in a number of associated co-benefits. It is necessary to ensure the availability of alternative materials and address their low reactivity in cement formulations. In technical-economic terms, we can highlight the lack of consolidated arrangements for production and poor understanding of the technical and economic viability of new cements. Finally, the sector needs training for the application of the technology in construction. Among the main co-benefits of SCMs in cement production, the following stand out: i) cost reductions (compared to clinker); ii) significant potential for job and income generation with the creation of an SCM supply chain; iii) reduced demand for fossil fuels; iv) reductions in process emissions (the same molar ratio between the SCM and the cement produced), as well as reductions in particulate matter (NO_x and SO_X); and v) preservation of biodiversity due to the reduction in limestone mining.



Innovative Materials for Cement

Before and after implementing the Action Plan

Current situation → **Action Plan** → **Impacts**

Current situation

RAW MATERIALS

- Low reactivity of additions or supplementary cementitious materials.
- Lack of knowledge of the availability of supplementary cementitious materials (SCMs), such as granulated blast furnace slag, coal fly ash, limestone and calcined clays.

PRODUCTION

- Absence of production arrangements for the production of new cements.
- Lack of knowledge of the technical and economic viability of new cements (addition of SCM).
- Technology readiness level of proof of concepts of critical functions in an experimental manner (TRL 3).

END USE

- Conservatism and lack of acceptance of the sector to use new materials.
- Lack of qualifications of self-employed builders.

Action Plan

Demonstrate the technical, economic and environmental feasibility of an innovative cement with a clinker content of 50% or less, with the addition of other abundant and low-cost raw materials by 2030.

Impacts

- Increased competitiveness in the industry due to lower production costs.
- Generation of jobs and income in the SCM supply chain.
- Mitigation potential of 6 $MtCO_2$ by 2030.
- Reduction in emissions of particulate matter (NO_x and SO_x), with human health benefits.
- New cement demonstrated in a relevant production environment (TRL 6).
- Less impact on biodiversity (less limestone mining).

Figure 16 – Before and after implementing the TAP

Source: the author.

The execution of the TAP includes four actions: i) selection of potential materials for the development of new cements; ii) product development and testing in the laboratory; iii) technical, economic and environmental assessment of the new cement production on an industrial scale; and iv) training, dissemination and education in the construction sector for the development and diffusion of new cement materials. The selection of potential materials involves a preliminary step aimed at the georeferenced quantification of inputs with the potential to substitute clinker in Brazil. This is followed by referencing this data with spatial data on cement production and the cement market to identify potential areas and alternative resources to substitute clinker. Based on these results, the experimental stage begins, aimed at identifying one or more potential resources identified in the regions for laboratory development and testing of the low clinker content cement formulations. Once an adequate product has been developed, technical, economic and environmental assessment studies are carried out on the production process of the developed and tested innovative cements. Finally, the last action involves activities for the diffusion of innovative materials for cement, with the dissemination of new technologies and training of professionals in the construction sector with different levels of professional training.

Innovative Materials for Cement

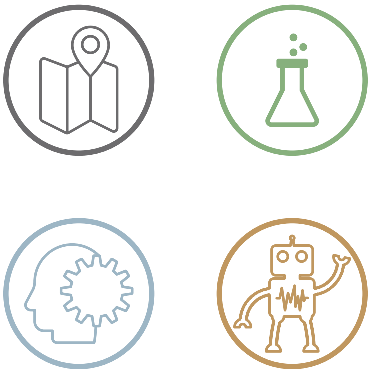
The strategy for developing innovative materials for cement is divided into four actions (8 years of execution)

1. SELECTION OF ELIGIBLE MATERIALS

Georeferenced quantification of inputs with potential to replace clinker in Brazil (1 year).

2. EXPERIMENTAL DEVELOPMENT

Development and testing of new cement formulations with low clinker content (4 years).



4. TRAINING AND DISSEMINATION

Training of construction personnel and dissemination of innovations in cement and good practices for construction (1 year).

3. TECHNICAL, ECONOMIC AND ENVIRONMENTAL EVALUATION

Technical, economic and environmental evaluation of the developed and tested production process for innovative cements (2 years).

Figure 17 – TAP macro-actions

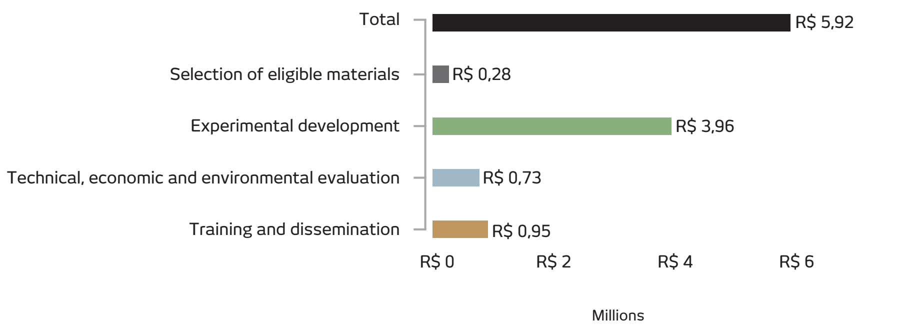
Source: the author.

The participation of a diverse group of stakeholders is extremely important for the implementation of the plan. For the development of innovative materials for cement phase, the general coordination could be conducted by MCTI, with partners from the Brazilian Network for Research on Global Climate Change (Rede Clima) for the technical coordination of activities. Alternatively, the Plan could be coordinated by cement sector institutions, such as the National Cement Industry Union (SNIC) and the Brazilian Portland Cement Association (ABCP), or by industry representative organizations like the National Industry Confederation (CNI). The Low Carbon Industry Technical Committee (CTIBC) could participate in the supervision of project activities in an advisory capacity to validate the results.

The time frame for implementing the action plan is nine years, with a total cost of BRL 5.9 million. Action 2, which includes laboratory activities, accounts for most of the costs in the Plan. These actions could be financed through non-repayable loans and technical assistance. Financing is accessible by state agents (federal, state and municipal), companies (public and micro companies and small, medium and large private sector companies), associations and cooperatives. The mechanisms to request resources are presented in the "Electronic guide to financing options for the technologies prioritized in the TNA_BRAZIL Project" (MCTI, 2021j).

Innovative Materials for Cement

Implementation costs



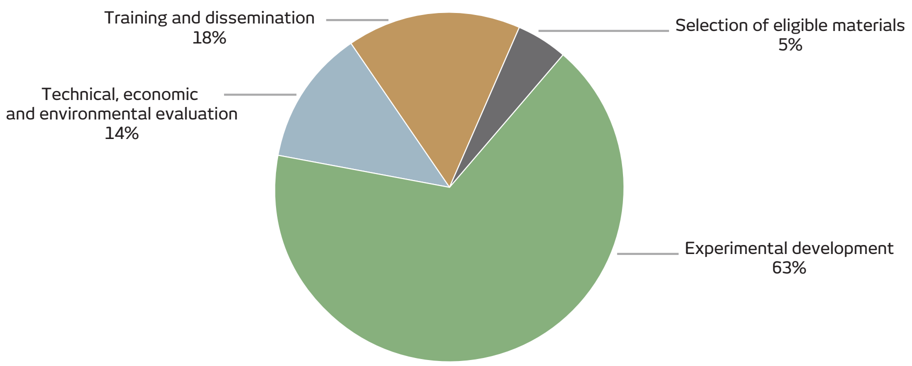


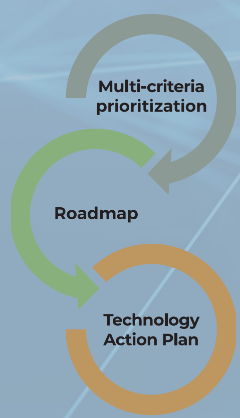
Figure 18 – TAP implementation costs

Source: the author.

Finally, a risk and contingency plan was proposed for the adoption of the TAP. There are high risks associated with the implementation of sub-activities 2.3, 2.4 and 2.5, which involve laboratory testing of the raw materials and cement products. These risks are associated with potential accidents in the laboratory or delays in activities due to potential failures of critical testing equipment. To mitigate these risks, it is necessary to ensure the observance of safety procedures in the experiments and a safe laboratory environment with an internal commission for accident prevention. Other important considerations are the performance of periodic maintenance, rigorously following the manufacturer's instructions and the planning of schedule alternatives to mitigate unexpected breakdowns of critical equipment. Other measures that could mitigate schedule delays include cooperation with technical assistance, as well as the prior verification of the institutional bureaucratic procedures for contracting maintenance services for critical testing equipment.

7.

Technology Needs Assessment **for Industry 4.0**

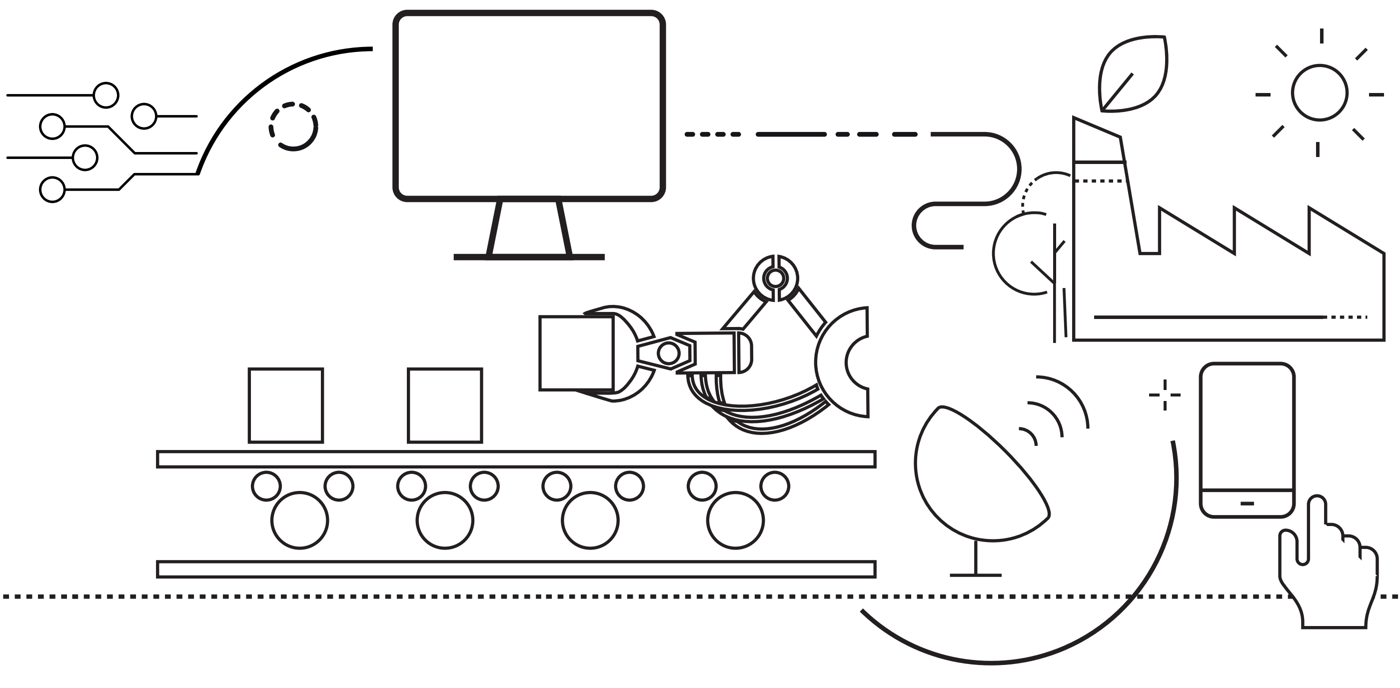


7. TAP FOR A INDUSTRY 4.0

Industry 4.0 is a cross-sectoral emission mitigation option for the industrial sector, as it fosters improved efficiency in the use of energy and other resources. Represented by a set of innovative technologies and a new mentality introduced with the advent of the internet, industry 4.0 allows for the internal and external integration of the production chain and the development of cyber-physical systems to support operations and new business models. The main technologies associated with viable 4.0 production system are: additive manufacturing or 3D printing; artificial intelligence (AI); Internet of Things (IoT); and cyber-physical systems (CPS).

Currently, the development and diffusion of 4.0 technologies faces barriers, including a lack of knowledge about this new global production trend in the industrial sector, which perpetuates the technological lag in Brazilian industry compared to external competitors. We can also highlight the lack of interoperability and data security standards, as well as the lack of qualified labor. To this, we can add the low degree of development in hardware, software and analytics.

To overcome these obstacles, we propose the implementation of the Circular Economy and Industry 4.0 Technology Network to foster research, development, innovation, training and infrastructure actions in industry 4.0 and circular economy techniques and technologies. It is clear that the achievement of this goal will result in a number of co-benefits, especially: greater competitiveness; improved labor productivity; reductions in energy consumption; the mitigation of GHG emissions; and the generation of new business activities and professions in industry.



Industry 4.0

Before and after implementing the Action Plan

Current situation → **Action Plan** → **Impacts**

TECHNOLOGICAL DEVELOPMENT

Current situation

- Poor performance in developing hardware, software and analytics.
- Concept not commonly known.
- Validation of 4.0 technology experiments in a relevant environment (TRL 5).

HUMAN RESOURCE MANAGEMENT

Current situation

- Insufficient workforce.
- Lack of digital culture and training.
- Lack of knowledge of the benefits, regulations and technical standards of 4.0 technologies.

INFRASTRUCTURE

Current situation

- Difficulty in digitally integrating companies across production chains.
- Security gaps with respect to protecting national industry data.
- Lack of data interoperability standards.

Action Plan

Implement the Circular Economy and Industry 4.0 Technology Network to promote research, development, innovation, training and infrastructure actions in industry 4.0 and circular economy techniques and technologies.

Impacts

- Improved competitiveness of national industry with respect to external competitors.
- 10 to 25% increase in labor productivity.
- 10 to 20% reduction in energy consumption.
- Mitigation potential of 11.8 $MtCO_2$ by 2030.
- Reduction in industrial waste disposal.
- Demonstration of 4.0 technologies in operational environment (TRL 7).
- Creation of new activities and professions in industry.

Figure 19 – Before and after implementing the TAP

Source: the author.

This TAP is composed of four macro-actions, subdivided in activities and sub-activities. In general, the macro-actions were defined as follows:

1. Creation of a network with activities to promote and develop Industry 4.0 technologies applied in the circular economy (Circular Economy and Industry 4.0 Technology Network);
2. Identification and development of promising demonstration projects in this field;
3. Training and dissemination of the knowledge generated in the demonstration projects;
4. Promotion and dissemination of regulations, technical standards and public policies related to the circular economy and industry 4.0.

The first macro-action is fundamental for the development of the following, and should be ongoing during the execution of the TAP. The macro-actions for technological development, training and diffusion of regulations, technical standards and public policies produce strategic results and provide data for the Network, so that the Plan can attain the scope and goals.

Industry 4.0

The circular economy 4.0 network is structured in 4 actions, with a 8-year implementation period

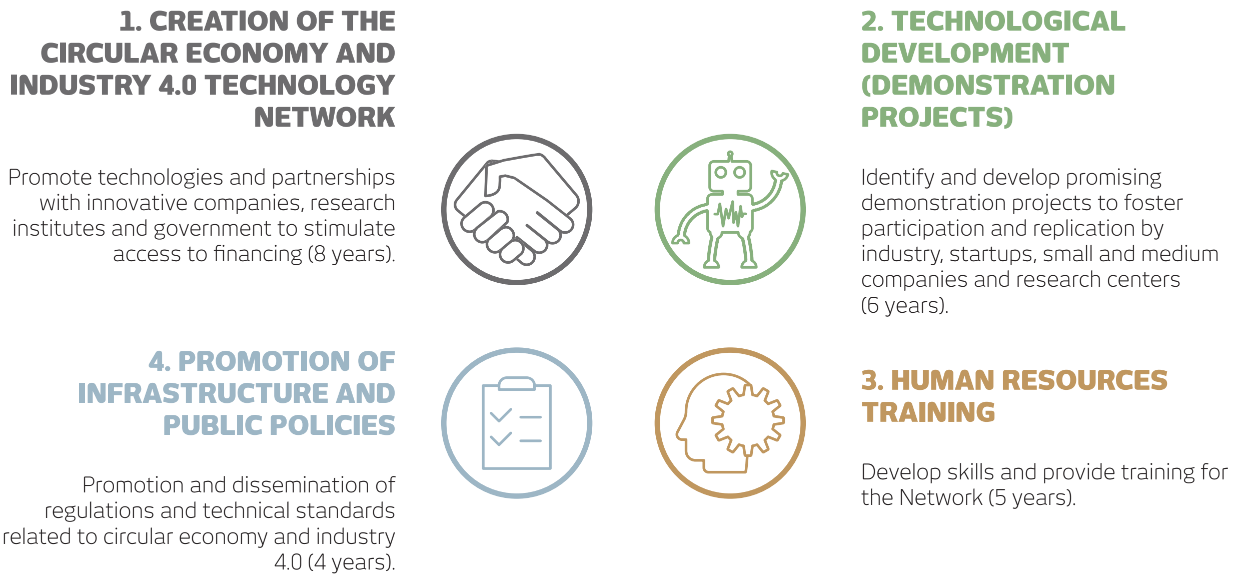


Figure 20 – TAP macro-actions

Source: the author.

For each of the macro-actions, we prospected stakeholders from the public and private sector, associations and sector representation entities that could participate in the implementation of the TAP. Due to the interdependence of the macro-actions, it is important to have a general coordination body for the entire Plan schedule. Ideally, the coordination of the Circular Economy and Industry 4.0 Technology Network would be composed of the same members of the Brazilian Industry 4.0 Chamber (Câmara I4.0), with the Chamber assuming the role of Network Management Committee. Similarly, the MCTI could assume the coordination of the macroeconomics of the Circular Economy Network and the development of promising demonstration projects. The coordination of the human resources management action could be undertaken by the CNI, while the macro-action for technical regulations and standards could be shared between the Ministry of Economy (ME), the National Institute of Metrology, Standardization and Industrial Quality (Inmetro), the Ministry of Communications (MCom) and the National Telecommunications Agency (Anatel). Furthermore, the ME could mobilize potential financing partners to implement the Plan, with potential financial support from Finep, BNDES, Embrapii and CNPq.

The time frame for implementing the action plan is nine years. The total cost is BRL 15.1 million, with the macro-action for technological development accounting for 60% of the total cost, or approximately BRL 9.1 million. This amount would be sufficient to realize the execution of projects among large companies; projects involving startups; and three demonstration projects in small and medium-sized companies.

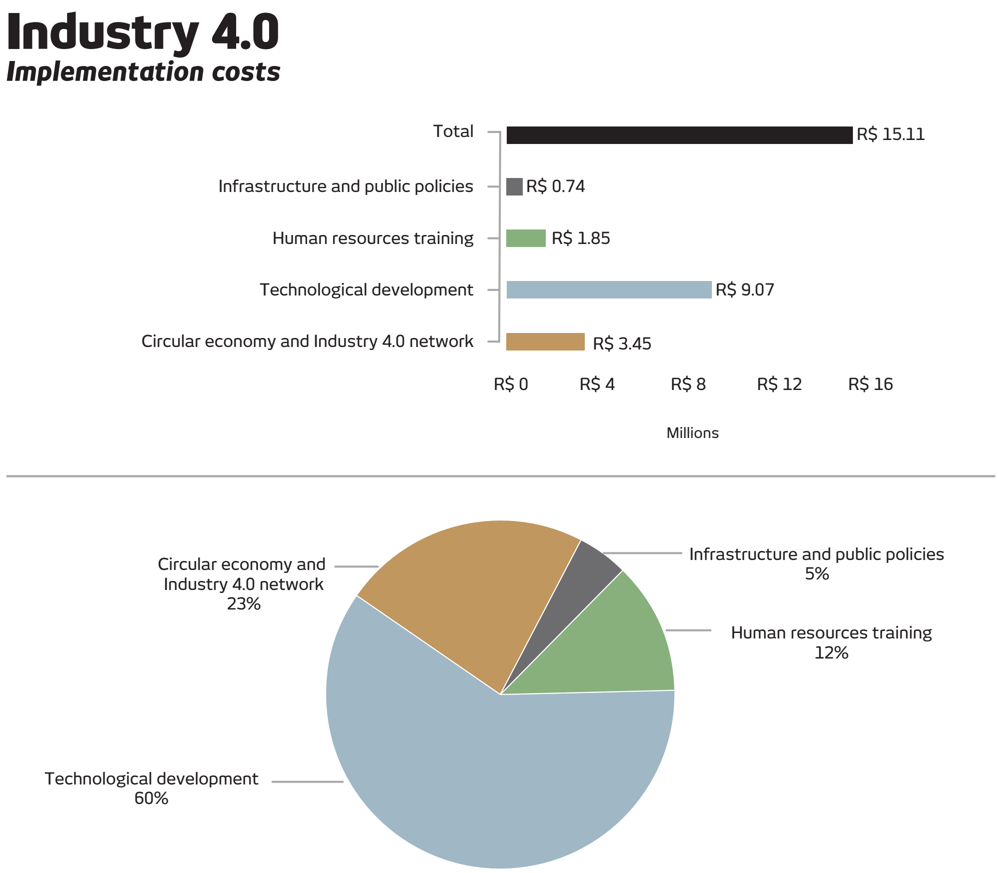


Figure 21 – TAP implementation costs

Source: the author.

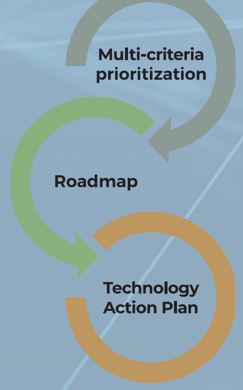
With respect to potential sources of financing for the activities, with a view to financial results and the focus of macro-actions 1, 3 and 4, we determined the typical means of financing would be non-repayable loans and technical assistance. Financing is accessible by state agents (federal, state and municipal), companies (public and micro companies and small, medium and large private sector companies), associations and cooperatives. The mechanisms to request resources are presented in the "Electronic guide to financing options for the technologies prioritized in the TNA_BRAZIL Project" (MCTI, 2021j). The macro-action for technological development involves the implementation of demonstrative projects, which must submit a technical-economic feasibility study. This also makes the activities eligible to access repayable loans.

We analyzed the potential implementation risks for each group of activities in each action. The highest risks are associated with activities 9, 10 and 11. The high cost and competition for financial resources could hinder the development of the demonstration projects in the industry 4.0 TAP. Another significant risk is the lack of institutional coordination, as the Plan requires networked and cross-sectoral coordination. There are also risks of a technical nature, such as: i) risk of contracted parties failing to fulfill obligations for various reasons; ii) poor definition of objectives and understanding of the results of the technological challenge; iii) lack of qualified human resources in small and medium-sized companies and resistance to change by employees.

As contingency actions for these risks, we suggest that the Network make efforts to demonstrate the benefits of the TAP for the competitiveness of the industrial sector as well as for the transition to a low carbon economy. Clear and strategic action by the Network is essential to ensure the necessary financial resources. To mitigate technical risks, we suggest a prior evaluation of the skills and references of contracted individuals, clearly defining the roles of contracted individuals to ensure success (activity 9). In activity 10, detailed goals of the technological challenge should be determined before launch, with a dedicated team to address questions and create prototypes of the final product. One way to mitigate the risks in activity 11 would be to train employees in small and medium-sized companies, thus raising awareness of the benefits of the project.

8.

Technology Needs Assessment **for Precision Agriculture**



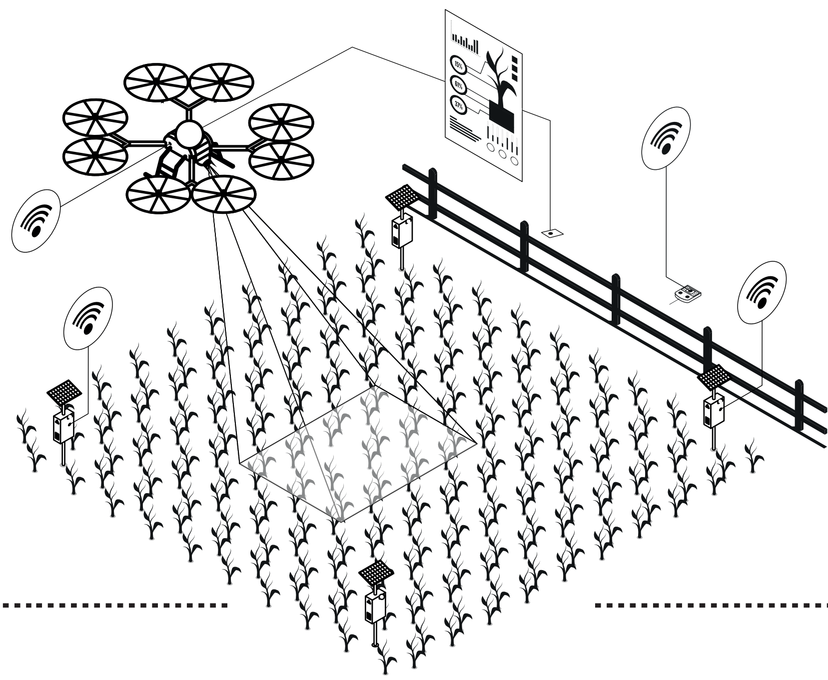
8. TAP FOR PRECISION AGRICULTURE

Precision agriculture (PA) can be defined as a set of tools and technologies for an agricultural management system based on the spatial and temporal variability of the production unit.

The TAP for PA is aimed at removing barriers, including: deficiencies in connectivity, interface availability and data security; inadequacies in national technology; and inaccessible autonomous systems, among others. To this end, it seeks to promote, disseminate and train the Brazilian agricultural sector in PA by 2030.

The goal of the TAP is aligned with the Strategic Agenda 2014-2030 - Precision Agriculture, prepared in 2014 by the Ministry of Agriculture, Livestock and Supply (Mapa). This document contains 51 actions in nine strategic areas, addressing all links in the chain, as well as bottlenecks (BRASIL, 2014). In the strategic area of research, development and innovation (RD&I), the expected result is the creation of an RD&I Network to support a permanent PA innovation process through the following actions: i) systematization of the need for research in the chain; ii) creation of the PD&I Network of the Brazilian Precision Agriculture Commission (CBAP); iii) promotion of strategies to secure resources for RD&I; iv) place PA on the agenda of the National Fund for Scientific and Technological Development (FNDCT), via Mapa; and v) coordinate the allocation of budget resources with the Federal Government. In this way, the TAP for PA aims to foster the achievement of the expected results of the strategic area of RD&I in the Agenda, as well as actions "i," "ii" and "iii".

Attaining this goal will positively impact the sector by democratizing access to technology, mitigating greenhouse gas (GHG) emissions and improving agribusiness competitiveness.



Precision Agriculture

Before and after implementing the Action Plan

Current situation → **Action Plan** → **Impacts**

TRANSMISSION

INTERFACE AND RELATIONS

Current situation:

- Low connectivity, interface availability and data security.
- Lack of local content on technologies.

PROXIMAL SENSING

AUTOMATION OF ACTUATORS

Current situation:

- High cost of equipment with high technology content.
- Inaccessible autonomous systems.
- Complete, tested, qualified and demonstrated system (TRL 8).

- Low perception of value, particularly by small and medium producers.

Action Plan:

Foster the development, innovation, diffusion, training and dissemination of precision agriculture in the country by 2030.

Impacts:

- Democratic access to technologies
- PA training for at least 1,000 rural producers.
- Promotion of PA training in undergraduate courses.
- Contribution to the mitigation of 400,000 tCO_2eq. by 2030.
- Implementation of precision agriculture technologies in all conditions, regions and scope (TRL 9).
- Greater agribusiness competitiveness with the increase in productivity and profitability.

Figure 22 – Before and after implementing the TAP

Source: the author.

The creation of a Network to promote PA development, innovation and diffusion is of fundamental importance, as it is an action that interacts with the proposed activities to implement initiatives, as well as training and dissemination for different stakeholders. The purpose of the Network is to propose, promote, support and supervise activities to make PA increasingly accessible to all farmers. The Network will be responsible for bringing together leading research institutions, companies and government agencies involved with PA in order to increase demand in the sector, and propose and monitor research and actions for PA, precision forestry, agriculture 4.0, digital agriculture, agricultural automation and Internet of Things (IoT). In this capacity, it will propose and monitor activities to develop or improve equipment, practices and machinery for PA. The Network will also train and disseminate the knowledge acquired in partnership with educational institutions and entities directly linked to rural producers.

Precision Agriculture

The implementation of this technology is structured in 3 actions, with a 8-year implementation period

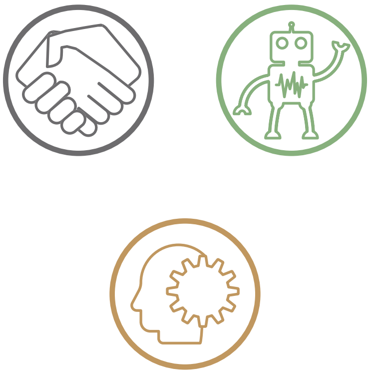


Figure 23 – TAP macro-actions

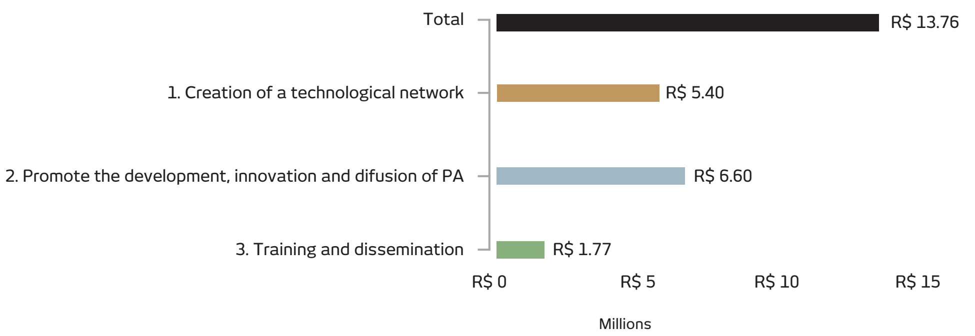
Source: the author.

For the implementation of the TAP to be more effective, different stakeholders (public and private sector, associations and sector representation entities, among others) were prospected for each of the three actions to collaborate in the implementation of the Plan. Some of the institutions that could initially coordinate the TAP should be highlighted. The Brazilian Commission for Precision and Digital Agriculture (CBAPD) has responsibilities that are in line with the objectives of the proposed actions. Thus, the Plan would serve as an instrument to support the Commission's actions. Given their expertise in PA technology and coordination, the Ministry of Science, Technology and Innovation (MCTI) and Mapa could participate in the coordination of Action 1 and in the technical coordination of research, development and innovation activities (MCTI) and dissemination and training in PA (Mapa).

The time frame for implementing the action plan is eight and a half years, with an estimated cost of BRL 13.8 million. Action 2, which concerns the development of PA technologies, is the most significant in terms of costs, followed by the activity for the creation of the Network, which has significant costs as it extends over the time frame of the Plan.

Precision Agriculture

Implementation costs



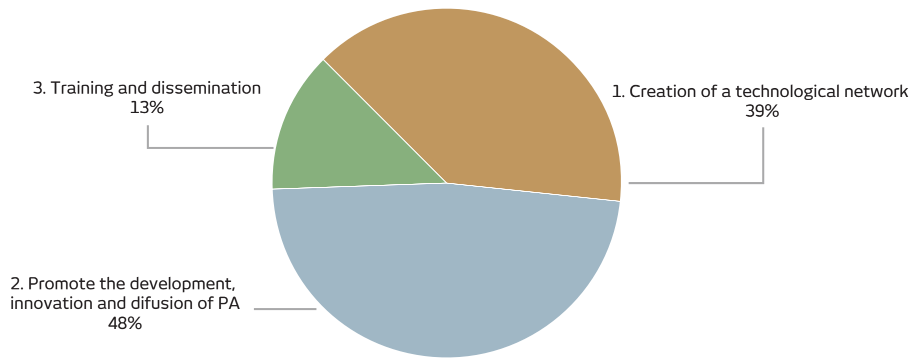


Figure 24 – TAP implementation costs

Source: the author.

With respect to potential sources of financing for the activities, and with a view to financial results and a focus on research, development, equipment testing and pilot applications, we determined the typical means of financing would be non-repayable loans and technical assistance. Financing is accessible by state agents (federal, state and municipal), companies (public and micro companies and small, medium and large private sector companies), associations and cooperatives. The mechanisms to request resources are presented in the "Electronic guide to financing options for the technologies prioritized in the TNA_BRAZIL Project" (MCTI, 2021j). Activities involving financing of demonstration projects (6 and 7) would be financed by repayable loans. This source of financing is applicable to all the stakeholders cited above.

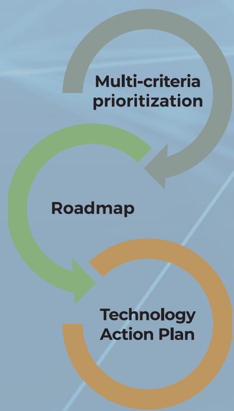
Finally, potential risks in the implementation of the TAP activities were analyzed. The risks were classified as follows: "low risk" (risks with minor consequences); "medium risk" (risks with reversible consequences in the short and medium term with low costs); and "high risk" (risks with reversible consequences in the short and medium term, but with high costs). Contingency actions were proposed to minimize these risks.

The highest risks are associated with the technology development activities (6 and 7). These two activities involve large budgets and different stakeholders. These risks include difficulty in accessing producers, problems with equipment testing and incorrect process monitoring. Risks associated with competing priorities could also interfere with the progress of the project. In addition, there are risks associated with poor definition of the scope and the minimum requirements for project submissions. There are also the risks of failing to secure financing for the projects and contracted parties no fulfilling their obligations.

The principal measures to mitigate these risks are: partnerships with institutions that interact with small and medium producers; partnerships with producer associations and key representatives in PA; cooperation with the main development agencies and international development agencies; contracting a consulting team to evaluate and validate calls for projects; and clear actions by the Network to demonstrate the benefits of PA, among others.

9.

Technology Needs Assessment **for the Genetic Improvement of Beef Cattle**



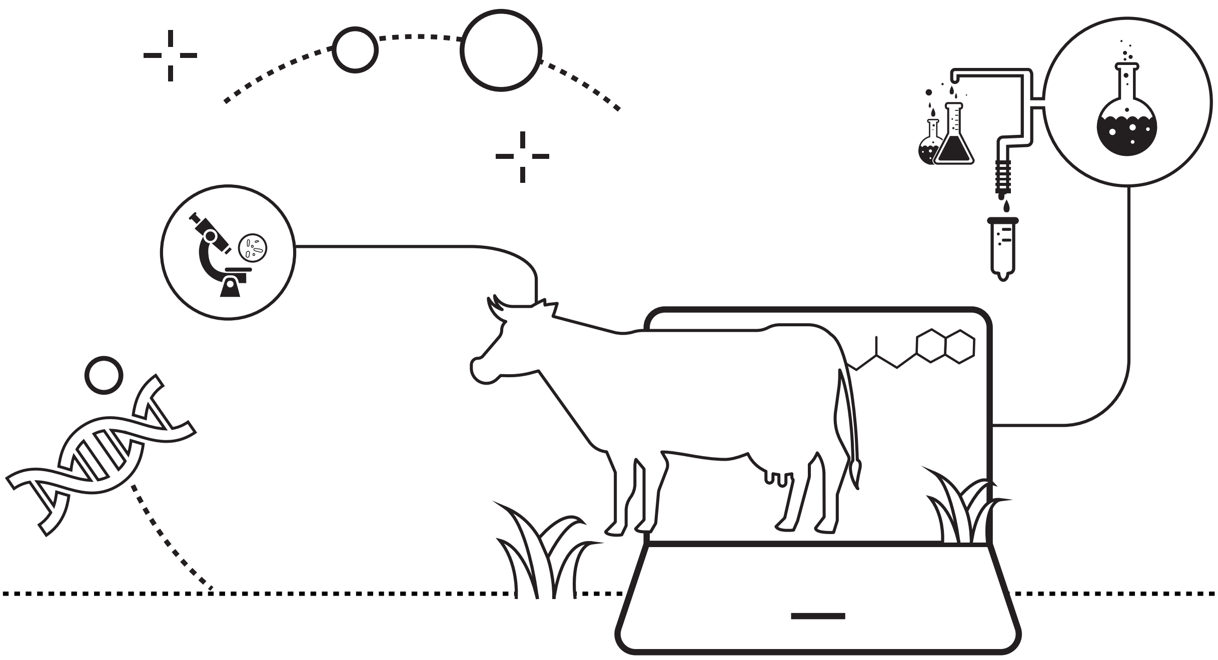
9. TAP FOR THE GENETIC IMPROVEMENT OF BEEF CATTLE

Genetic improvement involves the modification of the genetic composition of herds over generations, aimed at optimizing it for the production environment, performance expectations and market demands. It plays an important role in the development of the main animal production chains in Brazil, including poultry, swine, beef and dairy production.

The genetic composition of herds can be modified through selection (selection of breeding individuals) and mating (strategies for pairing individuals). Genetic improvement is efficient for modifying the averages of economically important characteristics in a positive manner, as long as they are measurable and there is genetic variability. Thus, it is possible to improve characteristics related to reproduction, growth, feeding efficiency and adaptation to climate and parasites.

The TAP for the genetic improvement of beef cattle seeks to remove barriers such as: lack of knowledge of the economic importance of genetic characteristics; and lack of integration and agility among the stakeholders involved in genetic improvement programs, among others. To this end, the TAP seeks to develop a platform for integration, dissemination, training and analysis of economic, zootechnical, genealogical and genotype data for beef cattle by 2030.

Among the benefits of genetic improvement, we can cite improved resilience to climate change and reductions in emissions. In the latter case, enteric fermentation in cattle is considered the principal source of GHG emissions in the beef production chain. In traditional beef cattle production systems, most GHG emissions occur in the gestation and fattening phases. In intensive livestock systems (with a younger slaughter age), the gestation phase becomes the main source of GHG emissions. Thus, the use of tools (such as genetic improvement) to improve reproductive and growth characteristics will lessen the environmental impacts of the beef production chain. In technological terms, the implementation of the TAP would make it possible to move from the stage of tested, qualified and demonstrated selection objectives (TRL 8) to providing a widely available integrated genetic improvement platform (TRL 9).



Genetic Improvement of Beef Cattle

Before and after implementing the Action Plan

	Current situation	Action Plan	Impacts
DEFINITION OF SELECTION OBJECTIVE	• Differences between production systems in Brazil. • Lack of knowledge of the economic importance of characteristics. • Lack of integration and agility among the stakeholders involved in animal genetic improvement programs. • Technology readiness level of tested, qualified and demonstrated selection objectives (TRL 8).	Develop a platform for integration, dissemination, training and analysis of economic, zootechnical, genealogical and genotype data for beef cattle by 2030.	• Improved livestock profitability • Greater utilization of national genetic material.Contribution to the mitigation of 10% of emissions from cattle farming (35 $MtCO_2eq$. by 2030). • Increased herd resilience to climate change. • General availability of the integrated platform for genetic improvement (TRL 9).

Figure 25 – Before and after implementing the TAP

Source: the author.

To achieve the goals of the TAP, six actions were proposed. Actions 1 and 2 consist of steps for the analysis of beef cattle production and the perceptions of bovine genetics suppliers and users. Action 3 seeks to expand the knowledge base on available genetic resources for beef cattle production. Action 4 is important to demonstrate the economic potential of genetic improvement in beef cattle, and depends on the results of the previous actions. Action 5 is essential to ensure that the benefits of the Plan contribute to the development of the beef production chain, even after the completion of all the planned actions. The development of the platform for data integration, analysis and reporting will ensure that the economic and zootechnical performance parameters on the genetic selection farms (and commercial farms) is routinely and continuously analyzed, so that data is extracted and made available in a timely manner for breeders and beef producers. Finally, but not less important, Action 6 includes the dissemination of the results obtained in the previous stages, as well as training people to use the platform.

Genetic Improvement of Beef Cattle

The TAP for this technology is structured in six actions, with a 8-year implementation period

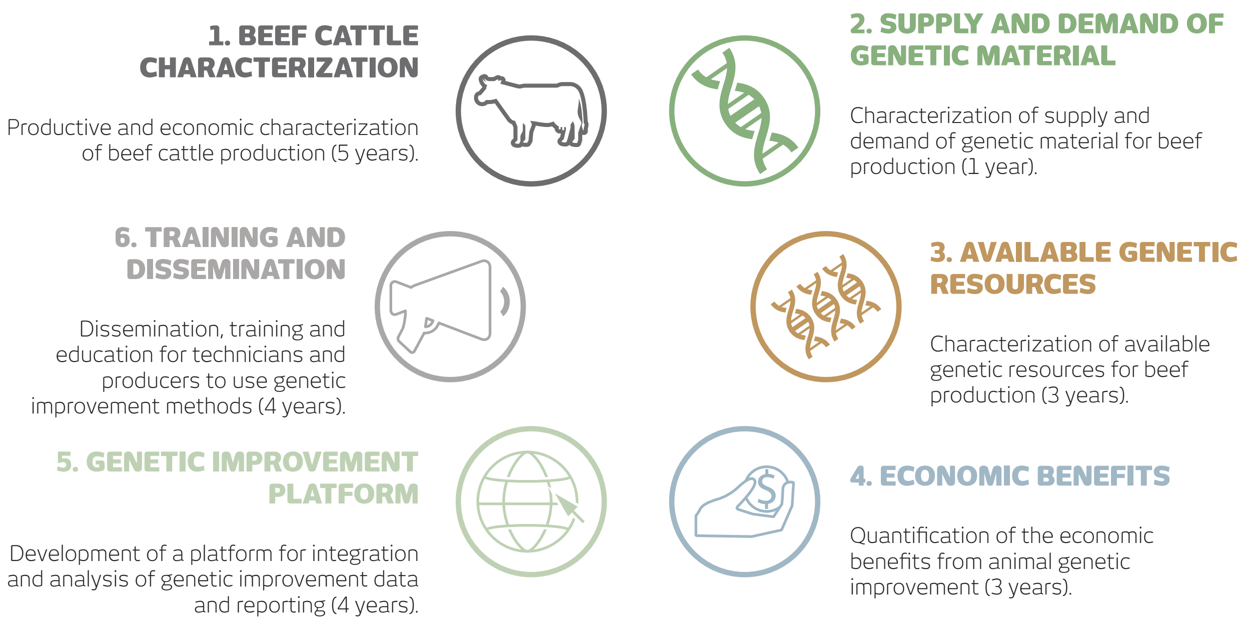


Figure 26 – TAP macro-actions

Source: the author.

The successful and complete execution of this TAP depends on the collaboration of stakeholders from the public sector (educational and research institutions and development agencies) and the private sector (genetic improvement programs, breeders' associations, consulting companies, genotyping laboratories and software development companies). We suggest that a Committee made up of a coordinator and advisory members manage this Plan. The coordinator could be a highly qualified technical expert (professor or researcher) linked to an institution with the capacity to support the project's needs and cooperate with the other stakeholders needed for the execution of the proposed actions. It is essential that there are no conflicts of interest between the coordinator (and institution) and the Plan and stakeholders involved. The other members will be Plan advisory and technical partners, whether they be development institutions, implementation partners or public or private stakeholders.

The time frame for implementing the action plan is eight and a half years, with an estimated cost of BRL 9.4 million. Actions 3 and 5 account for approximately 35% of the budget as they are complex actions and largely dependent on specialized and outsourced services.

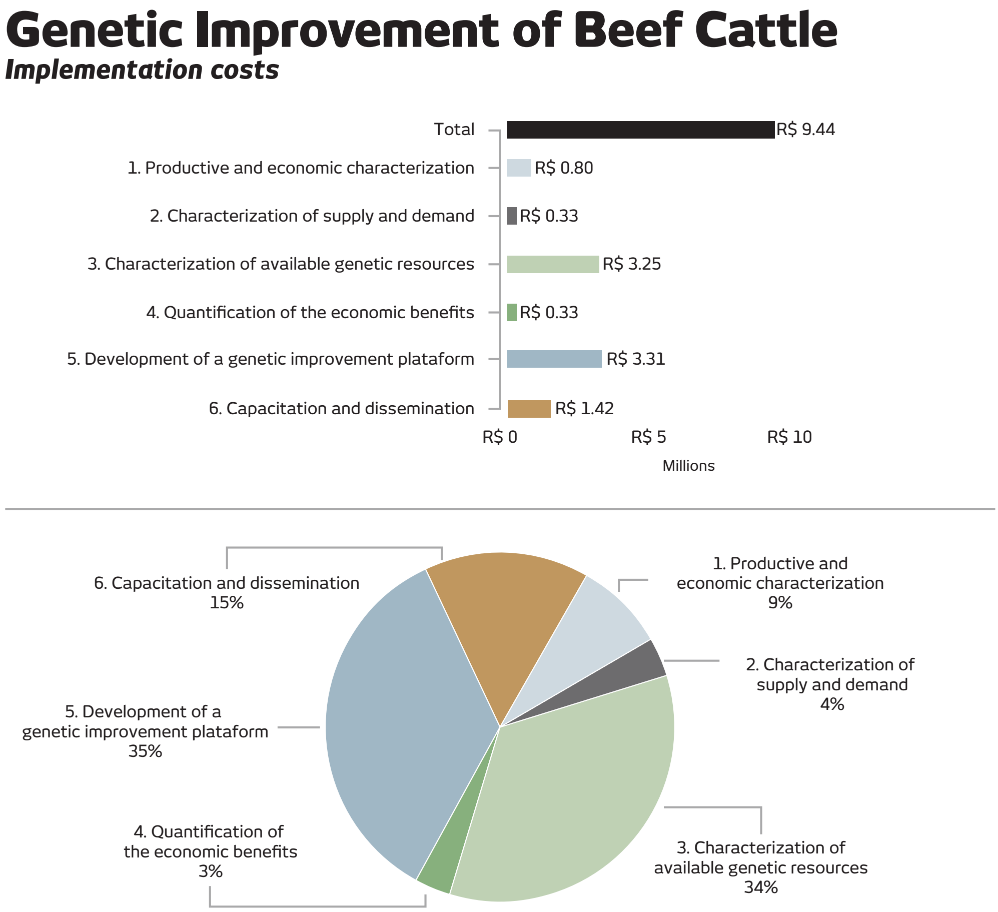


Figure 27 – TAP implementation costs

Source: the author.

With respect to potential sources of financing for the activities, and with a view to financial results and a focus on research and development, we determined the typical means of financing would be non-repayable loans and technical assistance. Financing is accessible by state agents (federal, state and municipal), companies (public and micro companies and small, medium and large private sector companies), associations and cooperatives. The mechanisms to request resources are presented in the "Electronic guide to financing options for the technologies prioritized in the TNA_BRAZIL Project" (MCTI, 2021j).

Finally, a risk and contingency plan was proposed for the implementation of the TAP actions and activities. High risks were associated with sub-activities 3.2, 3.3, 5.1, 5.2, 5.3 and 5.4, which account for approximately two thirds of the Plan's budget.

With respect to sub-activities 3.2 and 3.3, the necessary raw materials are subject to exchange rate variations (cost risk). These activities should be performed by highly qualified professionals (technical risk), and the activities still need to be subdivided into steps that depend on different stakeholders and organizations, requiring high levels of control and coordination (organizational risk). They also need to be carried out by stakeholders from different public and private institutions, with different objectives and views (institutional risk). There is also a potential political risk that could arise from conflicts of interest when determining the breeds to be studied and, especially, how the data is used.

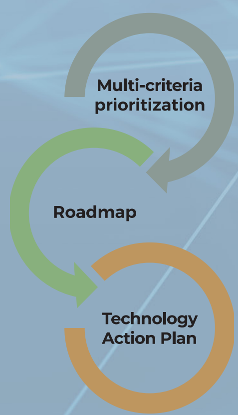
The suggested actions to eliminate or mitigate these risks include contingency actions to objectively select the breeds to study (taking into account their relative importance in beef production): an official agreement on how the data will be shared; specification of the services, costs and execution deadlines; contracting of qualified and experienced professionals and companies to carry out the activities; establishing contracts with the parties involved; contracting external experts to validate activities and data; and efficient communication between parties involved and activity management, among others.

The risks involved in sub-activities 5.1, 5.2, 5.3 and 5.4 include: a high degree of uncertainty about previously defined costs and difficulties in securing financing and partners for maintenance and continuous validation of the platform (institutional risk); different financing institutions may have different objectives, which can generate conflicts of interest (institutional and political risks); requirement for detailed specifications of the types of data to be included in the platforms, the procedures to be performed and the functionality of the products (platforms) to be delivered (technical risk); reliance on efficient coordination, especially for defining requirement documents and meeting deadlines (organizational risk). These activities are part of the most complex and difficult actions to be carried out, which are unprecedented in scale.

To maximize the chances of success, it is essential to clearly specify each participant's role; maintain efficient communication; define targets and responsibilities, monitor the execution of activities; contract experienced and qualified professionals and institutions in the areas of genetic improvement and software development; establish contracts with technical and institutional partners; and organize workshops to validate the modules and platforms developed.

10.

Technology Needs Assessment **for Silviculture and Genetic Improvement of Native Species**



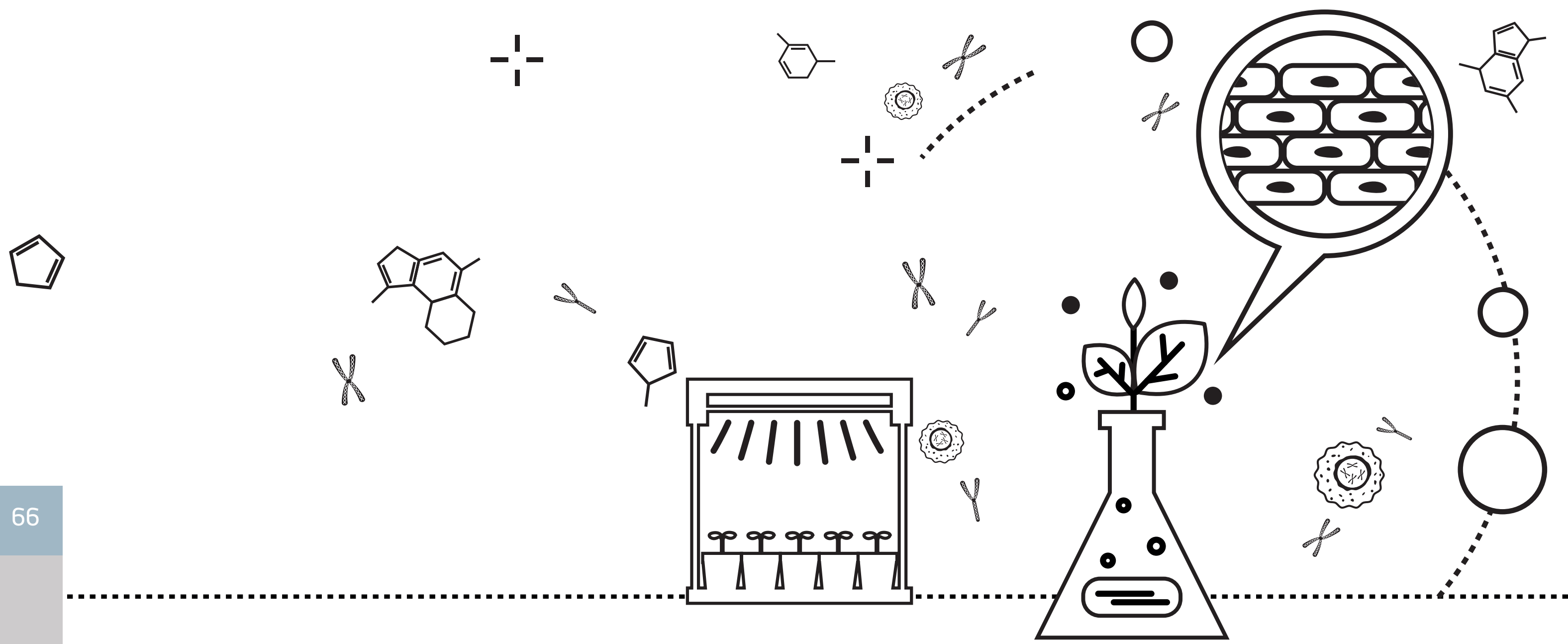
10. TAP FOR SILVICULTURE AND GENETIC IMPROVEMENT OF NATIVE SPECIES

This TAP aims to implement programs for the genetic improvement and management of tree species with economic potential to obtain seeds with genetic quality to meet the needs of forest sector industries in a sustainable manner. It involves expanding native species silviculture through genetic improvement, ensuring gains in the competitiveness of native species silviculture over the currently prevalent cultivation of exotic species in Brazil.

Although native species silviculture production cycles are relatively long, this technology has a degree of maturity that, with additional investments, can offer economic, social and environmental benefits with the increased use of diverse Brazilian forest species.

This TAP aims to remove barriers, such as the rejection of juvenile wood produced by the native tree silviculture system; the high cost of implementing forest improvement programs; and technology readiness level of concept validation only in native species genetic improvement laboratories (TRL 3), among others. To this end, the Plan proposes to implement genetic improvement programs for at least ten naturally occurring tree species in Brazilian biomes and to develop silviculture technologies that can make silviculture enterprises economically viable by 2030, in synergy with the selected genotypes.

The TAP offers important benefits for the sector and the country, including generating employment and income in regions with low human development indexes (HDIs), as well as contributing to the restoration of native vegetation. In the case of GHG emission mitigation, this technology offers important potential benefits such as increasing carbon stocks and the provision of ecosystem services. In addition, the use of native trees in reforestation is expected to improve the process of water generation and storage in the soil and increase the matrix of wood uses, mainly by incorporating and expanding multiple uses in order to alleviate pressures on the remaining native vegetation in different Brazilian biomes. It is also important to highlight technological development, considering that the TAP would allow for the demonstration of native species with genetic improvements (TRL 7).



Silviculture and Genetic Improvement of Native Species

Before and after implementing the Action Plan

	Current situation	Action Plan	Impacts
IMPROVING THE ECONOMIC VALUE OF TIMBER AND NON-TIMBER PRODUCTS **DEFINITION OF POPULATIONS BY SPECIES OF INTEREST** **COMBINED PROVENANCE-PROGENY TESTS** **SEED PRODUCTION** **SELECTION OF INDIVIDUALS**	• Rejection of juvenile timber produced by the native tree silviculture system. • Long term for achieving productivity gains. • High cost to implement forestry improvement programs. • Lack of confidence among businesses due to insufficient technological material. • Technology readiness level of concept validation only in native species genetic improvement laboratories (TRL 3).	By 2030, implementation of genetic improvement programs for at least ten naturally-occurring tree species in Brazilian biomes and the development of silviculture technologies so that, in synergy with the genotypes selected, they can make forestry enterprises economically viable.	• Contribute to the restoration of 9.3 million hectares of native vegetation by 2030. • Expansion of the total planted area of exotic species by 3 million hectares by 2030. • Contribute to the mitigation of 33 $MtCO_2eq$. by 2030. • Demonstration of native species with genetic improvement (TRL 7). • Employment and income generation in low HDI regions. • Conservation of biodiversity.

Figure 28 – Before and after implementing the TAP

Source: the author.

The actions to develop silviculture techniques will adhere to equine forestry concepts. As the target species for studies and technological development will only be defined after initial evaluations, based on specialized literature, expert opinions and the experience of educational and research institutions (public and private), the nature of the cultivation system, whether pure or mixed, will depend on knowledge of their ecological succession under natural conditions.

After defining the ten target species, the actions and activities should be carried out simultaneously, as a priority, to optimize the study time for a given species or group of species. Of course, some of these actions and activities cannot be carried out simultaneously, since some depend on the prior completion of another. For example, market studies can only be carried out after understanding the properties of juvenile wood, the suitability of its uses and the implementation of demonstration units.

Extremely important for the diffusion of this technology are the actions to establish silviculture and genetic improvement strategies based on the experiences acquired in the technological studies of tree species (Action 6) and to develop and conduct education and training plans focusing on native silvicultural technologies and potential markets (Action 7).

Silviculture and Genetic Improvement of Native Species

The TAP for this technology is structured in 7 actions, with a 8-year implementation period

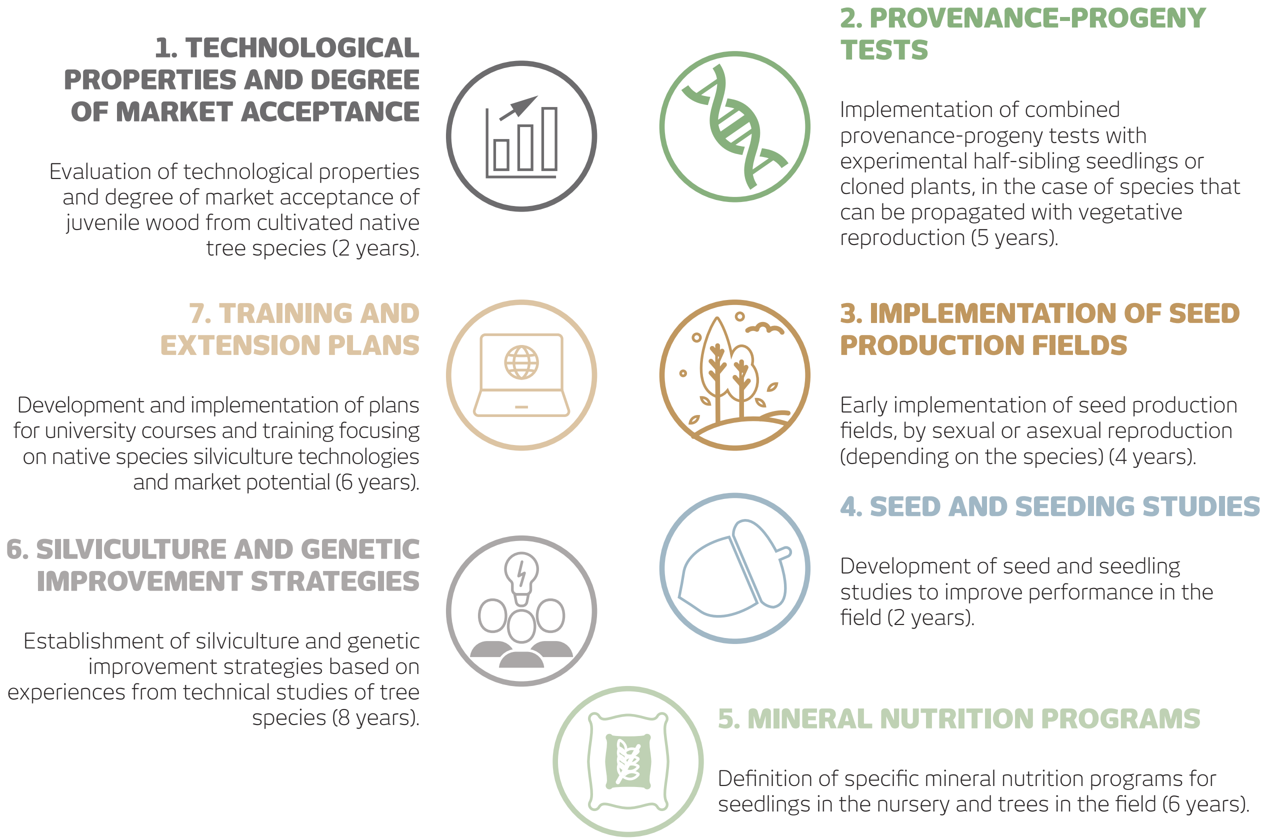


Figure 29 – TAP macro-actions

Source: the author.

For the seven actions for the development of silviculture and genetic improvement of native species, potential stakeholders were identified to participate in carrying out the activities involved. We believe that the Plan could be coordinated by Mapa and the MCTI, with the Brazilian Agricultural Research Corporation (Embrapa) as the main technical partner responsible for the technical coordination of the actions and activities. The Ministry of Environment (MMA) could also be part of the Plan's Technical Advisory Committee, in conjunction with the institutions mentioned above. Research and educational institutions and institutes located in the different biomes could act as technical partners and agents for disseminating TAP results. Finally, a permanent team should be established to coordinate the execution of activities, reporting directly to the aforementioned coordinating institutions.

The time frame for implementing the action plan is eight and a half years, with an estimated cost of BRL 16.3 million. Among the actions and activities, the implementation of Action 2 (the most capital-intensive) should account for approximately 29% of the budget.

Silviculture and Genetic Improvement of Native Species

Implementation costs

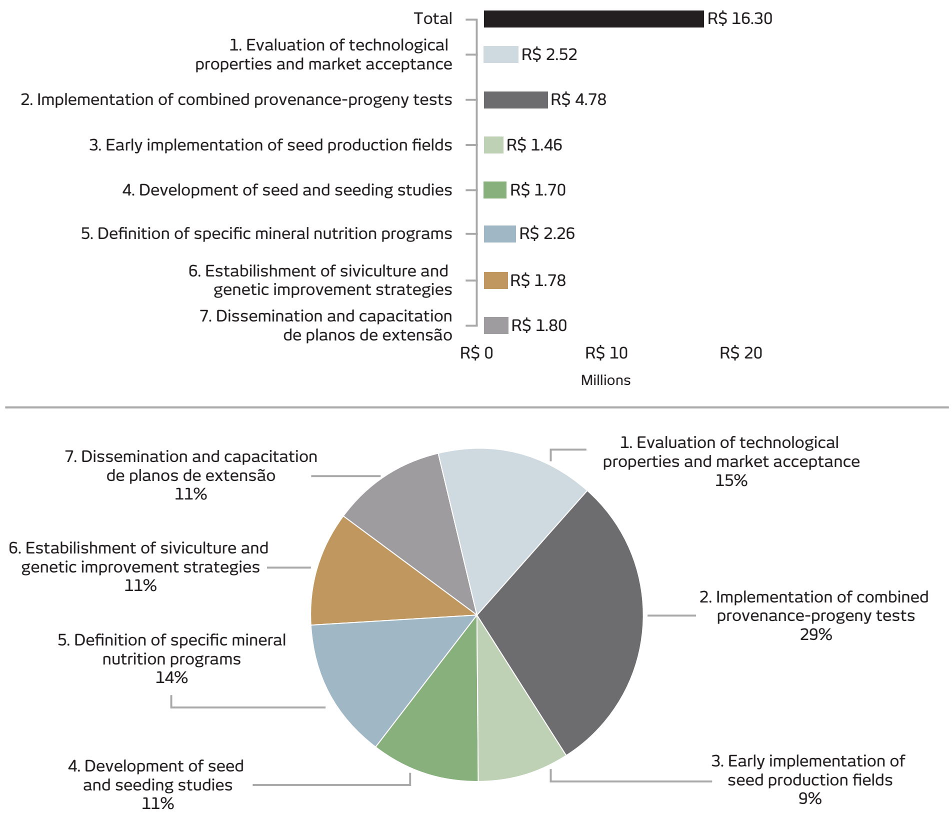


Figure 30 – TAP implementation costs

Source: the author.

With respect to potential sources of financing for the activities, and with a view to results and a focus on research and development, we determined the typical means of financing would be non-repayable loans and technical assistance. Financing is accessible by state agents (federal, state and municipal), companies (public and micro companies and small, medium and large private sector companies), associations and cooperatives. The mechanisms to request resources are presented in the "Electronic guide to financing options for the technologies prioritized in the TNA_BRAZIL Project" (MCTI, 2021j).

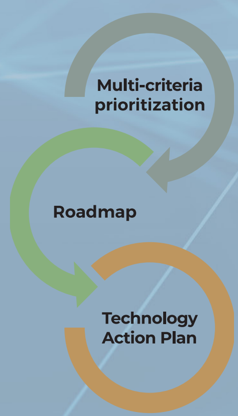
Finally, a risk and contingency plan was proposed for the implementation of the TAP actions and activities. Of the 21 scheduled activities, 11 (52%) were considered low risk, eight (38%) medium risk, and two (9%) high risk.

Special attention should be paid to sub-activity 2.3 for the implementation of genetic testing in four different environmental zones, considering the predominant edaphic and climatic characteristics of the Amazon, Cerrado, Atlantic Forest and Caatinga biomes. This also applies to sub-activity 3.1 for the implementation of 40 untested seed production plantations for ten species from four biomes. In both activities, the high risks stem from the fact that the aforementioned implementations, in order to reduce costs, must be maintained over a long period, which, depending on the species, can be decades and involve the use of public or private lands (established in partnerships), which may be subject to changes in use or ownership through sale or inheritance.

To mitigate the risks in sub-activities 2.3 and 3.1, partnerships should be formalized for the concession of experimental areas and the areas for seed production units, respectively. In addition, it is necessary to supervise the tests and ensure the delivery of results, as well as compliance with the partnership agreements.

11.

Technology Needs Assessment **for Silviculture with Mixed Planting for Restoration**



11. TAP FOR SILVICULTURE WITH MIXED PLANTING FOR RESTORATION

The technological scope of the TAP includes the use of mixed planting systems in Legal Reserve (LR) and Permanent Preservation Areas (PPAs) using exotic and native species in silviculture as an alternative to the Plan for the Recovery of Degraded Areas (Prad), considering the determinations of the Brazilian Forest Code (FC). Thus, the implementation of this technology aims to develop plantations for the purposes of environmental restoration combined with socioeconomic gains for landowners who need to carry out the changes proposed under the Environmental Regularization Plan (ERP).

This approach determines the use of tree species as the most suitable alternative for environmental restoration, coupled with the possibility of producing and selling related products for subsistence and income generation on properties. Besides silviculture, other activities, such as agriculture and livestock (integrated crop-livestock-forest systems - ICLFS), represent other options, making the application of silviculture with mixed planting more flexible.

The Plan proposes actions and activities to overcome obstacles, such as: bureaucratic procedures and complex federal, state and municipal legislation; limitation on the use of exotic species for properties of up to four fiscal modules; technology readiness level of validation in native species nurseries (TRL 5); high cost of inputs, transport and implantation; and the limited viable logistical radius for receiving inputs and supplies and for distributing products, among others. To this end, by 2030, it aims to strengthen institutions and validate efficient mixed planting systems in the field that provide ecological and economic benefits and comply with regulations, developed for restoring different biomes and protected environmental areas.

Although the goal of the technology is environmental restoration, allowing land owners to use their properties to produce and commercialize different products is also an opportunity for them to participate in restoration and conservation actions. In addition, this involvement can generate regional employment and income, contributing to the socioeconomic development of regions with low HDIs. The expansion of silviculture with mixed planting for restoration has great potential for mitigating climate change by removing CO_2 through the growth of biomass, as well as a potential reduction in the use of fertilizers.

Silviculture with Mixed Planting for Restoration

Before and after implementing the Action Plan

Current situation → **Action Plan** → **Impacts**

ERP

- Bureaucratic procedures and complex federal, state and municipal legislation.
- Forest recovery, preferably with native species.
- Limitation on the use of exotic species for properties of up to four fiscal modules.

MIXED PLANTING

NURSERIES

- Few studies and reported results.
- Lack of investment in research.
- Lack of specialized technical support in the region.
- Difficulty in accessing equipment.
- Technology readiness level of validation in native species nurseries (TRL 5).

COMMERCIALIZATION

- High cost of inputs, transport and implementation.
- Limited viable logistical radius for receiving inputs and supplies and for distributing products.

Action Plan

By 2030, create institutions and validate, in the field, mixed planting systems that are ecologically and economically efficient, and that comply with regulations, developed with the purpose of restoring different biomes and protected environments.

Impacts

- Contribute to the restoration of 9.3 million hectares of native vegetation by 2030.
- Contribute to the mitigation of 9.5 $MtCO_2eq$. by 2030.
- Ensure the commercial availability of native species for restoration (TRL 8).
- Compliance with Environmental Regularization Program (ERP) regulations.
- Generation of employment and income in low HDI regions.
- Conservation of biodiversity.

Figure 31 – Before and after implementing the TAP

Source: the author.

Three actions and 13 activities were proposed to achieve the TAP objectives. Initially, it is necessary to implement a number of activities aimed at elaborating or improving the regulatory and institutional base, and to make this information available to the forestry sector. This action is directly related to the elaboration or improvement of regulatory and/or infra-legal instruments, in addition to disseminating these to all stakeholders in the restoration chain. Following this, it is important to survey and refine existing data on mixed planting systems and carry out new studies, when necessary, taking into account the need for validating this data in the field. The objective of the action is field validation of mixed planting systems to demonstrate their ecological and economic benefits. Finally, the dissemination of information and more practical and comprehensive proposals are necessary to support the restoration chain.

Silviculture with Mixed Planting for Restoration

The creation of the network is structured in 3 actions, with a 8-year implementation period

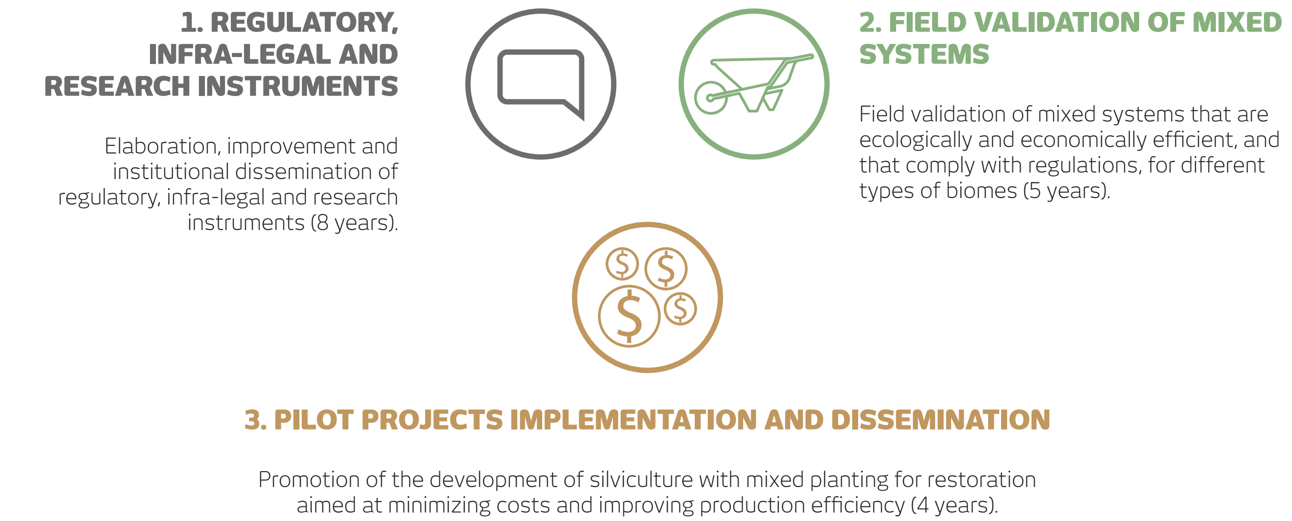


Figure 32 – TAP macro-actions

Source: the author.

The identification of key stakeholders for implementing the actions is fundamental for the expansion of mixed planting systems for restoration. As the technology has synergy with the activities of numerous organizations, there is a high degree of diversity among stakeholders. In addition, the mapping of local stakeholders and networks is an essential step for the success and expansion of the restoration chain, aimed at promoting and strengthening initiatives and links that already exist, as well as removing bottlenecks and encouraging cooperation.

We identified numerous stakeholders considered important for the success of this TAP. We can highlight the roles of the following institutions: Mapa, Embrapa, the Ministry of Communication, Technology and Innovation (MCTI) and the Ministry of Environment (MMA). Given its expertise, Mapa could assume the role of general coordination of the actions, including some of the secretariats and specific sectors, such as the Seedling Quality Control and Forestry Nursery Inspection Sector and the Executive Plan Commission for Cocoa Crops (Ceplac), which have extensive expertise in the Agroforestry System. Due to its technical-scientific expertise, Embrapa could be the main technical partner for carrying out the activities. The MCTI could technically coordinate Action 2, in view of the alignment of the scope and goal of the TAP with the Regenera Brasil Initiative (created with Ordinance No. 3.206/2020). Finally, the MMA could play a role in the technical coordination of sub-activities 1.1 and 1.2.

The time frame for implementing the action plan is eight and a half years, with an estimated cost of BRL 31.4 million. This forecasted budget is distributed evenly across the three Plan actions, with the activities involving studies and infrastructure having the highest costs.

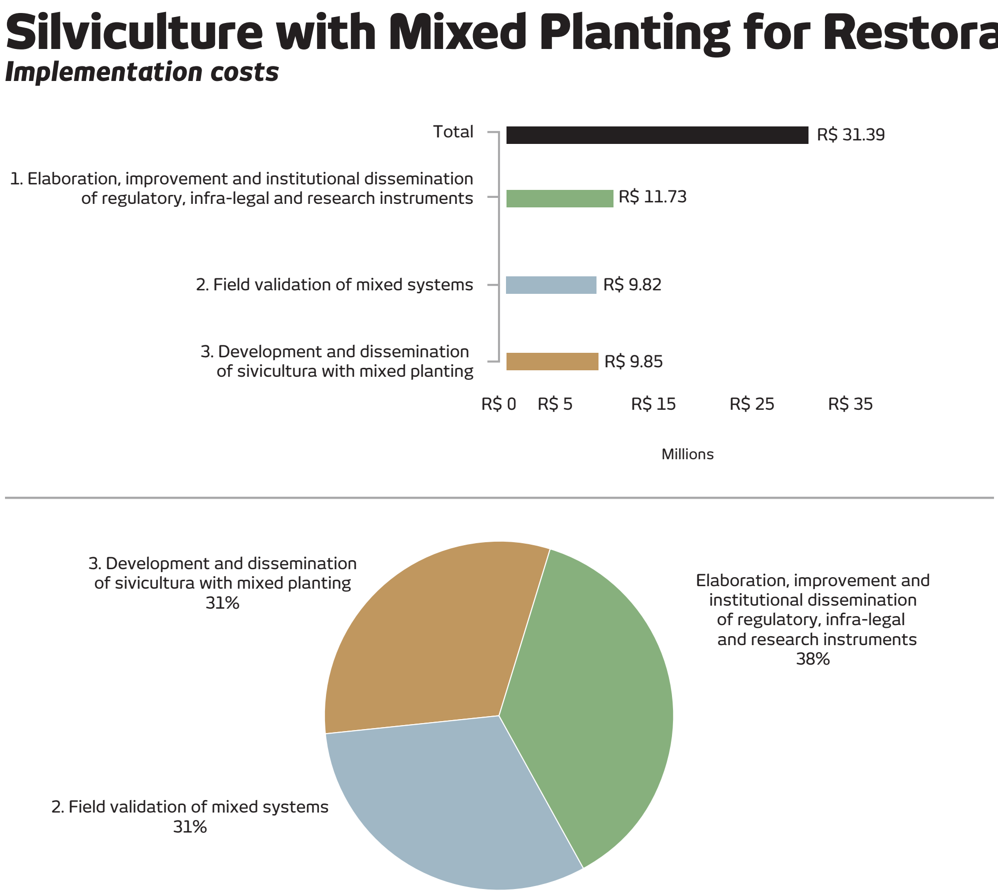


Figure 33 – TAP implementation costs

Source: the author.

With respect to potential sources of financing for the activities, and with a view to results and a focus on research and development, we determined the typical means of financing would be non-repayable loans and technical assistance for Actions 1 and 2. Financing is accessible by state agents (federal, state and municipal), companies (public and micro companies and small, medium and large private sector companies), associations and cooperatives. The mechanisms to request resources are presented in the "Electronic guide to financing options for the technologies prioritized in the TNA_BRAZIL Project" (MCTI, 2021j). In the case of Action 3, in view of the implementation of demonstration units, payment for environmental services could also be used.

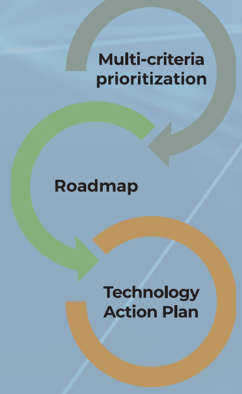
Finally, we mapped the risks associated with the activities and proposed measures to mitigate them. In general, the activities considered medium risk involve a large number of stakeholders who have different expectations and, thus, conflicts of interest and lack of engagement could arise. The activities that involve the development of infrastructure (and more financial resources, especially for long-term maintenance), were considered high risk.

Sub-activity 3.2, for the implementation and monitoring of 12 pilot demonstration units for mixed planting for restoration, poses a high risk due to potential difficulties in implementing and maintaining the units, as well as keeping the property owner engaged in the activity. Thus, it requires planning and coordination for the units to become self-sustainable and continue operating in the long term. In the short term, a resource concession contract should be drawn up for the implementation of the units, and monitoring should be carried out for a period of two years. Subsequently, a technical cooperation agreement (TCA) to maintain the units should established with technical assistance and rural extension companies (Ater).

Sub-activity 3.3, which involves the analysis and organization of the nurseries to supply the forestry chain for restoration, presents potential difficulties for implementing and maintaining the nurseries. Furthermore, there is the challenge of including new nurseries and maintaining existing ones in the dynamics of the restoration chain. In this context, the main obstacle is to keep stakeholders engaged in the activities. To minimize these risks, a resource concession contract should be established for the implementation of the nurseries, and provisions should be made for monitoring them for a period of two years. Subsequently, a TCA should be signed with Ater companies to maintain the nurseries.

12.

Technology Needs Assessment **for Satellite Monitoring**



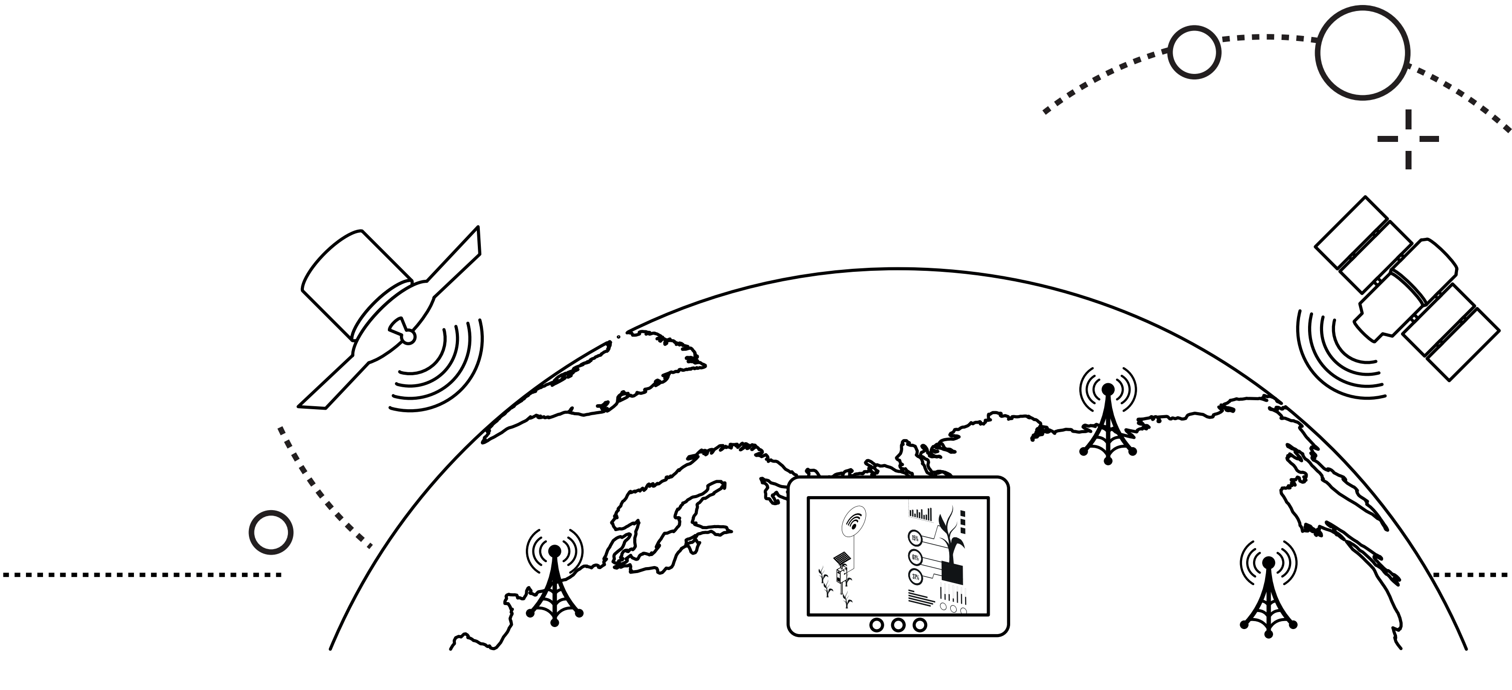
12. TAP FOR SATELLITE MONITORING

Satellite monitoring systems operate using remote sensing approaches, a set of techniques that make it possible to obtain data on targets on the Earth's surface (objects, areas, phenomena) based on recording the interaction of electromagnetic radiation with the surface via long distance, or remote, sensors. This technology makes it possible to monitor both land use and land cover changes, as well as the main landscape elements of rural activities.

One of the bases of Precision Agriculture (PA) is the availability of high resolution spatial data capable of supporting decisions at the rural property level. Currently, remote sensing applications assist agricultural production in the early detection of pests and damaged plants, assessing nutrient levels in plants, detecting water stress and in forecasting the harvest at the field level. As in the case of environmental restoration, the current use of remote sensing in PA is mainly via unmanned aerial vehicles (UAVs). Another important application of satellite monitoring is tracking agricultural production. By monitoring changes in land use at the rural property level, and in conjunction with spatially explicit modeling techniques, it is possible to verify compliance with Forest Code regulations and detect illegal deforestation and its role in the production chain.

This TAP seeks to overcome significant obstacles to satellite monitoring in the country, such as: lack of a national strategy for developing monitoring systems, with the replication of efforts, and lack of planning to integrate current systems and the agenda to develop the next generation of systems; lack of investments in basic and applied research for the development of automatic identification methodologies based on high resolution images; and the lack of use of spatial data in territorial intelligence applications to support the implementation of the Forest Code and intensification of livestock production. To remove these barriers, the aim is to develop a monitoring system by 2030 that uses high resolution images (<5 meters) and automatic recognition techniques to provide annual data on land use and land cover in at least two biomes (Amazon and Cerrado) in the following categories: native vegetation, secondary vegetation, pastures and agricultural crops.

Given the importance of satellite monitoring for activities to monitor compliance with the Forest Code and increase agricultural productivity, the improvement of these systems should contribute to increasing forest restoration aimed at environmental regularization and reducing illegal deforestation. In this way, these systems contribute indirectly to removing GHGs and to a reduction in emissions from land use change, among other positive impacts.



Satellite Monitoring

Before and after implementing the Action Plan

Current situation → **Action Plan** → **Impacts**

IDENTIFICATION OF COVERAGE AND EARTH USE CLASSES

Current situation:

- Lack of an integrated national strategy for the development of monitoring systems.
- Lack of investment in basic and applied research.

OPTIMIZATION OF LAND USE AT THE PROPERTY LEVEL

Current situation:

- Lack of application of monitoring system data to generate territorial intelligence.
- Consolidated monitoring system (TRL 9).

↓

- However, there is little use of technology among small and medium producers, and by municipal public officials.

Action Plan:

Develop a monitoring system by 2030 that uses high resolution images (<5 meters) and automatic recognition technology to provide annual data on land cover and use in at least two biomes (Amazon and Cerrado) in the following categories: native vegetation, secondary vegetation, pastures, and agricultural crops.

Impacts:

- Contribute to the implementation of an ERP and agriculture 4.0 (increase in productivity).
- Contribute to the mitigation of 48 $MtCO_2eq$. by 2030.
- Expand the use of the territorial intelligence system.
- Provide higher quality geospatial data, which can be applied in other public policies.
- Income generation with increased productivity.
- Maintenance and restoration of ecosystems.

Figure 34 – Before and after implementing the TAP

Source: the author.

To achieve the TAP goals, five interrelated actions and 25 activities were proposed in a coordinated order of execution. Action 1 serves as the basis for the development of technology, with the objective of creating a Committee for establishing, monitoring, reviewing and validating technical criteria, guidelines and results of actions for the harmonization of current and future land use and land cover satellite monitoring systems. In parallel, Action 2 aims to develop and validate a methodology for automatic classification of land use and land cover monitoring using high resolution satellite images. Actions 3 and 4 aim to develop and provide a high resolution monitoring system and territorial intelligence system to support the implementation of the Forest Code and the intensification of livestock and agriculture, respectively. Finally, Action 5 aims to promote training and dissemination of the use of the systems developed in Actions 3 and 4 for public and private stakeholders.

Satellite Monitoring

The TAP for this technology is structured in five actions, with a 8-year implementation period

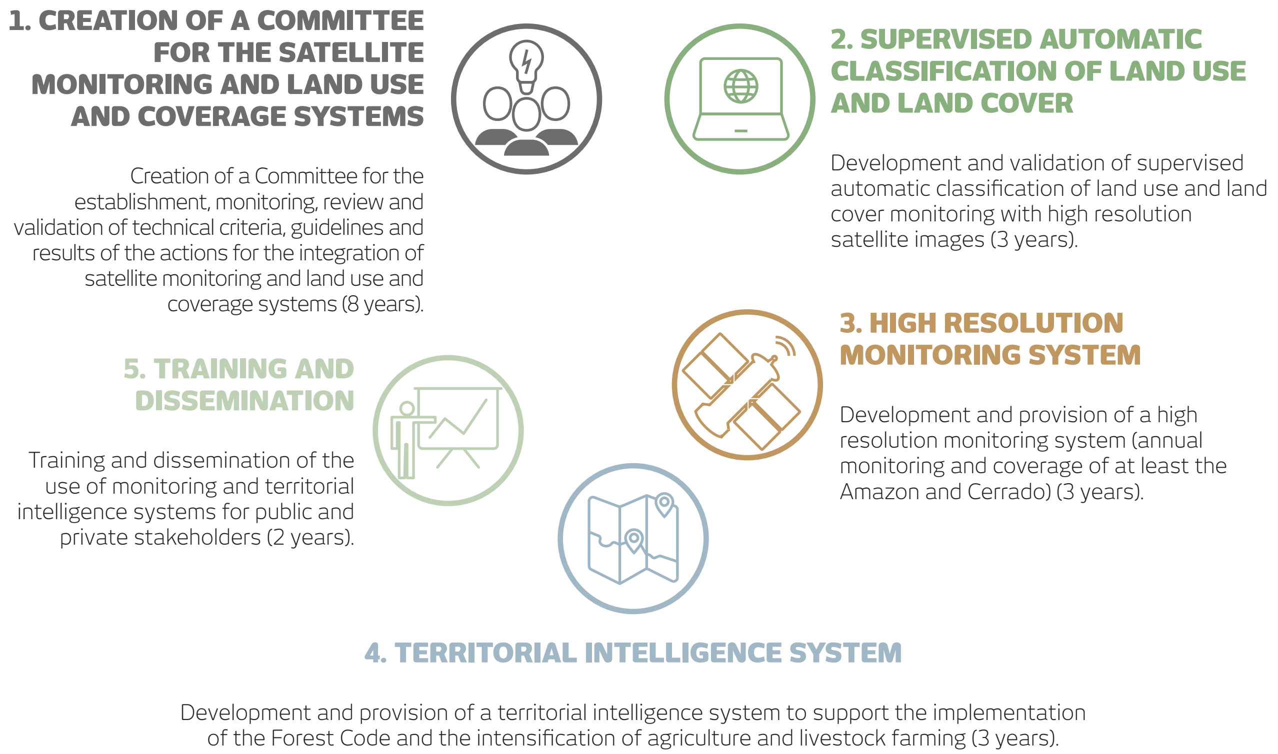


Figure 35 – TAP macro-actions

Source: the author.

For each of the five actions, we prospected multiple stakeholders with recognized expertise in this technology and whose mission is aligned with the goals of the Plan. We can highlight the National Institute for Space Research (Inpe), in view of their 50 years of experience in the satellite monitoring system value chain, from the development of hardware to the use of data in applications in environmental and agricultural areas. Thus, we recommended that Inpe assume the technical coordination, with the MCTI in the role of general coordination of the TAP.

The time frame for implementing the action plan is eight and a half years, with an estimated cost of BRL 193 million. Among the actions and activities, we estimate that the implementation of Action 3 will consume 61% of the budget.

It is worth noting that the item with the highest cost is the acquisition of high-resolution satellite images with national coverage. As a cost reference, the Ministry of Environment contract was used to purchase high-resolution RapidEye images with national coverage in 2012 at a cost of BRL 87 million. However, if these images, with the characteristics defined by the activities, are made available at no cost, or at a lower cost, it is possible to substantially reduce the total investment in the project. It would also be important to evaluate the possibility of investing these resources to support the development of national satellites, thus also stimulating national industry and technology transfer.

Satellite Monitoring

Implementation costs

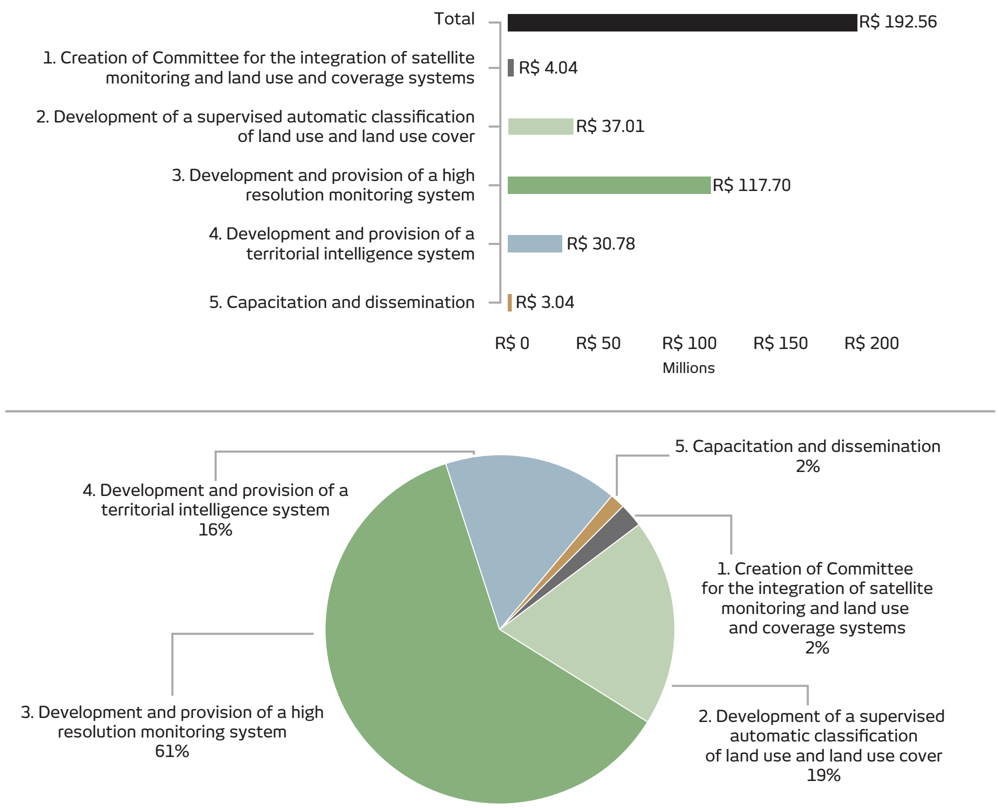


Figure 36 – TAP implementation costs

Source: the author.

With respect to potential sources of financing for the activities, and with a view to results and a focus on research and development, we determined the typical means of financing would be non-repayable loans and technical assistance. Financing is accessible by state agents (federal, state and municipal), companies (public and micro companies and small, medium and large private sector companies), associations and cooperatives. The mechanisms to request resources are presented in the "Electronic guide to financing options for the technologies prioritized in the TNA_BRAZIL Project" (MCTI, 2021j).

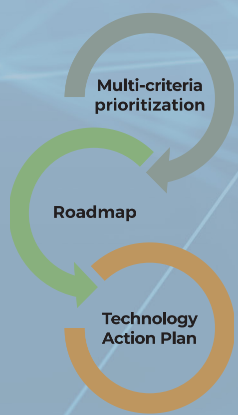
In addition to the estimated necessary resources, we analyzed potential risks and contingency actions for the implementation of the TAP activities. The risks associated with sub-activities 2.3, 3.4 and 4.1 were considered high.

In the first activity, there is a risk of divergence among specialists regarding automatic classification, the evaluated methods providing poor results, delays in prior activities and lack of methodology validation. For example, experts may disagree on the criteria for defining an area as deforested (vis-à-vis an area with degraded vegetation) or an early stage secondary forest (vis-à-vis an unmaintained pasture). To avoid this, it is important that stakeholders describe the requirements in detail to align them with expectations, analyzing their feasibility together. It may be necessary to reevaluate the classification process, reducing or combining classes with a high level of uncertainty in the automatic classification process. Finally, contingency resources should be secured for any revisions of the classification and international specialists should assist in the validation process.

Sub-activities 3.1 and 4.3 involve the definition of the technical team and institutions responsible for the development and maintenance of monitoring and territorial intelligence systems to support the Forest Code and the intensification of agriculture and livestock. We classified these activities as high risk due to potential conflicts of interest between the institutions involved when determining the organization responsible for the development and maintenance of the system. In addition, contracting specialized labor is complex, and carries the risk of lack of technical coordination and coordination with the Satellite Monitoring Committee. To mitigate these risks, we suggested establishing objective criteria for selecting the organization responsible for carrying out the activities, with minimum requirements for institutional capacity, to reduce the risk of political conflicts. Political support and cooperation from relevant stakeholders is also important to avoid significant obstacles. Finally, we suggest contracting labor from centers and institutions with extensive expertise, defining a work plan validated by the Monitoring Committee and technical coordination.

13.

Project **Ideas**



Project Ideas

With a view to advancing the development of projects based on the TAPs, the following are six project ideas with plans that share similar scopes and goals. It should be noted that the dissemination of these project ideas was prioritized by the National Directorate of the TNA_BRAZIL project, and were the topic of presentations for numerous stakeholders from the private sector, financing agencies and international cooperation agencies, such as Finep (the Brazilian Funding Authority for Studies and Projects); the Brazilian Development Agency (ABDE); and the United Nations Industrial Development Organization (UNIDO). These project ideas do not exhaust all the possibilities for projects using the subsidies from the TAPs. Thus, it is understood that interested parties may formulate other proposals based on the goals and scopes of the Plans.

The proposal to create the 4.0 Technology Network, initially proposed in partnership with stakeholders from the public and private sectors, is an example of a project in synergy and aligned with the goals of the TAPs. Once created institutionally, the Network will support the creation of startups to foster the development of technologies at the level of focused sectors (cities, industry, health and agriculture). The next stage involves the establishment of partnerships for the implementation of eight demonstration pilot projects (2 per sector) using 4.0 technological solutions by 2030, in accordance with the cost structure and segmentation in the action plans for precision agriculture and industry 4.0. Concomitantly with the execution, reporting, verification and dissemination of results of the pilot initiatives, training activities for the use and maintenance of the technologies developed should be carried out.

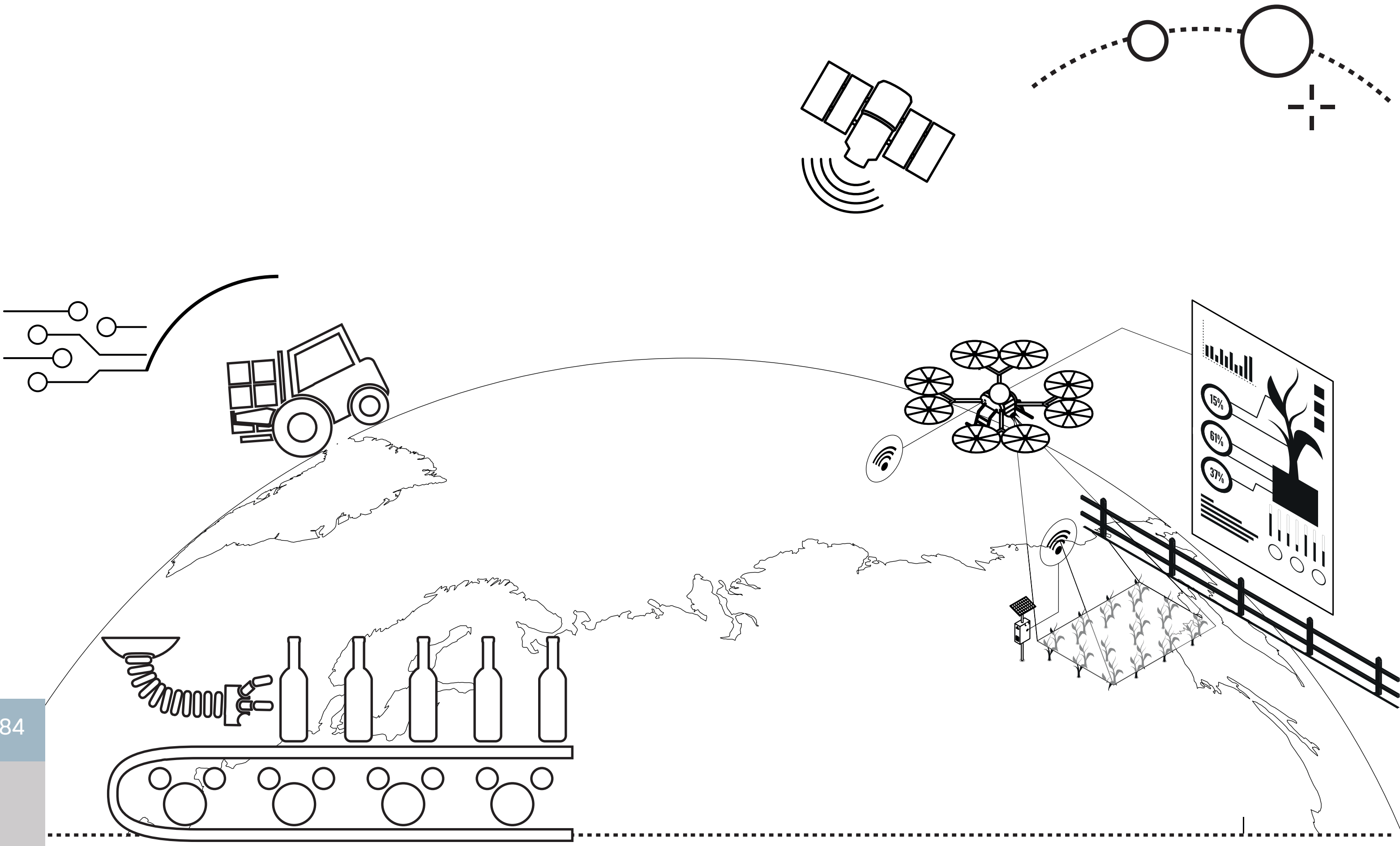


Table 1 – Project idea for 4.0 technology in cities, agriculture, industry and health

PROJECT 1	BRAZILIAN NETWORK FOR CIRCULAR ECONOMY AND 4.0 TECHNOLOGY DEVELOPMENT AND INNOVATION (4.0 NETWORK)
Technology	Energy storage; Edge computing; Mist computing; Cloud computing; Machine-to-machine computing; Advanced 5G communications; Digital twins; Geolocation; Georeferencing; Smart sensors; Artificial intelligence; Internet of Things; Additive and predictive maintenance; Advanced materials; Nanotechnology and advanced robotics
Scope	Industry; Cities; Agriculture; Health
Scope of application	National
Main activities	• Creation, management and MRV of the 4.0 Technology Network • Development and implementation of eight demonstration projects • Provision of training courses in 4.0 technologies • Promotion and dissemination of regulations, technical standards and public policies on 4.0 technologies
Benefits	• Gains in the competitiveness of national industry • Improved labor productivity • Reductions in the consumption of energy and natural resources • Reductions in public health spending • Mitigation of GHG emissions and local pollutants • Reductions in industrial and agricultural waste disposal • Demonstration of 4.0 technologies in an operational environment (TRL 7) • Control of epidemics • Creation of new activities and professions in industry
Beneficiaries	Public and private sectors and civil society
Stakeholders to mobilize	Government bodies • Sector Associations • National and international development agencies • National and international cooperation agencies • Universities and research centers • Professional associations • Companies • Service providers
Implementation period	9 years (2022 – 2030)
Cost (BRL)	33.6 million
Business model	Public-private partnerships, with reimbursable funds to implement the pilot initiatives. Technology transfer at the end of the project. 4.0 technology training, management and promotion activities, with reimbursable resources and technical assistance.

Source: the author.

For the transport sector, we propose to jointly enable and scale the technologies in the TAPs for an Innovative Technology Integrated Transport System (ITS). In a public-private partnership, the ITS aims to produce hybridization kits for flex hybrid engines for buses, as well as to test and produce the complete pilot serial-connected ethanol fuel cell system according to different transportation conditions in urban areas across the country. Following this step is the pilot application of the technologies in new vehicles and replacement of internal combustion engines (retrofitting). In this phase, the expectation is to implement the pilot application in a fleet of 300 vehicles, with 50 cars equipped with the ethanol fuel cell and 250 buses retrofitted with flex hybrid engines. Every operation should be monitored and reported to the ITS, which, following the pilot stage, should patent and transfer the technology for use by partner bus manufacturers and dealers for its commercial application.

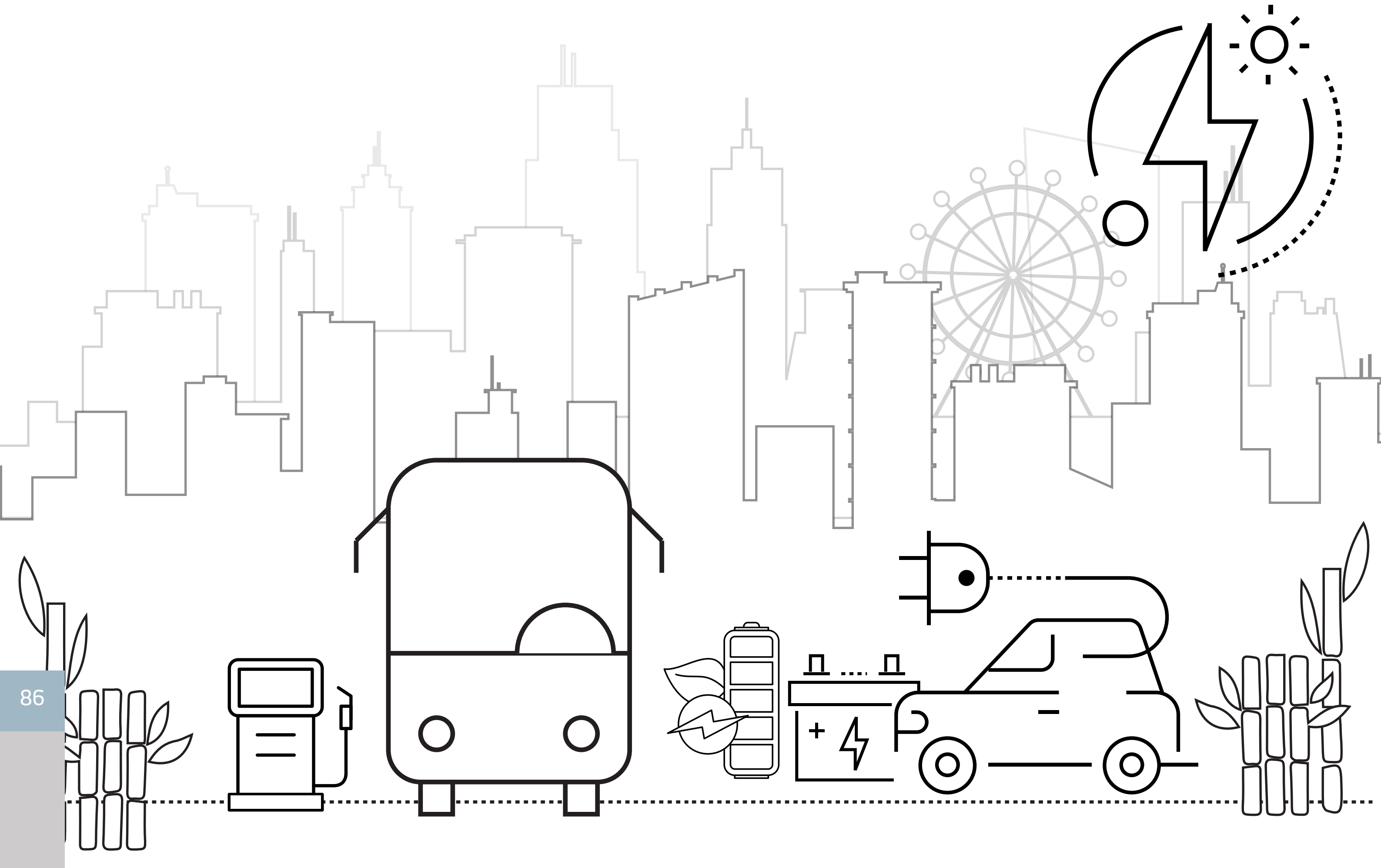


Table 2 – Project idea for the creation of an Innovative Technology Integrated Transport System (ITS)

PROJECT 2	INNOVATIVE TECHNOLOGY INTEGRATED TRANSPORT SYSTEM (ITS)
Technology	Hybridization kits for flex hybrid engines; complete pilot serial-connected ethanol fuel cell system
Scope	Transport; Cities
Scope of application	Regional application of the ITS for road transport, with commercialization of technologies by vehicle manufacturers at national and international levels
Main activities	• Constitution of the ITS and the design and installation of hybridization kits and the pilot serial-connected ethanol fuel cell • Production of hybridization kits and pilot serial-connected ethanol fuel cells • Selection of fleet characteristics and municipalities for the pilot application • Training for the operation and maintenance of pilot applications • Pilot application of hybridization kits in 400 buses (retrofitting) and ethanol fuel cells in 100 cars • Monitoring and reporting of pilot results to the ITS • Patenting and transferring technologies for use by partner bus manufacturers and dealers
Benefits	• Efficiency gains (compared to the internal combustion engine) • Mitigation of GHG emissions and local pollutants • Preservation of jobs and income in the sugar-energy sector • High penetration power in large urban centers, with niche markets • Reductions in public health spending • Development of local technological content, including flex fuel cell electric vehicles • Demonstration of 4.0 technologies in a commercial environment (TRL 7) • Creation of new activities and professions in the automotive industry and bus dealerships
Beneficiaries	Public and private sectors and civil society
Stakeholders to mobilize	• Government bodies • Sector associations • National and international development agencies • National and international cooperation agencies • Universities and research centers • Professional associations • Patent offices and component quality assurance organizations • Auto companies and bus dealerships • Business incubators
Implementation period	9 years (2022 – 2030)
Cost (BRL)	134.8 million
Business model	Public-private partnerships, with reimbursable funding for the assembly and installation of the hybridization kits and pilot serial-connected ethanol fuel cells. Transfer of technologies at the end of the project to automakers and bus dealerships. Other project activities with reimbursable funding and technical assistance.

Source: the author.

With respect to genetic improvement and mixed planting systems in the forestry chain to support environmental restoration and commercial plantations, we propose to establish a network for the development of technologies to support restoration and recovery of biomes. Initially, the network should be created to be responsible for organizing the actions and activities, with funding aimed at ensuring the sustainability of the project. The next step is the implementation of 40 nurseries to produce exotic and native species seeds and seedlings, evenly distributed in the Amazon, Cerrado, Caatinga and Atlantic Forest biomes. With the production of seeds and seedlings, pre-commercial scale cultivation of exotic and native species of interest should be implemented and monitored over a period of at least 4 years by the Regenera Biomas Network. This involves implementing 40 pilot demonstration units for mixed planting of exotic and native species for restoration. Once the technical and economic viability of the crops is established, the seedlings and seeds developed should be patented for commercialization.

It is important to note that the Network aims to instrumentalize the Regenera Brasil Initiative through actions to develop technologies to support the restoration and recovery of biomes (MCTI, 2020).

All of the aforementioned stages require investments, with long-term economic returns coming solely from the sale of seedlings, creation of nurseries and timber from crops. In view of the potential for environmental restoration from these efforts, however, projects could receive financing through payment for environmental services, which is a financing source that encourages the large-scale diffusion of exotic and native forest species.

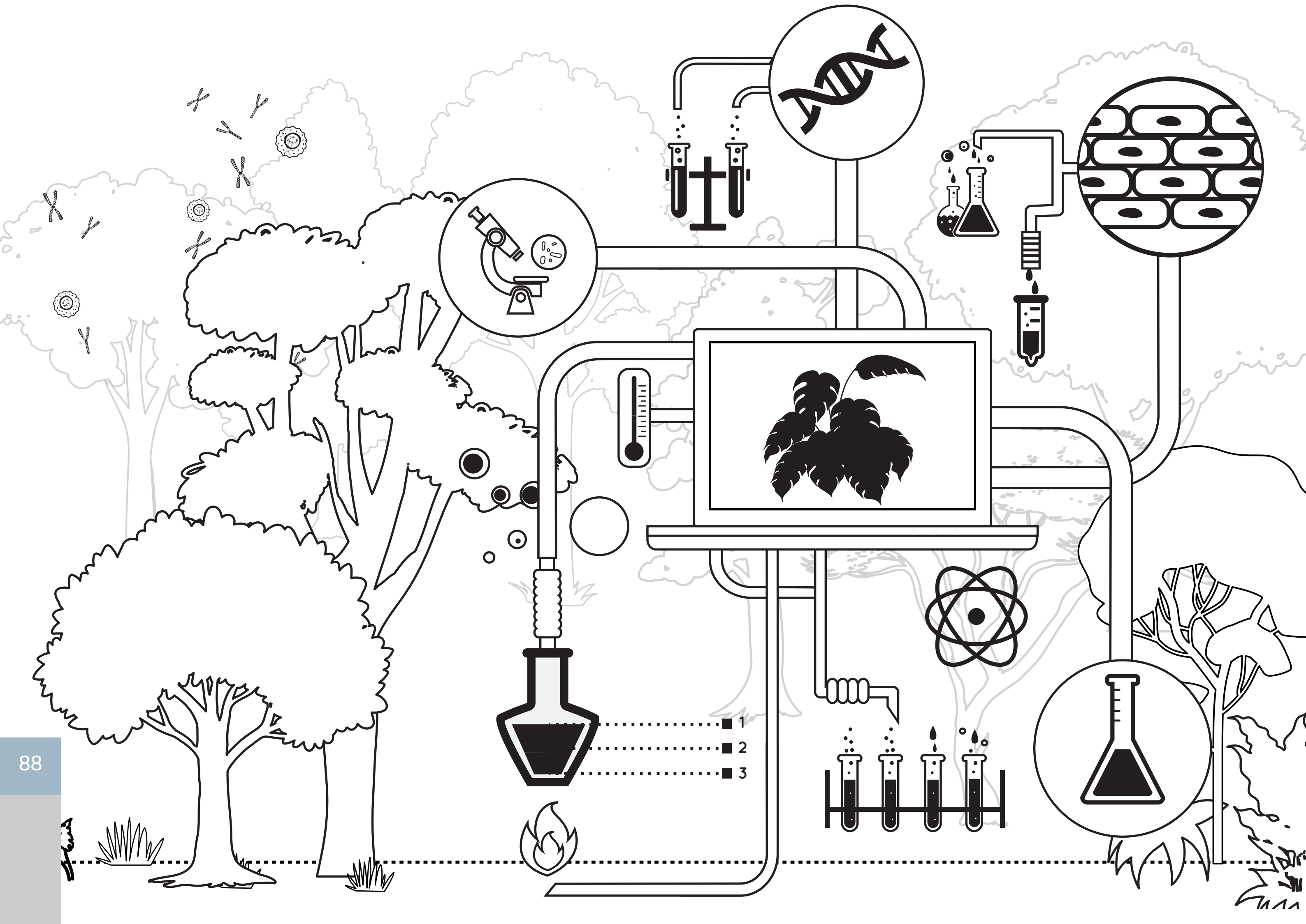


Table 3 – Project idea for the development and production of exotic and native tree species

PROJECT 3	TECHNOLOGY NETWORK TO SUPPORT BIOME RESTORATION AND RECOVERY
Technology	Genetic improvement of tree species (combined provenance-progeny tests); exotic and native seed and seedling nurseries; exotic and native crops for biomes; mixed planting of exotic and native species for restoration
Scope	Forests
Scope of application	Brazilian biomes
Main activities	• Creation, management and MRV of nurseries and pilot demonstration units by Regenera Biomas Network • Securing of resources from national and international funding sources • Development of studies on the production of seedlings and seeds in 40 nurseries • Implementation of mineral nutrition programs for seedlings in nurseries and for trees in the field • Field (commercial) implementation of exotic and native species • Patenting of exotic and native species that are efficient from an ecological, economic and regulatory perspective • Commercialization of exotic and native species • Elaboration and submission of projects for payment for environmental services of the demonstration units • Elaboration of a platform to disseminate the results of the project • Education and training programs for the cultivation of exotic and native species
Benefits	• Forest restoration and recovery • Conservation of biodiversity • Expansion of areas planted with exotic and native species • Mitigation of GHG emissions • Generation of jobs and income in the forestry chain • Commercial demonstration of native species with genetic improvement • Compliance with Environmental Recovery Plan (ERP) regulations
Beneficiaries	Public and private sectors and civil society
Stakeholders to mobilize	• Government bodies • Producer associations and cooperatives • National and international development agencies • National and international cooperation agencies • Universities and research centers • Forestry institutes and state environmental agencies • Forest sector companies • ATER companies • Rural training service providers
Implementation period	9 years (2022 – 2030)
Cost (BRL)	59.5 million
Business model	Project in partnership with international and national funding agencies with non-reimbursable resources and technical assistance. Given the potential for payment for environmental services, a public-private partnership model could also be adopted.

Source: the author.

In the case of the energy and cement sectors, the aim is to develop and offer a platform for the dissemination of sustainable technologies (Inova Sustentável), including floating solar plants and low clinker content innovative cement. The project for the creation of the platform begins with the design and funding from national and/or international funding agencies in the form of non-reimbursable resources and technical assistance. Following this, the platform should be validated by technology developers to identify its technical feasibility and possible design modifications. In parallel to the development of the tool, there should be training actions for using and updating the database in the public and private sector. Once the platform is online and running, a monitoring, reporting and verification (MRV) system for the adoption of technological solutions based on it should be developed. To this end, it is important that the tool is interactive and open; that is, it allows target users (including suppliers and users of the technologies) to add to the database to update the technical-economic parameters of the technologies, as well as report success stories and lessons learned. Once the platform is made available, there should be dissemination at national and international levels concerning the implementation of sustainable technologies using the tool. This involves the creation of digital content and the publication of scientific studies in national and international journals, as well as the actions provided for in the communication plan for the dissemination of the platform. At the end of the project, the platform should be transferred, under a technical cooperation agreement, to an institution with extensive knowledge in the area of sustainable technologies. Ideally, this would be a state technology research center, such as one of the national research and technology institutes.

Table 4 – Project idea for developing a platform for promoting the application of sustainable technologies based on the TAPs

PROJECT 4	PLATFORM FOR DISSEMINATING INNOVATIONS IN SUSTAINABLE TECHNOLOGY (INOVA SUSTENTÁVEL)
Technology	Floating solar power plants; Innovative materials for cement; Energy storage; Solar photovoltaic concentrators; Flex hybrid engines; Ethanol fuel cell electric motors; Biogas plants; Solar photovoltaic induction stoves; Smart meters for electricity distribution; Synchrophasors; Satellite monitoring systems; Territorial intelligence systems; Edge computing; Mist computing; Cloud computing; Machine-to-machine computing; Smart sensors; Artificial intelligence; Internet of Things; Additive and predictive maintenance
Scope	Industry; Cities; Agriculture; Transport; Energy
Scope of application	National
Main activities	• Creation, management and MRV of the Inova Sustentável Platform • Financing for the development of the platform • Design, validation and operation of the platform by technology solution developer • Training for using and updating the platform database • Dissemination activities for good practices and lessons learned from the implementation of projects based on the platform • Transfer of the platform to government agency
Benefits	• Gains in the competitiveness of national industry • Reductions in the consumption of energy and natural resources • Subsidies for developing good project proposals for sustainable technologies • Increase in the ratio of renewable sources in the national energy matrix • Mitigation of GHG emissions and local pollutants • Reductions in industrial and agricultural waste disposal • Increase in the availability of water for human consumption and generating electricity • Employment and income generation • Conservation of biodiversity • National technological development • Training of human resources for the adoption of sustainable technologies
Beneficiaries	Public and private sectors and civil society
Stakeholders to mobilize	• Government bodies • National research and technology institutes • National and international development agencies • National and international cooperation agencies • Universities and research centers • Companies • Sustainable technology solutions service providers
Implementation period	3 years (2022 – 2024)
Cost (BRL)	2.2 million
Business model	Technical cooperation agreement with the institution responsible for managing the platform, with non-reimbursable funding and technical assistance for the execution of the project.

Source: the author.

Within the scope of TAPs for genetic improvement of beef cattle and satellite monitoring, the project idea seeks to consolidate the Plan platforms to provide solutions for decision-making in the agricultural, forestry and other land use sectors. Initially, the structure of the platform has to be designed, partners identified and funding secured from national and international funding sources for its subsequent implementation. It is interesting to note that the platform can be made widely available, but with access restrictions for specific modules, or in full format upon payment of a license fee. This aspect also allows for financing for the project with reimbursable funds.

As the platform depends on the completion of the satellite monitoring and genetic improvement activities in the TAPs, the platform activities should begin in 2025.

In this case, training activities on territorial intelligence, monitoring and genetic improvement systems can be shared, with cost savings in scope, as considered in the project budget. Following this, the consolidated platform should be developed, with the plan to transfer it to a selected government research institution. This will ensure the sustainability of the tool, as it will guarantee the maintenance and updating of the modules. In addition, success stories and lessons learned using the agricultural and forestry management tool should be disseminated at the national and international level. It should be emphasized that, in view of the potential benefits from ecosystem services from the application of the tool, consideration should be given to the development of projects for payment of environmental services to ensure financial sustainability for the agency responsible for maintaining and improving the platform.

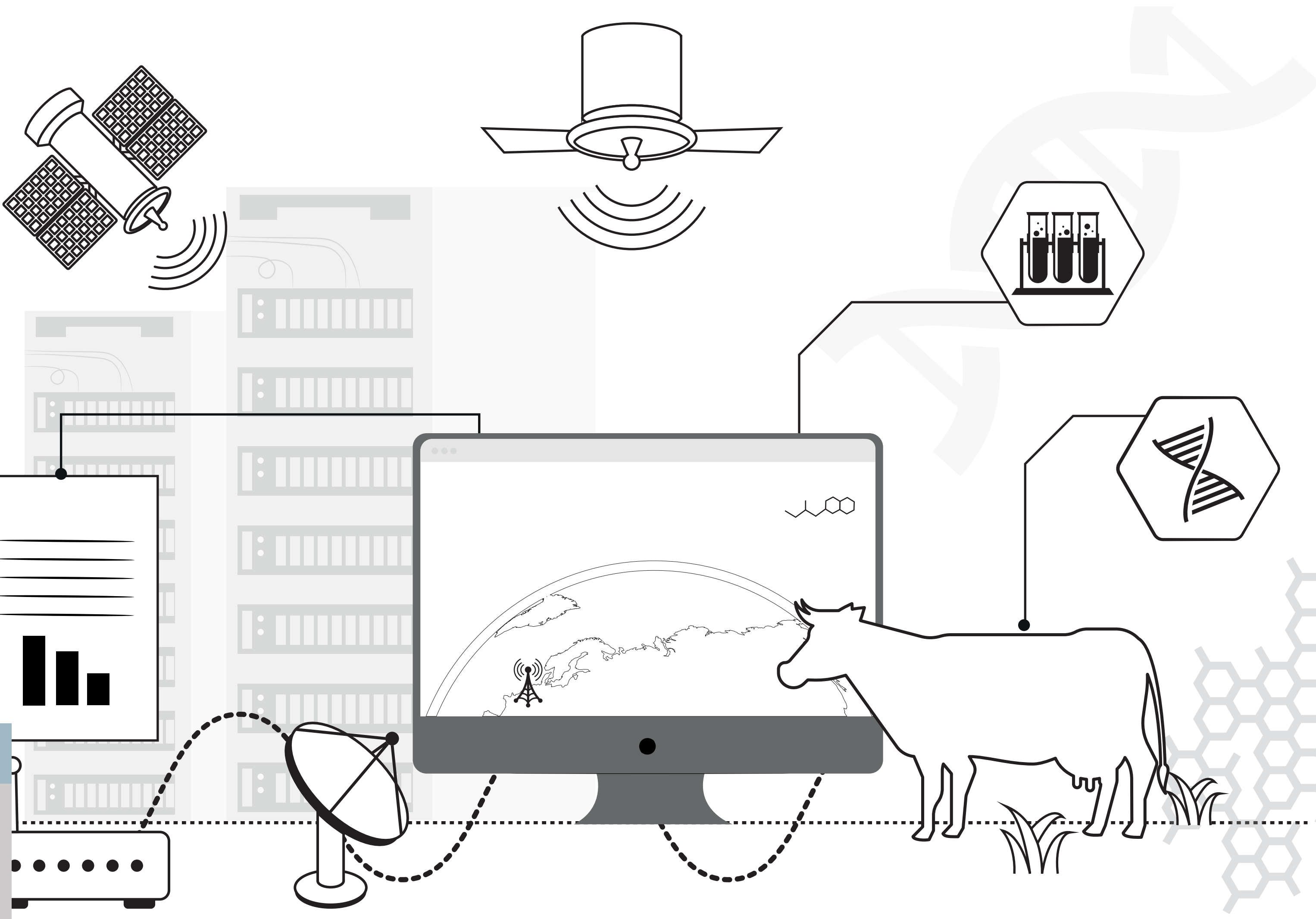


Table 5 – Project idea for capacity building to improve competitiveness in genetic improvement, satellite monitoring and territorial intelligence

PROJECT 5	PLATFORM FOR TRAINING AND COMPETITIVENESS IN GENETIC IMPROVEMENT, SATELLITE MONITORING AND TERRITORIAL INTELLIGENCE
Technology	Platform for economic, zootechnical, genealogical and genotype data on beef production; Supervised automatic classification of land use and land cover monitoring via satellite imaging; High resolution satellite monitoring system; Territorial intelligence system
Scope	Agriculture, forestry and other land use
Scope of application	National
Main activities	• Creation, management and MRV of the genetic improvement, satellite monitoring and territorial intelligence platform • Securing financing and identification of partners to make the platform available • Training on using and updating the platform database • Consolidation of modules and transfer of the platform to a selected partner • Dissemination activities on good practices and lessons learned using the platform • Elaboration and submission of projects for payment for environmental services
Benefits	• Gains in the profitability of livestock and agriculture • Greater use of national genetic material • Mitigation of GHG emissions • Increased herd resilience to climate change • Widespread availability of the integrated platform • Contribution to the implementation of the ERP and precision agriculture • Diffusion of territorial intelligence system • Increased competitiveness in agribusiness • Increase in the quality of spatial data • Maintenance and restoration of ecosystems • Conservation of biodiversity • National technological development • Training of human resources for the adoption of sustainable technologies
Beneficiaries	Public and private sectors and civil society
Stakeholders to mobilize	Government bodies Rural extension bodies and producer cooperatives Agricultural management consulting companies Government research institutions Professional associations National and international development agencies National and international cooperation agencies Universities and research centers Companies Subnational environmental and agricultural agencies Technology solutions service providers
Implementation period	4 years (2025 – 2028)
Cost (BRL)	6.6 million
Business model	Technical cooperation agreement with the institution responsible for managing the platform, with non-reimbursable and reimbursable funds and technical assistance for the execution of the project.

Source: the author.

Finally, with respect to energy generation from agricultural and agro-industrial waste and solar photovoltaic induction stoves, we propose to establish an Integrated Technology System (ITS) for renewable power generation in the semiarid Northeast region of Brazil, considering the energy potential in the region from biomass, solar and wind. To this end, a public-private partnership should initially be established for the creation of business incubators for the development of renewable technologies in partnership with local governments and research centers. These partnerships should focus on developing technological solutions for solar power generation and energy storage, mini-grid wind power and biogas plants using agricultural and agro-industrial waste. Education and training actions should be developed to train users in the solutions developed by the ITS, an activity that can be shared with the TAP actions for power generation from agricultural and agro-industrial waste and solar photovoltaic induction stoves. Following this, the intention is to implement 100 demonstration units of the technologies: 45 solar generation units with energy storage; 45 mini wind power generation units; and 10 agricultural waste power generation units in an ICLFS system. In parallel with the pilot applications, there should occur monitoring and technical assistance by the companies incubated at the ITS to ensure the sustainability and replicability of the initiatives. Finally, at the end of the project, the lessons learned and good practices resulting from the demonstration units should be disseminated, which will allow for the replication of these technological solutions in other regions in Brazil.

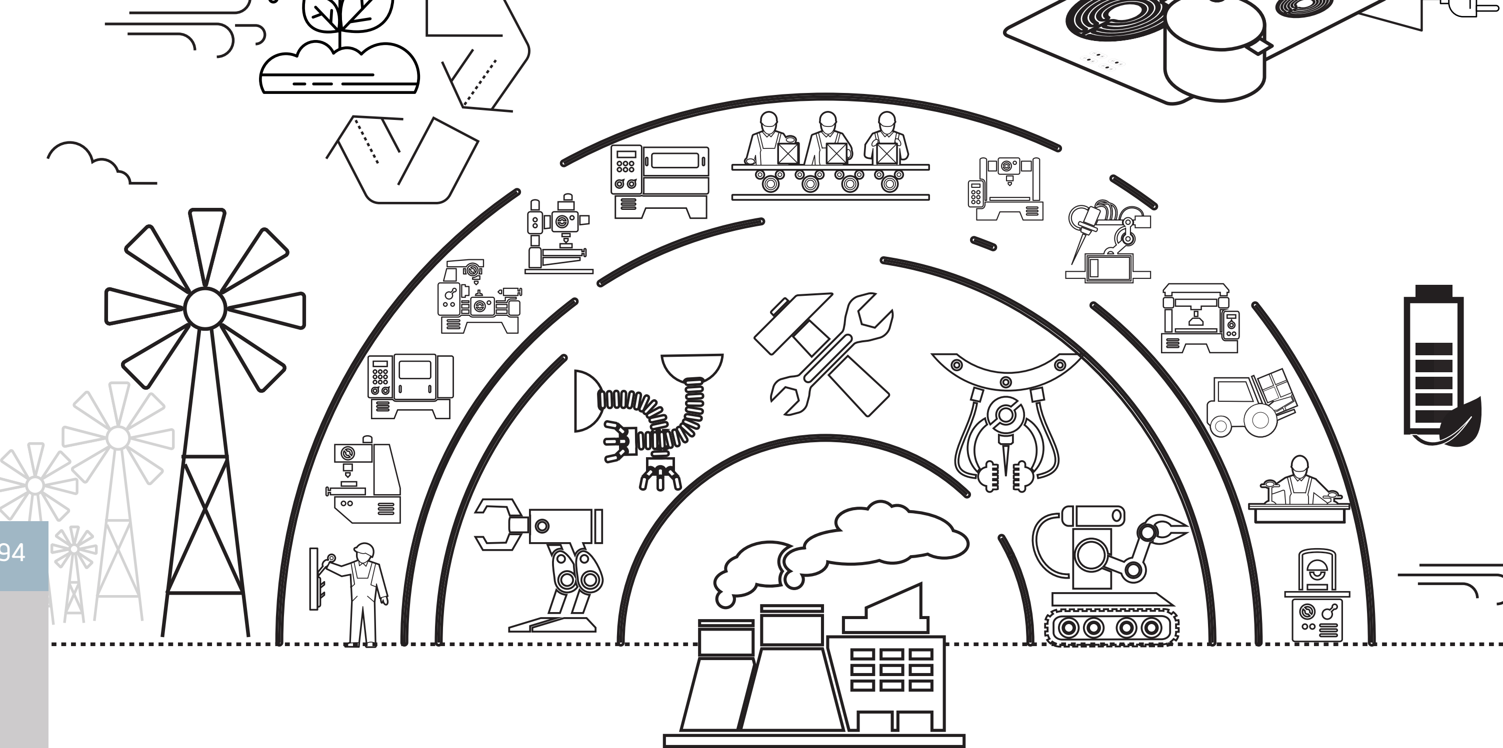
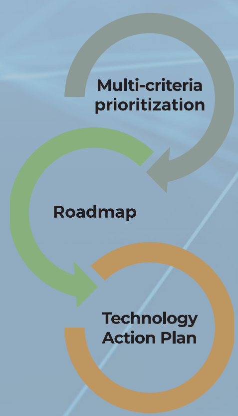


Table 6 – Project idea for the creation of the Integrated Technology System (ITS) for renewable power generation

PROJECT 6	INTEGRATED TECHNOLOGY SYSTEM (ITS) FOR RENEWABLE POWER GENERATION IN THE SEMIARID NORTHEAST REGION
Technology	Energy storage; photovoltaic solar panels; auxiliary components of photovoltaic systems; solar induction stoves; mini wind generators; biogas plants; anaerobic co-digestion processes
Scope	Cities; Residential, commercial, public and service buildings; Agriculture
Scope of application	National
Main activities	• Creation of the ITS for renewable power generation technologies • Partnerships with local governments and research centers • Development of technological solutions for solar power generation with energy storage, mini-grid wind power, and energy from agricultural and agro-industrial waste using the co-digestion process • Identification of locations for the implementation of the technologies • Training people to use the technologies • Pilot application of 100 technology demonstration units • Monitoring and technical assistance to support the demonstration application of the technologies • Dissemination of lessons learned and good practices for replicating the technological solutions in other regions of Brazil
Benefits	• Increase in the ratio of renewable sources in the national electricity matrix • Employment and income generation in the semiarid Northeast region • Contribution to the achievement of the Renovabio targets • Reductions in public health spending • Mitigation of GHG emissions and local pollutants • Reduction in agricultural waste disposal • Demonstration of technologies in an operational environment • Energy autonomy of buildings, with potential revenues from selling surplus power to the grid • Creation of new activities and professions in the semiarid Northeast region • Increased free time for women to pursue remunerated activities
Beneficiaries	Public and private sectors and civil society
Stakeholders to mobilize	• Government bodies • Local governments and research centers • Sector associations • National and international development agencies • National and international cooperation agencies • Universities and research centers • Professional and resident associations • Rural producer cooperatives • Companies • Service providers
Implementation period	9 years (2022 – 2030)
Cost (BRL)	19.8 million
Business model	Public-private partnerships, with reimbursable funds to implement the pilot initiatives. Technology transfer at the end of the project, with payment by users. Training activities and technology promotion with reimbursable funds and technical assistance.

Source: the author.

Conclusions



Conclusions

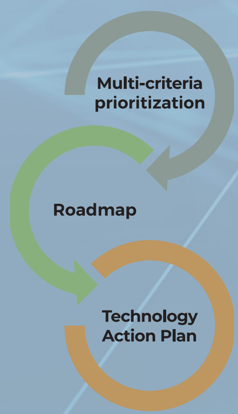
The Ministry of Science, Technology and Innovation (MCTI), with support from the United Nations Environment Programme (UNEP) and technical partners, prepared these Technology Action Plans (TAPs) within the scope of the "Technology Needs Assessment for the Implementation of Climate Action Plans in Brazil (TNA_BRAZIL)" to foster the development and diffusion of technologies to promote sustainable development in the country.

Action plans were developed for 12 prioritized technologies based on the application of a multi-criteria methodology in conjunction with key stakeholders from the Technical Advisory Committee (TAC) and Sectoral Chambers. The importance of the Plans lies in the potential of these technologies to foster economic growth and sustainable development. The actions become even more important in the current context and for the post-pandemic future, as information is essential for the implementation of projects that depend on national or international funding. The action plans were developed with the participation of diverse stakeholders from the private sector, academia and government. Their involvement contributed greatly to making these technologies not only technically and economically viable, but also, and equally importantly, socially acceptable.

The TAPs seek to remove obstacles that hinder the development and diffusion of the prioritized technologies in Brazil, with implementation schedules that vary from four to eight years, starting in 2021 and with a conclusion date (with achieved co-benefits) by the end of 2030. The total cost for adopting the Plans was estimated at BRL 328 million.

In conjunction with the Plans, it is necessary to improve cooperation and increase national and international support, with greater participation from the private sector, to guarantee access to financial resources for the development and implementation of the prioritized technologies. In addition, to ensure the sustainability of the actions, it is necessary to disseminate the results of the Plans, as well as to develop the skills to implement and monitor the results, especially from the pilot initiatives. To this end, the TNA_BRAZIL project developed activities for training and disseminating results and the tool developed to support the adoption of the Plan. Examples of these activities include the webinar series "How low carbon technologies can contribute to sustainable development"; the regional "Support for the adoption of Technology Action Plans" webinars; the webinar on "Subsidies for financing the prioritized technologies of the TNA_BRAZIL project", and the "Electronic guide to financing options for the prioritized technologies in the TNA_BRAZIL Project." We believe that the project goals will be achieved, ensuring Brazil effective results in terms of economic, social and environmental sustainability, thus supporting the implementation strategy and contributing to the achievement of Brazil's NDC targets.

References


Multi-criteria prioritization
Roadmap
Technology Action Plan

References

BRASIL. Ministério da Ciência, Tecnologia e Inovações. **Contribuições aos Planos de Ação Tecnológica para o desenvolvimento e difusão das tecnologias priorizadas nos setores da agricultura, florestas e outros usos da terra.** Brasília: MCTIC, 2020a. Available at: https://drive.google.com/file/d/1toR3W5JqKh0lK4WPGxvecrMblqBCExKQ/view?usp=sharing. Accessed on: December 26, 2020.

______. **Contribuições aos Planos de Ação Tecnológica para o desenvolvimento e difusão das tecnologias priorizadas nos setores do sistema energético.** Brasília: MCTIC, 2020b. Available at: https://drive.google.com/file/d/1JYbdx2_K5tN1zx22GXn4AbEEqaTkDFmK/view?usp=sharing. Accessed on: December 26, 2020.

______. **MCTI Youtube channel**: Playlist Tecnologias de Baixo Carbono. Ciclo de webinários Contribuição das tecnologias de baixo carbono para o desenvolvimento sustentável. Brasília: MCTIC, 2020c. Available at: https://www.youtube.com/watch?v=Q0k-bQRJp_E&list=PLa8HqSGatmeQOU1Yh7bmgkWnWM6f5Nn1g. Accessed on: December 26, 2020.

______. **Plano tecnológico propõe uso de etanol em veículos elétricos e híbridos para descarbonizar transporte.** Brasília: MCTIC, 2020d. Available at: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/noticias/2020/11/plano-tecnologico-propoe-uso-de-etanol-em-veiculos-eletricos-e-hibridos-para-descarbonizar-transporte. Accessed on: December 26, 2020.

______. **Criação de Redes de tecnologia busca democratizar acesso à agricultura de precisão e fomentar indústria 4.0.** Brasília: MCTIC, 2020e. Available at: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/noticias/2020/11/criacao-de-redes-de-tecnologia-busca-democratizar-acesso-a-agricultura-de-precisao-e-fomentar-industria-4.0. Accessed on: December 26, 2020.

______. **Planos tecnológicos propõem ações de melhoramento genético e plantios mistos na cadeia florestal.** Brasília: MCTIC, 2020f. Available at: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/noticias/2020/11/planos-tecnologicos-propoem-acoes-de-melhoramento-genetico-e-plantios-mistos-na-cadeia-florestal#:~:text=Planos%20tecnol%C3%B3gicos%20prop%C3%B5em%20a%C3%A7%C3%B5es%20de%20melhoramento%20gen%C3%A9tico%20e%20plantios%20mistos%20na%20cadeia%20florestal,-Iniciativa%20desenvolvida%20pelo&text=De%20acordo%20com%20o%20coordenador,mistos%20de%20nativas%20e%20ex%C3%B3ticas. Accessed on: December 26, 2020.

______. **Produção sustentável de cimento e geração de energia solar fotovoltaica são temas de webinário.** Brasília: MCTIC, 2020g. Available at: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/noticias/2020/12/producao-sustentavel-de-cimento-e-geracao-de-energia-solar-fotovoltaica-sao-temas-de-webinario#:~:text=temas%20de%20webin%C3%A1rio-,Produ%C3%A7%C3%A3o%20sustent%C3%A1vel%20de%20cimento%20e%20gera%C3%A7%C3%A3o%20de,fotovoltaica%20s%C3%A3o%20temas%20de%20webin%C3%A1rio&text=%E2%80%9CO%20desenvolvimento%20das%20a%C3%A7%C3%B5es%20tecnol%C3%B3gicas,de%20pain%C3%A9is%20fotovoltaicos%E2%80%9D%2C%20analisa. Accessed on: December 26, 2020.

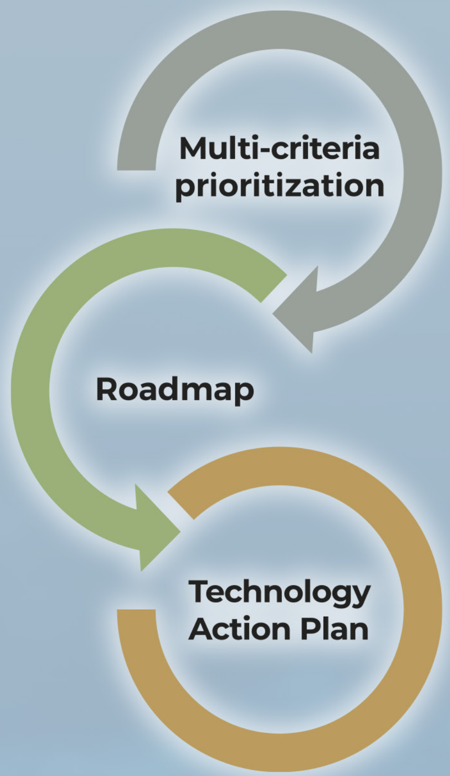
______. **Melhoramento genético animal e ampliação de monitoramento por satélite para uso da terra são debatidos pelo MCTI.** Brasília: MCTIC, 2020h. Available at: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/noticias/2020/12/melhoramento-genetico-animal-e-ampliacao-de-monitoramento-por-satelite-para-uso-da-terra-sao-debatidos-pelo-mcti#:~:text=debatidos%20pelo%20MCTI-,Melhoramento%20gen%C3%A9tico%20animal%20e%20amplia%C3%A7%C3%A3o%20de%20monitoramento%20por%20sat%C3%A9lite%20para,terra%20s%C3%A3o%20debatidos%20pelo%20

MCTI&text=Segundo%20o%20coordenador%20t%C3%A9cnico%20dos,animal%20e%20monitoramento%20por%20sat%C3%A9lite. Accessed on: December 26, 2020.

______. **MCTI**: aproveitamento energético de resíduos agrícolas e agroindústria e fogões solares encerram ciclo de webinários. Brasília: MCTIC, 2020i. Available at: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/noticias/2020/12/mcti-aproveitamento-energetico-de-residuos-agricolas-e-agroindustria-e-fogoes-solares-encerram-ciclo-de-webinarios. Accessed on: December 26, 2020.

______. **Guia eletrônico das opções de financiamento para as tecnologias priorizadas no projeto TNA_BRAZIL.** Brasília: MCTIC, 2021j. Available at: http://antigo.mctic.gov.br/mctic/opencms/ciencia/SEPED/clima/tna_brazil/tna_brazil.html. Accessed on: January 26, 2021.

______. **Portaria MCTI nº 3.206, de 25 de agosto de 2020.** Institui, no âmbito da Ministério da Ciência, Tecnologia e Inovações, a Iniciativa Regenera Brasil e o respectivo Comitê Gestor. Brasília: MCTI, 2020. Available at: http://antigo.mctic.gov.br/mctic/opencms/legislacao/portarias/Portaria_MCTI_n_3206_de_25082020.html. Accessed on: September 17, 2020.



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