INCOBRA Strategic Action Plans to Foster Cooperation Patterns between EU and Brazil in Priority Areas

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1 | *EXECUTIVE SUMMARY*

1.1 | *Introduction*

INCOBRA is a three-year Horizon 2020 project aiming to increase EU-BR R&I cooperation through partnerships, consortia and joint R&I projects and to enhance the relevant framework conditions addressing EU-BR R&I cooperation areas. INCOBRA has developed strategic Action Plans to foster Research and Innovation (R&I) cooperation in five Priority Areas:

- Green Energy;
- Sustainable Use of Bioresources;
- Food Security and Adaptation of Agriculture to Climate Change;
- Advanced Manufacturing and Nanomaterials; and
- Smart Cities and Smart Systems.

The Action Plans were developed under the following INCOBRA's Grand Vision:

> *'Stakeholders from Brazil and EU are working together, like an orchestra, in a harmonious and complimentary fashion on scientific research and technological innovation projects.*
> *Given the results of this successful cooperation, societies feel that Brazil-EU collaboration contributes to their balanced social, environmental, and economic development.*
> *The cooperation is led by a multi-lateral, representative steering committee, with collaborative actors from research, policy, industry, academia, and civil society.*
>
> - *Project governance that is simple, transparent, and based on trust that allow for the orchestration of work teams.*
> - *Governance instruments and actors that are synchronized, harmonized, and aligned to complement each other.*
> - *A long-term commitment to funding policies.*
> - *Diverse partners interact like an open and flexible research and innovation network.*
> - *Clear and stable framework for cooperation that guides the research agenda while accommodating creativity and original ideas in a flexible manner´.*

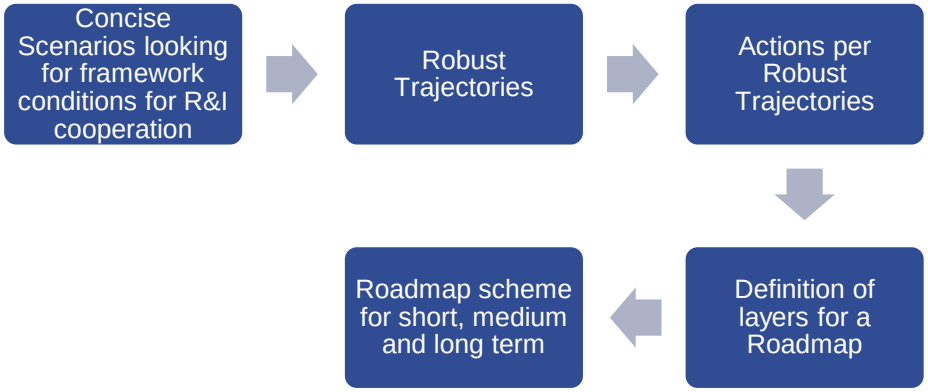
The purpose of this exercise (Task 1.3) morphed along the way into something bigger than INCOBRA itself. In addition to supporting the planning of forthcoming INCOBRA initiatives, it was understood that the results would also support the "sister" project CEBRABIC in its effort to identify desirable R&I activities for its Centres. Finally, the results could also provide input for the negotiation and planning of the next European Framework Programme in Research and Technological Innovation.

1.2 | *Methods*

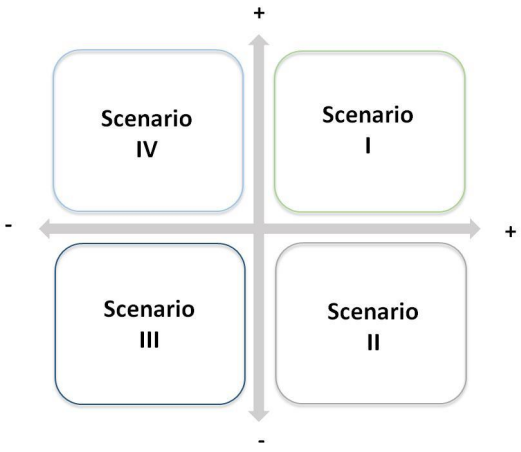
The analytical methodology was based on the scenario approach which, in turn, helped identify robust trajectories towards greater, more successful and socially responsible R&I cooperation between the European Union and Brazil. The systematic consideration of the relevant markets, knowledge base, resources, and regulation in each case allowed building socio-economic roadmaps and displaying Actions for three timelines: 2020, 2025, and 2030. These were chosen to roughly represent the short, medium and longer terms

and to be relevant to both Horizon 2020 as well as its follow-up being negotiated right now.

The methodological approach followed the following sequence:



Concise scenarios were generated on the basis of two critical variables whose intersection generates four quadrants characterized as scenarios for R&I cooperation in each of the five Priority Areas. The quadrant can be more (+) or less (-) favorable according to other variables that cross the quadrants. The selection of the critical variables is dependent on the specificities of each Priority Area and may vary among Areas.



Robust Trajectories (RTs) were subsequently built to deal with critical issues in terms of opportunities and threats for each scenario. Once defined, RTs were translated into Actions for the short-, medium- and long-term.

1.3 | *Conclusions*

Two types of conclusions have been drawn: a) specific findings from thematic Action Plans; and b) common findings cutting across the five Action Plans (APs).

a) Action Plans specific findings

Green Energy

Green Energy

Green Energy focused on two main clusters of energy sources:

- **Sustainable biofuels and biorefineries; and**
- **wind, solar and mixes of renewables.**

Four cross-cutting themes have emerged as particularly interesting for R&I cooperation in these two groups:

- **Energy modeling/policy and regulation - benchmarking of best practices;**
- **Energy efficiency - applications, mobility, metering, data collection and treatment;**
- **Energy storage;**
- **Smart Grids.**

Robust Trajectories for Green Energy

1. **Incorporate into R&I cooperation a component of monitoring policies and regulatory frameworks that affect the future of Green Energy;**
2. **Focus on complementary niches/strategies for EU and BR in biofuels, solar and wind energy R&I themes;**
3. **Monitor/build long term financial strategy related to R&I cooperation among the EU, Brazil and others;**
4. **Monitor/build long-term competences and research capabilities related to Green Energy in the EU and BR;**
5. **Be extremely selective in setting priorities for collaborative R&I projects and activities with really high potential of technological cum market success;**
6. **Establish a minimum level of density for R&I cooperation to guarantee scale and scope economies;**
7. **Engage the private sector in both sides of R&I cooperation.**

Sustainable Use of Bioresources

Sustainable Use of Bioresources

The following key aspects were highly prioritised for Sustainable Use of Bioresources:

- **Sustainable industrial biotechnology especially future generations of sustainable bio-refineries;**
- **Rational and effective use of industrial and agricultural waste/effluent;**
- **Conservation and sustainable use of biodiversity for new therapies;**
- **Rational and effective discovery and screening of bioactive compounds from the Brazilian biodiversity;**
- **Plant biotechnology.**

Robust Trajectories for Sustainable Use of Bioresource

1. Brazil/EU supportive regulatory framework for sustainable use of bio-resources;

2. Brazil/EU common knowledge base and research protocols on sustainable use of bio-resources;

3. Bilateral Brazil/EU commitment to long-range funding;

4. Involving civil society in the development of bioeconomy;

5. EU/Brazil sharing of bioeconomy research facilities;

6. EU-BR shared educational curriculum in sustainable use of bio-resources;

7. Create durable personal relationships between Brazilian and European researchers and innovators in sustainable use of bio-resources;

8. Foster EU/Brazil pioneering coalitions;

9. Experimenting breakthrough solutions in protected niches;

10. Optimising bio-waste collection and utilization processes through bi-lateral development of policies, partnerships, and technologies.

Food Security and Adaptation to Climate Change

Food Security and Adaptation to Cimate Change

This Priority Area clustered priorities in two groups. Here bellow the main topics for each group:

Global Food Supply:

- **Food Security;**
- **Compliance with International Standards;**
- **South – South cooperation;**
- **Traceability;**
- **Zero Food Waste;**
- **Improvements in Agrifood Systems;**
- **Digital Farming.**

Climate Change and Sustainability:

- **Nutritional aspects of food products;**
- **Sustainble increase of productivity;**
- **Integrated Systems;**
- **Low Carbon and low GHG emissions;**
- **Precision Agriculture;**
- **Circular economy and Eco-innovation.**

Robust Trajectories for Food Security and Adaptation to Climate Change

1. **Use of interdisciplinary or transdisciplinary teams;**
2. **Stimulate transformative and systemic projects to satisfy consumers' needs;**
3. **Develop collaborative networks to strengthen learning and strategic goals;**
4. **Different agricultural models;**
5. **Creation of a new food-quality policy;**
6. **Use of different tools and co-creation methods at some stage of the research/production process;**
7. **Monitor efficient supply chains and benchmark best technological practices;**
8. **Monitor and benchmark for financial support for Food Security and Adpatation of Agriculture to Climate Changes.**

Advanced Manufacturing and Nanomaterials

Advanced Manufacturing and Nanomaterial

Priorities selected for Advanced Manufacturing and nanomaterial:

- **Strategic nanomaterials for applications in:**
  - **Energy and environment,**
  - **Consumer and security electronics,**
  - **Biotechnology,**
  - **Health and pharmaceutics,**
  - **Agriculture and food security and**
  - **Textiles**
- **Advanced manufacturing of innovative nanoscale materials, sensors and devices;**
- **Nanoscale metrology;**
- **Toxicity of nanomaterials, specific to each application field.**

Robust Trajectories for Advanced Manufacturing and Nanomaterials

1. **Establishment of a legal framework for the Brazil-EU collaboration in Advanced Manufacturing and Nanomaterials R&I**
2. **Development of a joint Brazil-EU multi-annual work Program in Advanced Manufacturing and Nanomaterials R&I**
3. **Brazil-EU industry participation in the definition of collaboration priorities in Advanced Manufacturing and Nanomaterials R&I**
4. **Joint Brazil-EU establishment of Open Innovation Hubs for strategic Nanomaterials Advanced Manufacturing R&I**
5. **Joint Brazil-EU commitment to develop a continuous training program in Advanced Manufacturing for science and engineering graduates and technicians**
6. **Design of a common evaluation protocol for BR-EU collaboration R&I programs in Advanced Manufacturing and Nanomaterials.**

Smart Cities and Smart Systems

Smart Cities and Smart Systems

The following topics summarize priorities set for Smart Cities and Smart Systems:

- **Citizen engagement - including distributed governance sharing economy;**
- **Ecosystems of wellbeing - including urban environment, health and social security;**
- **Privacy and Security - including Blockchain, data policies and analytics;**
- **New economies - including fintech, cryptocurrencies and collaborative economy;**
- **Internet of Everything - including autonomous systems, sensors, big data and analytics;**
- **Entrepreneurship - including innovation ecosystems, urban solutions and social.**

Robust Trajectories for Smart Cities and Smart System

1. Brazil/EU startup ecosystem for urban innovation;

2. Bilateral Brazil/EU commitment to long-range funding;

3. Cross-research between priority areas;

4. Brazil/EU common knowledge, research and development of IoT protocols and solutions and next generation networks;

5. Joint policy development for net neutrality, data security, privacy and management;

6. Development and sharing of Brazil/EU makerspaces and research facilities;

7. Joint development of policies and new business models for work, health and mobility platforms;

8. Joint research and innovation in Blockchain technologies (cryptocurrencies and smart contracts);

9. Joint strategies for digital Inclusion & "smart slums";

10. Joint design of new city governance labs.

b) Common findings across Action Plans

Eight common strategies have emerged across the five Priority Areas. These are the following:

1. **Monitoring of and contributing to regulation and policy**
2. **Maintaining long-term funding support**
3. **Sharing common knowledge and facilities to leverage economies of scale and scope**
4. **Selecting common R&I topics across the five Priority Areas that leverage the complementary knowledge, framework conditions and longstanding cultural linkages between Brazil and EU.**
5. **Identifying pioneering coalitions for R&I cooperation**
6. **Engaging the business sector as a core contributor in R&I cooperation**
7. **Involving civil society as a core stakeholder**
8. **Establishing best governance practices for R&I cooperation**

TASK 1.3

DESIGNING STRATEGIC ACTION PLANS TO FOSTER COOPERATION PATTERNS IN PRIORITY AREAS

Task leader: UNICAMP

Major contributors: SPI, FRAUNHOFER, PUCRS, CSIC and PORTO DIGITAL

2 | Introduction

2.1 | **Background**

INCOBRA means Increasing Science, Technology and Innovation (STI) International Cooperation between Brazil (BR) and the European Union (EU). INCOBRA is a three-year Horizon 2020 project aiming to increase EU-BR R&I cooperation through partnerships, consortia and joint R&I projects and to enhance the relevant framework conditions addressing EU-BR R&I cooperation areas[1].

This report corresponds to task 1.3 of Work Package 1 (WP1). The task aims to designing strategic Action Plans to foster Research and Innovation (R&I) cooperation in priority areas.

Prior activities of WP1 set out five Priority Areas[2]:

- Green Energy;
- Sustainable Use of Bioresources;
- Food Security and Adaptation of Agriculture to Climate Change;
- Advanced Manufacturing and Nanomaterials; and
- Smart Cities and Smart Systems.

Action Plans identify and detail strategic actions for R&I cooperation in those five Priority Areas[3].

Task 1.3 was developed under the following INCOBRA's Grand Vision[4]:

1 For details see https://www.incobra.eu/
2 These activities comprise two strategic workshops held in Campinas and in Frankfurt, an open consultation on the conditions of R&I cooperation; a survey to collect opinions from different stakeholders about priorities on R&I cooperation; an Evaluation Synthesis over foresight studies in BR and EU; data and text mining over publications and patents. All these information has been continuously updated to be aligned with priorities from both European and Brazilian sides.
3 Annex 9.1 presents the technical justification for the choice of these five areas.

'Stakeholders from Brazil and EU are working together, like an orchestra, in a harmonious and complimentary fashion on scientific research and technological innovation projects.
Given the results of this successful cooperation, societies feel that Brazil-EU collaboration contributes to their balanced social, environmental, and economic development.
The cooperation is led by a multi-lateral, representative steering committee, with collaborative actors from research, policy, industry, academia, and civil society[5].

- Project governance that is simple, transparent, and based on trust that allow for the orchestration of work teams;
- Governance instruments and actors that are synchronized, harmonized, and aligned to complement each other;
- A long-term commitment to funding policies;
- Diverse partners interact like an open and flexible research and innovation network;
- Clear and stable framework for cooperation that guides the research agenda while accommodating creativity and original ideas in a flexible manner´.

Action Plans address two main categories of stakeholders: the INCOBRA team - as an input to other Work Packages -, and external stakeholders involved in upcoming R&I cooperation.

2.2 | **Methodological Approach**

Methodology was based on the scenario approach, which in turn generated the main framework to identify Robust Trajectories and Actions capable to face different situations towards R&I cooperation between EU and Brazil.

A roadmap exercise built upon comprehensive layers (namely: market, knowledge base, resources and regulations) complemented the methodological approach displaying Actions in a three distinct time frames: 2020, 2025, and 2030.

Both scenarios and roadmaps were defined under a set of general guidelines to pursue in R&I cooperation in each prioritized area. The specific and detailed subjects of research will be determined by concrete cooperation projects.

The methodological approach followed the following sequence (Figure 2.1):

[4] INCOBRA (2017). SFW Frankfurt Report.
[5] To better discuss the Grand Vision, the group used the metaphor of an „Orchestra“ as representative of a well functioning EU-Brazilian STI collaboration. While the photograph reflects this conversation, the participants thought it was important that the Grand Vision be re-written so as to de-emphasize the metaphor.

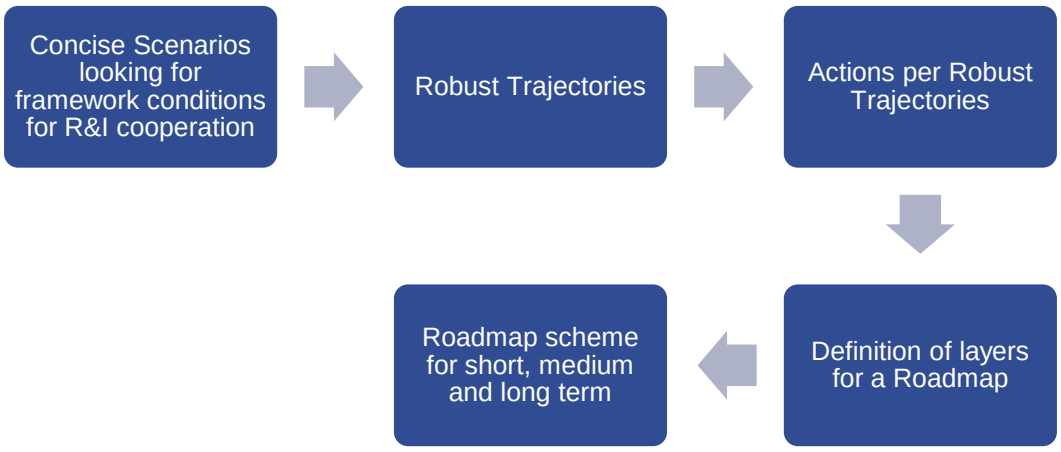


Figure 2.1: A schematic of the methodological approach

2.2.1 Scenarios

We adopted the general approach of "scenario planning", involving the description of alternative scenarios based on possible futures delineated by critical uncertainties[6].

The central idea of scenario planning is to organize a structured framework able to build a forward look to possible futures on the basis of highly critical variables that will shape the future of the prioritized topics of INCOBRA. At the same time, scenario planning allows a first approach to roadmapping, that is, it entails the necessary dimensions that must be taken into consideration in developing prioritized items.

There are two main scenario planning techniques:

- **Detailed Scenarios:** Deploy a list of critical uncertainties, describe the actual situation in each one, break them down into alternative futures, and analyze them in order to build scenarios;
- **Concise Scenarios:** Select and cross two critical uncertainties getting to four quadrants that described the scenarios (see Annex 9.2).

Methodologically speaking, both approaches are valid. The first is more detailed and embracing while the second more concise and straightforward. The choice between the two depends on objectives and available resources. Considering the time length of INCOBRA as well as the resources and the objectives of Task 1.3,

6 Godet M. (1987). Scenarios and Strategic Management, London: Butterworth.

the second option – concise scenarios – was chosen as the most suitable by the Consortium team involved in this task. Figure 2.2 shows a schematic approach of the concise scenarios in quadrants.

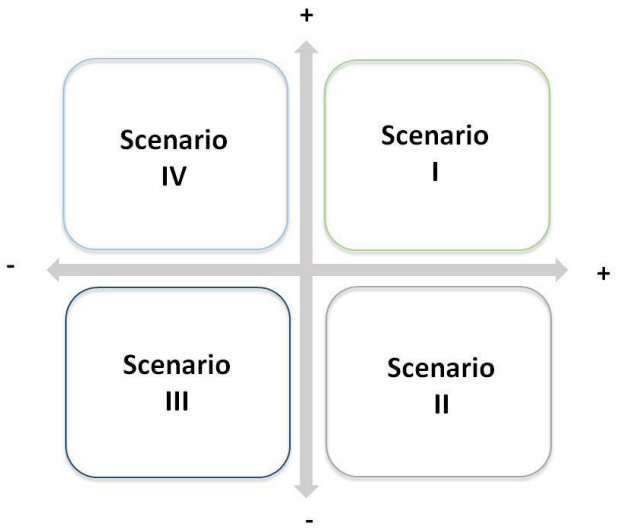


Figure 2.2: Crossing variables (reflecting uncertainties) and scenario designation

Scenarios have been prepared upon the concise approach departing from two critical variables whose intersection generates four quadrants characterized as scenarios for R&I cooperation in each of the five designated Priority Areas. The quadrant can be more (+) or less (-) favorable according to other variables that cross the quadrants. The selection of the critical variables is dependent on the specificities of each Priority Area and may vary among Areas. Each scenario was described in turn to identify the conditions that better characterize it and to extract implications for R&I cooperation in the specific Priority Area.

2.2.2 Robust Trajectories

Robust Trajectories (RTs) may be defined as the trajectories able to deal with critical issues both in terms of opportunities and threats throughout scenarios. A crosscutting analysis of the four scenarios of the concise approach helps defining RTs. Once defined, RTs are translated into Actions for the short-, medium- and long-term.[7]

[7] INCOBRA (2017). Time lengths defined during the 3rd Consortium Meeting in Rio e Janeiro. See Meeting Minutes.

2.2.3 Roadmap

Roadmaps are useful approaches to identify and choose the best path towards a predefined objective. Roadmaps are normally organized in layers (Figure 1.3) whose deployments over the future have to be taken into account[8]. Roadmap methodology is typically a prospective approach, but it is also a way to organize the most suitable paths to arrive at a predefined point in the future.

Task 1.3 employs roadmaps to identify measures needed to achieve a fruitful and successful R&I cooperation among Brazilian and European partners. Roadmaps were built over the results of robust trajectories in the five Priority Areas and other hints that emerged during the two Strategic Foresight Workshops. This perspective allows a smooth integration between the results of the scenario planning and the concrete measures of the Action Plan.

Four layers were defined for each Priority Area: i) regulation and policies; ii) market; iii) knowledge bases; and iv) competences and resources. The final step of the methodology is to distribute Actions along layers in a three different time frames: 2020, 2025 and 2030.

The following sections of this document present detailed scenarios, robust trajectories, roadmaps and actions for future cooperation for five Priority Areas: Green Energy; Sustainable Use of Bioresources; Food Security and Adaptation of Agriculture to Climate Change; Advanced Manufacturing and Nanomaterials; and Smart Cities and Smart Systems.

2.3 | **Supporting Documents and References**

Barney, J. B.; Delwyn, N. C. (2007) Reource-Based Theory: Creating and Sustaining Competitive Advantage, OUP Oxford, 328 pp.

EARTO, 2014. The TRL Scale as a Research & Innovation Policy Tool, EARTO Recommendations. The TRL scale was developed during the 1970-80's by the National Aeronautics and Space Administration (NASA).

Godet M. (1987). Scenarios and Strategic Management, London: Butterworth.

INCOBRA (2017). Meeting Minutes – 3rd Consortium Meeting.

INCOBRA (2017). SFWI Campinas Report.

[8] Phaal, R. and Farrukh, C.J.P. (2000): *"Technology planning survey—results"*, Institute for Manufacturing, University of Cambridge, project report, 14 March; Phaal, R., Farruch, C.J.P. e Probert, D.R. (2005). *Developing a Technology Roadmapping System,* pp. 99-111. http://ieeexplore.ieee.org/iel5/10096/32329/01509680.pdf?arnumber=1509680

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Teece, D. J; Pisano, G.; Shuen, (1997) Dynamic Capabilities and Strategic Management. Strategic Management Journal, vol. 18, nº 7, pp. 509-533.

3 | Action Plan for Green Energy

3.1 | **Background and Focus**

The energy field had been identified as a priority area for EU-BR R&I cooperation since the inception of the INCOBRA project. A variety of sources, data and activities around this area have been analyzed and discussed throughout the project's duration. Green Energy was set as a Priority Area for R&I cooperation since at least the first Strategic Foresight Workshop held at UNICAMP in November 2016.

Green Energy refers to emergy from natural sources such as solar, wind, and biomass, among others. It is, in other words, based on renewable energy resources with a much lesser detrimental footprint on the environment compared to carbon-heavy fossil fuels. This priority area also includes the reduction of Green House Gas emissions.

Green Energy is considered not only a priority *per se*, but also a cross-cutting priority capable to positively impact many other themes such as food security, climate change, advanced manufacturing, smart systems and smart cities, to mention just a few. It is also one of the key elements of bioeconomy strategy for Europe. Brazil has, meanwhile, been invited to become a member of the International Bioeconomy Forum.

Green Energy is a broad term that may encompass several themes. This Action Plan is focused on the opportunities for R&I cooperation on wind, solar and biofuels[9], including both vertical and horizontal collaboration. As for vertical we understand R&I cooperation focused on one single source; as for horizontal we mean combinations of those sources.

Brazil remains at the global frontier of research on biomass, particularly bioethanol of first and second generation, but also biodiesel, which is of high importance to Europe. Advanced biofuels are a specific topic of the Work Programme 2016-17 of Horizon 2020. Joint R&I work could benefit from both the Brazilian and European experience in biofuels. Solar and wind, on the other hand, are major ready-to-develop technologies with opportunities throughout the Technological Readiness Level spectrum.

It is also worth mentioning that Green Energy is a pervasive domain crossing smart cities and smart systems, nanomaterials, food security, climate change and Sustainable Use of Bioresources.

[9] These sources were set as priorities during the Strategic Foresight Workshop in held in Campinas in 2016.

3.2 | **Prioritized Items**

Drawing on information from the various scoping activities of WP1, namely two Strategic Foresight Workshops, Stakeholder Survey, Open Public Consultation, the Evaluation Synthesis of prospective studies, as well as technical reports issued by the European Commission during the past 2 years we have converged on the following two Green Energy priority areas for INCOBRA (Figure 3.1):

- Sustainable biofuels and biorefineries, and
- wind, solar and mixes of renewables.

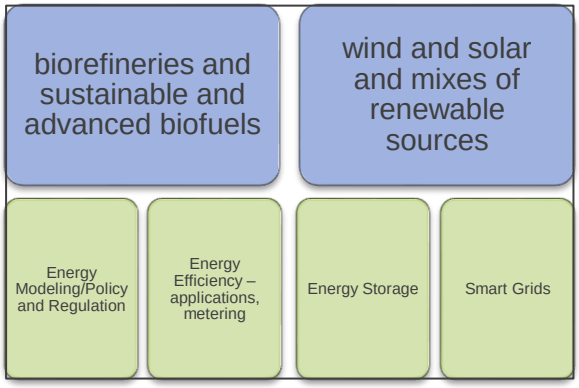

Figure 3.1 – Prioritized subjects in Green Energy

Four cross-cutting themes have emerged as particularly interesting for R&I cooperation in these two groups:

- Energy modeling/policy and regulation - benchmarking of best practices;
- Energy efficiency - applications, mobility, metering, data collection and treatment;
- Energy storage;
- Smart Grids.[10]

The following aspects of Green Energy provide orientation for the development of the Action Plan for future EU-BR R&I cooperation[11]:

- Studies of political, regulatory and planning importance need to be addressed considering specific goals from both sides. These studies also need to support new goals and policies.
- Monitoring and evaluation of energy efficiency: metering, data collection and treatment is a critical issue to be taken into consideration. The

[10] For a complete description of prioritized items see final report of task 1.2.
[11] INCOBRA (2017) SFWI Campinas Report.

importance of smart metering is related, among others, to its potential as a backbone of Internet of Things (IoT) and all services related to Big Data.

- The huge challenges in energy storage; the consideration of different stakeholders involved in generation, transmission, distribution and consumption; and the implications for the whole global value chain.
- Climate change and CO_2 emissions are critical topics to be faced by R&I EU-BR cooperation (see Action Plan on food security and adaptation of agriculture to climate change in this report). The 2015 Paris Agreement to limit the increase in the global average temperature bellow 2ºC and energy policy as a key factor to address climate change[12].
- The market of wind, solar and biomass – massive integration to the grid entails an opportunity for R&D cooperation focusing on integration and intermittence issues and networking amongst stakeholders.

3.3 | Concise Scenarios

3.3.1 Objective

The goal of this concise scenario analysis is to identify alternative scenarios for Green Energy looking for robust trajectories of R&I cooperation between the EU and Brazil. The alternative scenarios distinguish critical variables in order to develop a picture and a story describing possible futures in this priority area.

The scenario analysis and robust trajectories permit us to identify Actions for a roadmap towards R&I cooperation for Green Energy.

3.3.2 Critical Variables

The kick-off for building critical variables was a R&I Cooperation Survey Report (Deliverable 1.2) which provided a first list of priority R&I topics for long term cooperation. These prioritized topics were discussed extensively at SFW 1 and SFW 2 as reflected in the relevant reports. Several factors emerged that may critically interfere in setting up strategic R&I cooperation between Brazil and the EU. Three criteria were used to select critical variables:

- The intensity and frequency with which the variable (factor) was mentioned during the workshops, particularly during the debates about prioritization.
- The pervasiveness of the variable in defining the future of the priority topic.

[12] OECD (2017). Investment in renewable energy; and The Energy Union and European Diaglogue, March 2017.

- The impact the variable is expected to have on the practicability of R&I cooperation.

Considering these, the two critical variables chosen for Green Energy are:

- Evolution of policies and regulations related to supply and demand of green energy sources.
- Availability of financial and human resources for scientific and technological research in green energy.

3.3.3 What is inside the Variables?

VARIABLE 1:

"Evolution of policies and regulations related to supply and demand of green energy" encompasses:

- All relevant national policies and regulations that directly affect the decision of economic agents to invest in green energy, both for the supply side (agricultural producers, industry, and services) and for the demand side (consumers, whether final or intermediate).

VARIABLE 2:

"Availability of financial and human resources for scientific and technological research in green energy" encompasses:

- The importance and accessibility of skills and capabilities to carry research within the green energy domain in both regions;
- The level and accessibility of financial resources dedicated to green energy research in both regions.

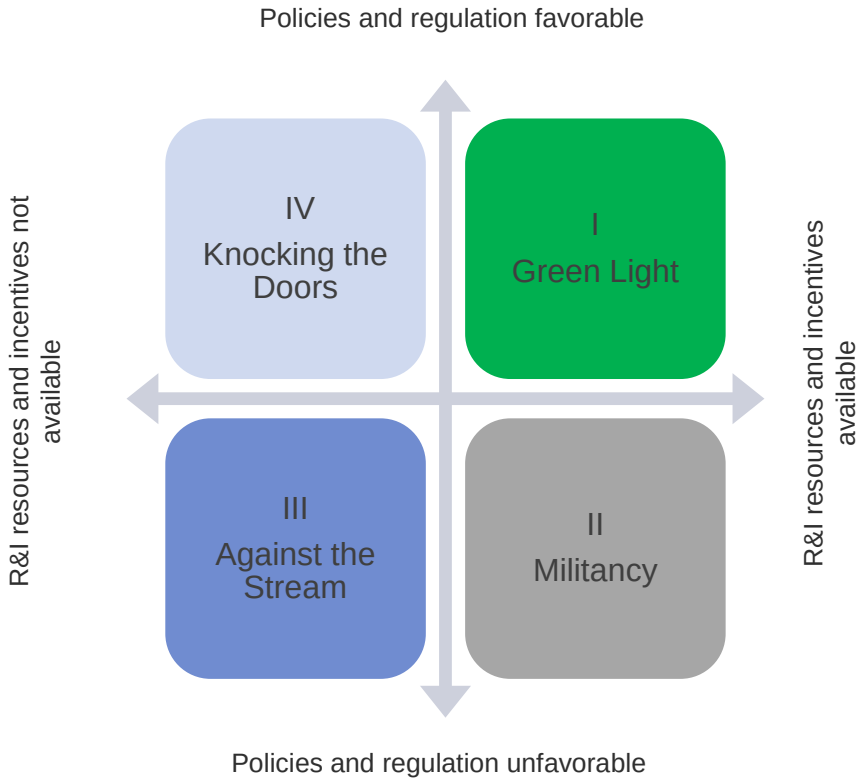

Figure 3.2. Crossing variables and scenario designation

The diffusion of Green Energy is the main drive to mitigate CO_2 emissions around the world. The use of incentives to promote sources like wind and solar is justified on the EU side. New laws and norms are regularly being approved following successes and failures of the previously existing ones and new regulatory instruments are continuously under study to cope with challenges to power system's operation and expansion.

On the BR side, the drive to mitigate CO_2 emissions is also critical although the differences in the energy matrix compared to Europe are quite extensive. Policies towards renewables have been somehow erratic because of contradictory incentives during the past decade towards renewables and fossil sources. For instance, Brazil leads renewable energy - considering both bioethanol and hydroelectric power. Going in the opposite direction, Brazil has been trying to capitalize on the huge opportunities created by one of the biggest discoveries of fossil fuel deposits of the 20th century as the pre-Salt offshore Basin.

Biomass and, to a less extent, wind and solar are the priorities for renewables in Brazil. Amongst them bioethanol is the chief trajectory, particularly in terms of achieving the Nationally Determined Contribution for GHG emissions.

"The biomass market in Brazil is probably the biggest in the world" "Bioenergy and renewables are naturally an important topic for Brazil. There are wide and deep capabilities in this country both genetic breeding and for physiology of plants."[13]

The Alternative Energy Source Incentive Program (PROINFA) is considered a milestone in the regulatory framework applicable to Green Energy, and remains the dominant piece of legislation relating to renewable energy regulation in Brazil.[14]

The EU has defined a set of sustainability criteria to ensure that biofuels will guarantee real carbon savings, control of land use change, and protection of biodiversity. For instance, to be considered sustainable, biofuels must achieve greenhouse gas saving of at least 35% in comparison to fossil fuels; biofuels cannot be grown in areas converted from land with previously high carbon stock such as wetlands or forests[15].

Both the European Union and Brazil are preparing and implementing strategic energy technology plans. The EU's strategy is to accelerate the development of low carbon technologies such as solar power, smart grids, and carbon capture and storage. On the Brazilian side is the "Plan of Action on Science, Technology and Innovation in Renewable Energy and Biofuels" to promote scientific knowledge and technological development in renewable sources both for transportation and electricity generation. Remarkable are also the initiatives of the National Regulatory Agency of Electricity (ANEEL) in setting priorities for R&D and innovation, particularly on alternative sources of electricity, thermal electricity, cogeneration of energy, and energy efficiency[16].

Even with these initiatives which promote research, development and innovation in both regions, the uncertainty about grants remains. In Brazil, research grants are at constant risk due to the current economic and political crises[17]. Both the EU and Brazil face uncertainties in terms of defining ambitious 2030 targets on Green Energy (low carbon, efficiency, smart grid, GHG, market options, demand changes, biofuels potential, modernization of infrastructure, etc.).

Nonetheless, Green Energy R&I will continuously play an essential role in developing cheaper, more efficient and reliable energy technologies requiring a continuous flow of new skills and capabilities. *"There are a lot of initiatives here and there, but not enough strategic approach with a long-term vision".*[18] Despite the different contexts between Europe and Brazil, there are several

[13] INCOBRA, 2016. Open Consultation Report (Deliverable 1.1).
[14] For more details see: IRENA, 2015. Renewable Energy Policy Brief: Brazil.
[15] EC, 2017. Definition of input data to assess GHG default emissions from biofuels in EU legistation.
[16] SFW Campinas: Energy Report, 2017.
[17] SFW Frankfurt Report. INCOBRA, 2017.
[18] Science/Business (2014:3). Europe's Energy Challenges.

complementary initiatives covering the whole gamut of possibilities related to sources of energy and energy efficiency[19].

3.3.4 Description of the Scenarios

The four scenarios are here described in general terms stressing implications for EU-BR R&I cooperation in Green Energy aligned with the framework of INCOBRA.

Scenario I: Green Lights

As observed in Figure 3.2, this scenario relates to the case where policies and regulations are favorable, on the one hand, and there are enough resources and competences to carry out sound and impactful research, on the other.

The conditions of cooperation in R&I are pro green energy, and priorities from both the European and Brazilian sides can be easily matched.

I.Green Lights

- Prioritizing themes to short the cycle of R&I and facing lead time;
- Concentrating efforts and resources in few and highly promissing projects;
- Scale in research will ve an important condition;
- Projects have need to be a set as truly innovation projects, pending more to business than science, although based on research.

Critical issues do arise, nevertheless, and must be considered in EU-BR R&I cooperation. They include:

- **Lead time**. In such a favorable scenario international competition in research and the time-to-market are challenges to be taken into consideration. This scenario assumes that “now it is for real” and the rush has started.
- **Priority mismatch.** Priorities in terms of sources of renewables may not be the same between the EU and BR. For instance, attention on biofuels in Brazil is strongly concentrated on bioethanol whereas biodiesel tops the European priority list. Overall, though, biofuels, solar and wind appear to be of high importance to both parties.
- **Regulatory framework**. Although pro-green energy in this scenario, regulation may evolve over different concerns and with different agendas.

These issues imply careful choice to build lasting and fruitful R&I cooperation. Guidelines for actions within INCOBRA’s framework could include:

- Prioritize themes on which parties have relevant and consistent advantages aiming at shortening the R&I cycle and lead time in a pre-competitive phase.
- Prioritize themes reflecting common priorities.

[19] INCOBRA, 2016. Foresight Studies in EU and Brazil (Deliverable 1.1).

- Concentrate efforts and resources in few and highly promising projects, precisely because of the competition, and the stage of the technological trajectories of different sources of green energy. The abundance of resources in this scenario cannot be interpreted as an authorization to spread money in several different trajectories.
- This means scale in research will be an important condition under scenario “green lights for green energy”.
- As a consequence projects need to be set as truly “innovation projects”, pending more to business than to science, although based on research. In green lights for green energy actions will be more based on innovation activities than on basic and applied research.
- Harmonize the regulatory framework.

Scenario II: Militancy

The scenario Militancy entails the idea that the pace of research is well ahead of that of innovation (market application). In other words, science-push will be more prevalent than demand-pull. In this scenario scientific and technological achievements will be plentiful but not well connected to market demand and, by extension, with little influence over the energy matrixes.

II. Militancy

- Being very selective in prioritizing research issues;
- Engaging companies in priorities investment;
- Engaging regulatory organizations and/or policy makers.

The core action items in the militancy scenario arise from the necessity to strongly act over policies in order to foster the adoption of technologies and services related to green energy. It also implies the need to involve industry in themes having stronger probability of buy-in.

Guidelines for actions regarding R&I cooperation within INCOBRA’s framework could include:

- Being very selective in prioritizing research issues that have well-known obstacles, capable to be overcome.
- Engaging the private sector in setting priorities of investment in R&I cooperation.
- Engaging regulatory organizations and/or policy makers from the early phases of programme selection.

Scneario III: Knocking doors

This scenario is a result of the combination of advanced pro green energy regulations and policies in a context of relative scarcity of financial and human resources for green energy research. It addresses the opposite situation to the previous scenario: now policies and regulations advance at a faster pace pressing for short-term solutions.

III. Knocking doors

- **Capacity to convince public and privace agents to fund;**
- **Focus in a major critical issue;**
- **Engage potential donors and funding organizations;**
- **Well-focused programs to avoid resources fragmentation;**
- **Research scale will be highly important.**

Knocking doors comprises the idea that for carrying out sound cooperative R&I in green energy it will be essential to raise funds. Funds and skills for R&I develop slower than that of industry regulation and policies.

Guidelines for actions regarding R&I cooperation within INCOBRA's framework could include:

- Focus – and not dispersion – is a major critical issue to take into consideration. Well-focused programs to convince funding agencies and companies to fund well selected projects may be more appropriate to this scenario than single projects.
- Engage potential donors and funding organizations during the set up of R&I cooperation projects/programs.
- Fragmentation of resources in many projects will make resources even scarcer and should be avoided.
- Research scale will be highly important once demands are stronger than the funding capacity.

Scneario IV: Against the stream

This is the least advantageous scenario where today's certainties will reverse to strong uncertainties. Unfavorable policies and regulations will postpone investments and fossil sources of energy will be on the march again. Research funding is expected to decrease and so will capabilities. The pace of R&I in Green Energy will probably slow down.

IV. Against the stream

- **Capacity to convince public and privace agents to fund;**
- **Focus in a major critical issue;**
- **Engage potential donors and funding organizations;**
- **Well-focused programs to avoid resources fragmentation;**
- **Research scale will be highly important.**

Guidelines for actions regarding R&I

cooperation within INCOBRA's framework could follow basic directions:

- Invest in selected strategic themes of green energy – some already listed in the reports of SFWs – in order to be prepared for a new reversal in this scene in the near future;
- Concentrate efforts in a few but very strategic enabling technologies that can be swiftly conversed into transformative technologies;
- More cautious attitude towards preserving capabilities and updating knowledge.

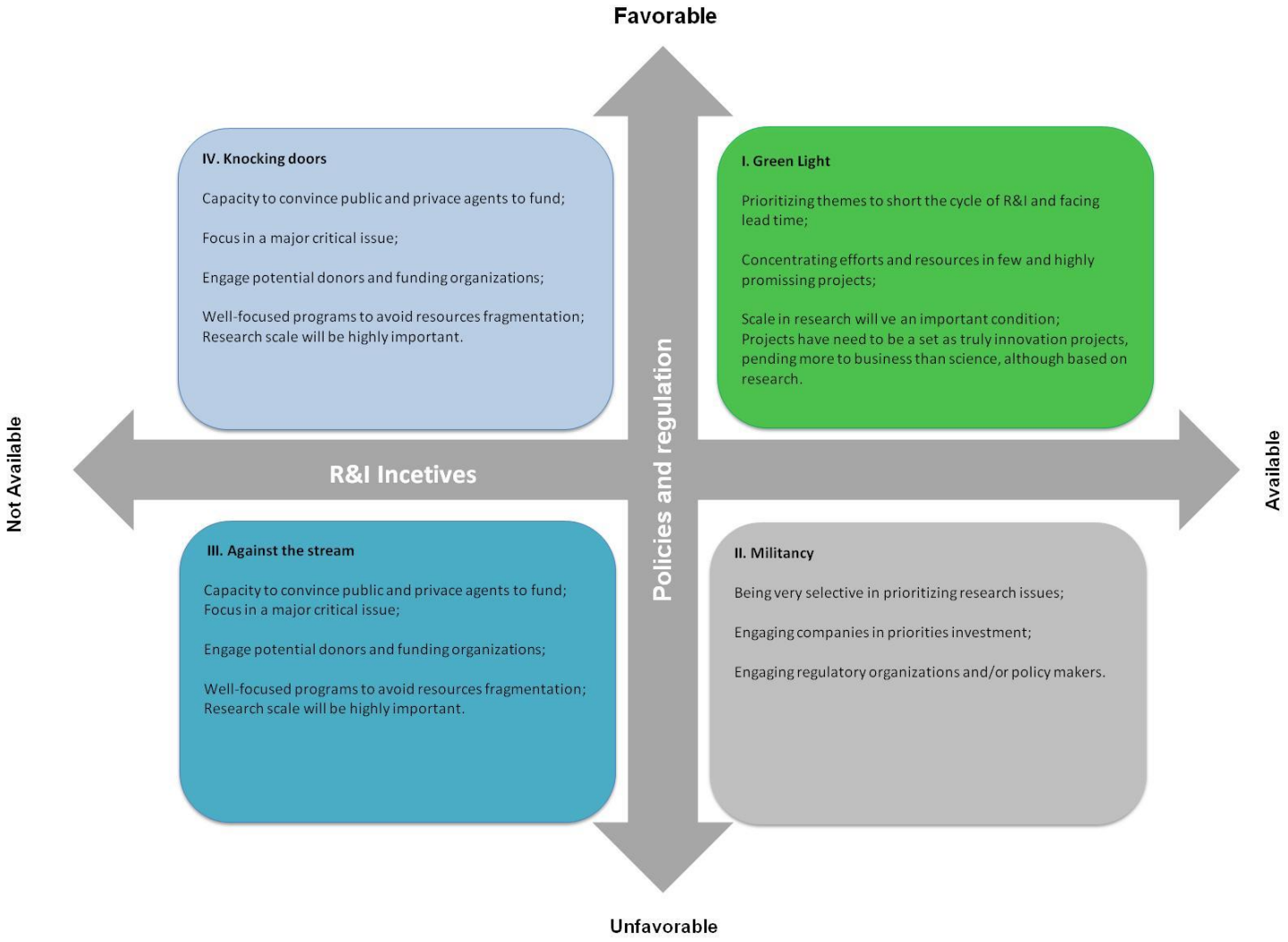

Figure 3.3. Scenarios overview based on scenarios descriptions

3.4 | **Robust Trajectories**

A crosscutting analysis of the four scenarios points at a set of measures to guide Action Plans for R&I cooperation in Green Energy between the EU and Brazil.

First of all, the present situation in Brazil and in the EU indicates a pro-green energy attitude, although both regions are experiencing significant changes in their internal political scene. Such changes notwithstanding, it's important to consider the recent decision of the United States to withdraw from the Paris Agreement and this country's explicit policies to "renew" the social image of fossil fuels.

Taking into account the uncertainty in the global situation of Green Energy, a robust trajectory for R&I cooperation in green energy should consider a mix of scenarios, as indicated in Figure 3.4.

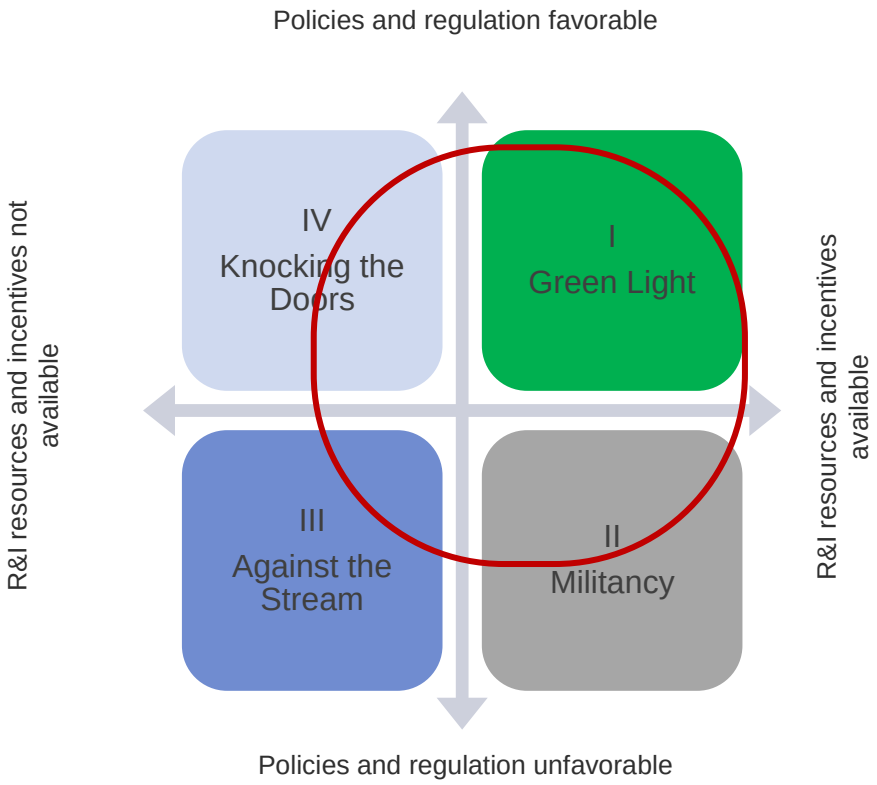

Figure 3.4 – Area for robust trajectories

The area delimited by the red line may be taken as representative of the present situation for both parties (the EU and BR). Green lights for green energy - although not prevalent - appears to be the driving scenario for the near future. Accordingly, a robust trajectory must consider elements from all scenarios, but adopting different weights.

A robust trajectory is a pathway that allows sound and effective R&I cooperation. Considering the four scenarios outlined above, the following measures may pave the ground for such cooperation:

1. **Incorporate into R&I cooperation a component of monitoring policies and the main regulatory frameworks, whether national or international, that may affect the future of Green Energy as this is defined elsewhere in this document**

Setting up effective and efficient monitoring and verification schemes[20] is a key issue to follow up the discussion and evolution of regulation and policies in EU and BR for biofuels, wind, and solar sources that contributes for establishing medium to long term R&I cooperation.

For instance, biofuels and solar power are living a moment of policy transition from mitigation to become transformative options[21]. The next generation of wind and solar power calls for next-generation policies which require an upgrade of existing regulation and market frameworks to encourage R&I projects that bring the highest value compared to their generation costs. A System-friendly renewable is also required and this "new system" demands tariff reform, customer's contribution to demand in a local distribution grid, the gradual introduction of time-based pricing, network tariffs to cover the costs of infrastructure and to send a signal for efficient use of the network and minimize the cost of future investment, etc[22]. These are just a few examples of possible indicators to track regulation and policies implementation effects that may affect EU-BR R&I cooperation until 2030. The way countries will regulate market to accomplish their National Determined Contribution – if any, must be systematically tracked.

2. **Focus on complementary niches/strategies for EU and BR in biofuels, solar and wind energy R&I themes**

Complementary niches and strategies for biofuels must consider that Brazil has abundant available land for bioenergy. This country employs just 15% of its land for agriculture (around 70 million ha out of 450 million ha total). For European countries this percentage reaches figures much higher (circa 30% to 40%) impacting food production[23].

[20] Cunningham P.; Nedeva M. (1999). Towards a System of Continuous Evaluation and Monitoring for European Co-Operation in Scientific and Technical Research (Cost). *Research Evaluation*, 8(3), 142-154. Hyvärinen, J. (2011). Tekes Impact Goals, Logic Model and Evaluation of Socio-Economic Effects. *Research Evaluation*, 20(4), 313-323. Salles-Filho, S.; Ávila, A.F.; Alonso, J.E.O.S.; Colugnati, F.A.B. (2010). Multidimensional Assessment of Technology and Innovation Programs: the impact evaluation of Incagro-Peru. *Research Evaluation*, 19(5), 361-372.

[21] OECD, 2017. Investment in renewable energy.

[22] IEA - International Energy Agency. Next Generation Wind and Solar Power: from cost to value. OECD/IEA, 2016.

[23] Cortez, L. A. B (Ed) (2014). Roadmap for Sustainable Aviation Biofuels for Brazil – A Flightpath to Aviation Biofuels in Brazil. São Paulo: Editora Edgard Blucher.

Brazil has dedicated substantial R&D efforts that allowed sugarcane and cellulosic raw material to be competitive for biofuels for first and second generations and to not displace food production. In the EU, new rules have come into force, amending existent legislation to limit to 7% the share of biofuels from crops grown on agricultural land. Still, biofuels production – biodiesel - in the region remained largely stable[24].

New foresight studies show that in 2050, the percentage of photovoltaics in the global electricity supply could be three times higher than previously projected. Solar energy will likely range from 30% to 50% of the total, also including the projected rise of global demand for electricity[25].

Given the technological and market capabilities and complementarities for EU-BR R&I cooperation in solar, both wind and biomass can work in smaller niches of revealed technological learning.

System integration[26] is amongst the big opportunities, both in a technological and a commercial perspective. On one hand, Brazil is responsible for about 57% of the market for wind energy in Latin America (circa 8.7 GW). About 357 MW of Brazilian new capacity was commissioned but not yet grid-connected[27]. On the other hand, Europe accounts for wind energy capacity of 153.7GW[28]. With almost 300 TWh generated in 2016, wind power covered 10.4% of the EU's electricity demand[29].

Wind energy technology is continuously evolving, driven by several factors, for instance, global competition; efforts to make turbine manufacturing easier and cheaper; the need to optimise power generation at lower wind speeds; to mention a few opportunities.

Attending demands towards grid codes is another top issue of research and development that can entail R&I cooperation, whether in solar or wind and biomass.

[24] REN 21 (2016). Renewables 2016. Global Status Report. Renewable Energy Policy Network for the 21st Century.
[25] Creutzig, F.; Agoston, P.; Goldschmidt, J.; Luderer, G.; Nemet, G.; Pietzcker, C. (2017): The underestimated potential of solar energy to mitigate climate change. Nature Energy, DOI: 10.1038/nenergy.2017.140: https://www.nature.com/articles/nenergy2017140
[26] Pietzcker, R. C., Ueckerdt, F., Carrara, S., Sytze de Boer, H., Després, J., Fujimori, S., Johnson, N., Kitous, A., Scholz, Y., Sullivan, P., Luderer, G. (2016). "System integration of wind and solar power in Integrated Assessment Models: A cross-model evaluation of new approaches" Energy Economics. Link to paper: doi:10.1016/j.eneco.2016.11.018 [freely accessible pre-print].
[27] REN 21 (2016). Renewables 2016. Global Status Report. Renewable Energy Policy Network for the 21st Century.
[28] EWEA (2015). Wind in Power. 2015 European Statistics. EWEA: The European Wind Energy Association.
[29] Wind Europe (2017). Wind in Power. 2016 European Statistics. Brussels: Wind Europe.

3. Monitor/build long term financial strategy related to R&I cooperation among the EU, Brazil and others

Monitoring of funding sources, and planning of new ones is a key factor for the development of an EU-BR long-term strategic partnership on Green Energy along with WP3 of INCOBRA, aiming to enhance framework conditions by promoting coherence and coordination at policy and funding programme levels. The importance of monitoring and evaluating the participation of different organizations from EU and BR in international cooperation programmes is being emphasized in WP4. Regarding H2020 Programme a good example is the second joint call on biofuels in 2016 for joint proposals among the EC, FAPESP, MCTIC[30] and Brazilian National Council for the State Funding Agencies (CONFAP). The Brazilian budget reached 5 million Euros in this program[31]. Europe has been investing in R&I for renewables at the rate of 4 billion Euros per year (by 2015), considering both corporate R&D investment and public funding available at the EU and national levels[32].

Besides the efforts in Science and Technology it is worth mentioning that renewable energy produced a new record of global investment in 2015. The amount of money committed, excluding large hydroelectric projects rose 5% to US$285.9 billion (134 gigawatts of new capacity added in 2015 globally came out from Green Energy sources, meaning 53,6%). Wind investment increased by 9% to a total of US$407 billion worldwide (in both the onshore and offshore sub-sectors), while the financing of solar assets increased 13%, reaching a total of US$89.9 billion. Total R&D spending on renewable energy technologies was almost unchanged at US$9.1 billion in 2015, government R&D was 3% lower than in 2014 at US$4.4 billion, but the fall was just offset by 3% rise in corporate R&D to US$4.7 billion.

Solar continues to dominate renewable energy R&D, with spending rising 1% to US$4.5 billion and equal to that in all sectors combined. Solar secured two and half times a much investment than wind, at US$1.8 billion, and three times more than biofuels, at US$1.6 billion. Following the Paris climate conference, governments and wealthy investors announced initiatives to raise investment in clean energy R&D[33]. An efficient monitoring system of R&I funding on Green Energy can provide very fruitful cooperation projects between EU and BR including other key partners around the world with common interest.

[30] Brazilian Ministry of Science, Technology and Innovations and Communications.
[31] INCOBRA 2017. Participation Monitoring in H2020 and Brazilian R&I Report. Annual Report 2016. (D4.5, report in progress).
[32] European Comission (2015). The European Union Leading in Renewables. Bruchure presented at COP 2015 by Commissioner for Climate Action & Energy.
[33] UNEP 2016. United Nations Environmet Programme. Global Trends in Renewable Energy Investment.

4. Monitor/build long-term competences and research capabilities related to Green Energy in the EU and BR

Complementarities over research capabilities are extremely important not only because this is an obvious path towards economies of scale and scope, but also because it entails the necessary reciprocity in effective R&I cooperation.

A division of labour must be sought because of asymmetries resulting from different policy environments as well as different geographical conditions. For instance, while the EU is more advanced in biodiesel than Brazil, the reverse is true for bioethanol. Looking at 2nd generation of biofuels as for hydrolysis of cellulosic material, European countries and Brazil are now scaling up industrial technologies. These recent experiences (industrial and pilot plants in both sides) may be used as a common platform for exploring complementarities of research competences in this area. The same is true for solar and wind. Geographical and climate conditions entail opportunities for developments through R&I cooperation.

Thereby, monitoring and building competences and research capabilities in Green Energy is related to mapping those already existing in EU and BR and also those needed to solve future R&D challenges in a complementary way. The competences and research capability prevailing on both sides should be mapped out to guarantee better and faster results from R&I cooperation.

There is continuous discussion about the need for sustainable development under terms and concepts such as “Circular Economy”, “Green Economy”, “Bioeconomy”, etc., which have gained more visibility around the world after 2015 Paris Agreement. In this context, a lot of breakthroughs in Green Energy technologies are expected.

In the context of INCOBRA project, new competences and research capabilities can be demanded and EU-BR R&I cooperation could foresee high qualification requirements, curriculum flexibility and further education programmes, consistent networks for exchange knowledge and to transfer skills. These actions will also support a comprehensive transfer protocol with business enterprises and institutions that will be involved with Green Energy by 2030[34]. Mobility of researchers and access to the research infrastructures, among others, will continue to be promoted between the European Research Council (ERC) and the Community of Latin American and Caribbean States (CELAC) in accordance to the EC priorities for implementation of the strategy international cooperation in R&I[35].

[34] OECD, 2017. Investment in Renewable Energy. The Energy Union and European Dialogue; March 2017. Changing Gerar in R&I: Green Growth for Jobs and Prosperity in EU, Advisory Group; EC 2016; EC 2015. Systemic Approach to Econo-Innovation to Achieve a Low-Carbon, Circular Economy, Advisory Group.
[35] {COM (2016) 657 final}. Report from the Comission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Comission Staff Working Document.

5. Be extremely selective in setting priorities for collaborative R&I projects and activities with really high potential of technological cum market success

The suggestion is to have few but high-density projects in upper TRL (closer to market) projects for each of the three prioritized energy sources: wind, solar and biomass. As high-density upper TRL projects we mean projects allocating high levels of human and financial resources to projects in the range TRL 7-9. That is, prioritizing R&I projects in Green Energy-related technologies to create a positive feedback cycle crowding-in private sector investments, accelerating learning by inducing private R&D, and reducing production costs of the new technologies[36].

Corporate leaders around the world are embracing Green Energy as a cornerstone of their operations[37]. For instance, Apple and Walmart for Solar; Siemens AG-REG for Solar, Wind Power and other renewables, etc. Europeans companies hold 40% of all patents for renewable technologies. Therefore, EU-BR R&I cooperative projects should find a road among research-technology-market interests.

It is worth mentioning that the EU initiatives to empowering citizens are also critical. In EU, consumers are eager to take part in the energy transition and cities are key enablers of energy policies. The EU is the world leader in residential PV with more than 40W installed per citizen[38]. Therefore, EU-BR R&I cooperation in Green Energy can display projects empowering consumers along with actions for Smart Cities and Smart Systems. Consumers will be able to know where their energy comes from and decide how to use it and make best energy choices, reducing their bills and taking control of how and when they consume energy.

6. Establish a minimum level of density for R&I cooperation to guarantee scale and scope economies

Few high-density projects in each one of the prioritized energy sources are needed in order to reach scale and scope economies for BR-EU R&I cooperation. This suggestion complements the previous one for it points to the necessity of avoiding fragmentation of resources, thus risking to have minor, non-impacting projects. It is recommended to move directly towards impacting – not disruptive –

[36] Luque, R.; Lin, C. S.; Wilson, K.; Clark, J. (2016). Handbook of biofuels Production. Processes and Technologies. Second Edition. UK: Whoodhead Publishing/Elsevier.
[37] Werner, T. (2016). A Unique Mix of Opportunities and Challenges for Solar Energy. Sun Power website. Access on 20170903: https://us.sunpower.com/blog/2016/08/09/sunpower-ceo-tom-werner-solar-industry/
[38] European Comission (2015). The European Union Leading in Renewables. Bruchure presented at COP 2015 by Commissioner for Climate Action & Energy.

projects in the sense that INCOBRA should be very selective in projects with higher foreseeable impacts.

Biofuel production shall follow international treaties and national laws regarding such things as air quality, water resources, agricultural practices, labour conditions, non-violatation of land rights, avoidance of negative impacts on biodiversity, ecosystems, areas of high conservation value, food security, etc. along with actions for Sustainable Use of Bioresources and food security and climate changes.

7. Engage the private sector in both sides of R&I cooperation

Over the last decade we have witnessed steady development of Green Energy technologies in most high-innovative countries. On the one hand, today there are hundreds of companies commercializing their technologies and services, and many of them are already established regionally and nationally. Exporting is particularly important for companies from both sides. On the other hand, some developing countries are experiencing important levels of economic growth. Brazil is Latin America's largest renewable energy market and despite its stagnant economic growth in recent years it is expected to keep investing in renewables, namely biofuels, wind and solar sources. For instance, Brazil maintains a 14% import tariff on wind turbines and charges a 12% tariff on imported solar equipment, both PV and thermal. Besides, there is no explicit local content requirement for participation in Brazil's renewable energy power auctions. In this context, EU-BR R&I cooperation projects provide an opportunity to engage the private sector and thus ensure that both sides reap the rewards of their research and innovation efforts[39].

The Actions for Green Energy were developed considering each one of this seven Robust Trajectories above described (Table 3.1).

[39] IRENA, 2015. Renewable Energy Policy Brief: Brazil; BNDES (2017); BNDES Approves first Financing for Generation of Solar Power in the amount of R$529,039 million. Published in 2017, August 05th: http://www.bndes.gov.br/SiteBNDES/bndes/bndes_en/Institucional/Press/Noticias/2017/20170511_generation_solar_power.html.; STEFFEK, J.; ROMEIRO, V. (2016) Private Actor in Transnational Energy Governance. *In*: KNODT, M.; PIEFER, N.; MULLER, F. (ed). Challenges of European External Energy Governance with Emerging Powers. USA: Routledge; ITA (2016). Renewable Energy Top Markets Report. USA: Intenational Trade Administration.

Table 3.1. Robust Trajectories and Actions for Green Energy for Short and Mid to Long-Term

Trajectories	Actions		
	Short-term	Mid-term	Long-term
	2020	2025	2030
1. To incorporate into R&I cooperation projects a component of monitoring policies and the main regulatory frameworks, whether national or international, that may affect the future of Green Energy as this is defined elsewhere in this document	To design a Monitoring and Evaluation System (M&E) for policies and regulation in Green Energy for EU and BR side to ensure that projects are efficiently implemented, reaching the intended targets and objectives	Establishing a Committee gathering representatives of R&I projects (with members from EU and BR) in order to advocate proactively towards pro Green Energy research policies.	
2. Focusing on complementary niches / strategies for EU and BR in biofuels, solar and wind energy R&I themes	To identify specific niches for the three sources of energy that are highly complementary and not competitive, particularly for near to market developments	To define a "division of labour" for long term, pre-competitive research agenda in biofuels, solar and wind	
	Having biofuels projects focused on in a significative reduce greenhouse gas emissions (GHG benefits)	To promote a few high-density projects in biofuels to contribute to the social economic and development of local, rural and indiginoues peoples and communites	
		Having a few high-density projects in solar PV and wind to develop learning and technologies allowing transmission and smart system grid integration and to reach the relevant role of solar PV and wind in enegery matrix, and also due the potential to be climate-friendly and affordable power supply.	Having a few high density R&I projects in solar PV to fill - technologically - the gap of different seasonality in solar production (solar cell efficiency) in EU-BR countries (a complementary model of productions considering where the sun shine).
3. Monitoring and building long term financial strategy related to R&I cooperation in the EU, Brazil and elsewhere	Developing a Monitoring System for long term financial sources in Green Energy, particularly to Biofuels, Wind and		
	Bilateral Brazil/EU commitment to long-range funding		
		Prioritizing funding for R&I projects that will be key to reach 2030 decarbonisation and climate changes along with actions for bioresources and food security and climate changes	
4. Monitoring and building long term competences and research capabilities related to Green Energy in the EU and BR	Developing a Monitoring System for long term competences and resources capabilites in Green Energy, particularly to		
		Bringing 3 specific research networks: one for biofuels, one for wind and one for solar for exchange/mobility between researchers and to develop common research	Prioritizing R&I EU-BR projects to reach supporting a transition of the labor force to incorporate greener skills and address skill shortages, including energy efficiency to the labor force from both sides
		Maintain investment in lower TRL projects in order to continuously build resources and competences for medium and long term R&I cooperation in Green Energy.	

Table 3.1. Robust Trajectories and Actions for Green Energy for Short and Mid to Long-Term (cont)

Trajectories	Actions		
	Short-term	Mid-term	Long-term
	2020	2025	2030
5. To be extremely selective in setting priorities upon projects and activities that really carry high potential of success, both in technological and in market terms	Establishing a Committee of Stakeholders that represents R&I actors' interests in market and technological terms to		
	Consider the interconnections between the time period of research activities and the development of new goods and		
	Give preference to projects that engage strategic stakeholders beyond the research domain, including private sector		
	Being extremally selective to promote R&I cooperation that put citizens at its core in EU and BR. Citizens should be able to participate in renewable energy markets, see reductions in their energy bills, produce and consume their own green energy along with actions in food security and climate changes	To promote research and incentives only for feedstocks systems which increase overall productivity of energy and food/feed/fiber on same land; consolidate the sustainability certification process.	
	To promote energy efficiency as an opportunity to deliver more services for the same energy input, or the same amount of services for less energy output (reduction of losses)	Integrating Green Energy in EV charging infrastructure	
6. To establish minimum level of density for R&I cooperation to guarantee scale and scope economies	Having few high-density projects in each one of the prioritized energy sources: biofuels, wind and solar power, and avoiding fragmentation of resources over broader scopes	Awarding prizes for the best practice or methodologies connecting different categories of stakeholders for biofuels, wind and solar power	Establish a EU-BR long term R&I program for integrated use of biofuels in all transportation modes in EU-BR to neutralize the cost difference of producing a drop-in fuel versus a product for biofuel-adapted engines
			Prioritizing projects that enables EU and BR accelerate their transition toward a climate resilient and greener energy to boost their competitiveness and to be able to have a sustainable growth and System-friendly for biofuels, wind and solar energy
			Supporting the competence-building and resources for Green Energy through training and exchanges of researchers and funding agents, and exchanges and promotion of good practices amongst peers
			Building common indicators (EU-BR) for both sides to reach sustainable perspectives for long term along with actions for bioresources and food security and climate changes applications
7. Engagement of companies in BR and EU with common interest in developing	Foster EU-BR pioneering coalitions and developing ongoing agreements amongst Brazilian and European companies in Green Energy	Having biofuels, wind and solar projects built and developed in a participatory processes that involve all relevant stakeholders in each value chain	

3.5 | **Components of a Roadmap**

In this section we develop a structure for a roadmap to successful (effective) R&I cooperation on Green Energy.

Altogether, the guidelines for R&I cooperation in Green Energy issued from the scenario analysis and the robust trajectories allow us to propose four main layers:

Regulation and Policies

Definition: Identifying and monitoring the legal, regulatory and institutional signals that may interfere over the trajectories of Green Energy, particularly on biofuels, wind and solar.

Main variables:

- Enforcement of environmental regulation, including GHG emissions, waste disposal, to mention a few;
- General policies and regulations regarding the use of different sources of energy, including nuclear, fossils and other non-green energy versus renewables. For instance, addressing the limitations of the ethanol-gasoline mix (E10, E20, E100);
- Commercial rules, and evolution of quality and trade certificates for internal and external markets, both inside and outside the European Union and Brazil.

Timing: continuous monitoring and analyzing the impacts for R&I cooperation.

Market

Definition: Identify the main challenges in supply and demand for green energy products in the foreseeable future: market influences on R&I and R&I influences on green energy market. Use foresight methods for early identification of possible market movements for either extant or radically new products and services.

Main variables:

- Growth of demand in electricity, trends in the energy matrix. For instance, Brazil forecasts an increase of 65% in electricity demand by 2024 (from about 516 TWh by 2013 to 790 TWh by 2024);
- Monitoring the levels of investment and the supply / demand curves for the three main energy sources of this Action Plan: wind, solar photovoltaic (PV), and biofuels;
- Monitoring relative prices of fossils and of renewables, broken down into biofuels, solar and wind;

- Evolution of licenses and permit systems and power auctions particularly monitoring for wind, solar and biomass, inside and outside parties.

Timing: short, medium and long term.

Knowledge bases

Definition: Main scientific, technological and empirical knowledge that are expected to support innovation in biofuels, solar and wind.

Main variables:

- Identifying and monitoring technological trajectories expected to be predominant in the future in renewables;
- Identifying and selecting priorities on technological solutions and patterns to invest in the three sources here selected: biofuels, wind, and solar;
- Identifying and applying technological solutions to guarantee transition of systems, from fossil to renewables (integration of generation, transmission and distribution).

Timing: short, medium and long term.

Competences and resources

Definition: Capabilities, and financial and physical resources needed to maintain/reinforce sustainable R&I cooperation.

Main variables:

- Taking into account ongoing EU-BR strategic energy programs and plans (e.g. BR plan of Action on Science, Technology and Innovation in Renewable Energy and the EU's strategy to accelerate the development of low carbon technologies such solar power, smart grids, and carbon capture and storage);
- Taking into account ongoing energy programs and plans between Brazil and EU member states;
- Defining the qualitaty and quantity of human resources necessary to develop R&I cooperative projects on biofuels, wind and solar, also addressing energy efficiency – applications and metering; energy storage; smart grids, just to mention some of the main topics prioritized in the two INCOBRA SFWs;
- Identifying emerging capabilities that will be necessary to join research projects in the near future (capabilities that can be foreseen as critical in the near future);

- Identifying necessary infrastructure and funds to carry large scale projects on biofuels, wind and solar.

Timing: short, medium and long term.

Taking into considerations the description of these layers, Figure 3.5 presents the actions emerging from the robust trajectories for short, medium and long term.

Layers	Actions		
	Short-term	Mid-Term	Long-Term
	2020	2025	2030
Regulation and Policies	To design a Monitoring and Evaluation System (M&E) for policies and regulation in Green Energy for EU and BR side to ensure that projects are efficiently implemented, reaching the intended targets and objectives	Establishing a Committee gathering representatives of R&I projects (with members from EU and BR) in order to advocate proactively towards pro Green Energy research policies.	
Market	To identify specific niches for the three sources of energy that are highly complementary and not competitive, particularly for near to market developments	To define a "division of labour" for long term, pre-competitive research agenda in biofuels, solar and wind	
	Establishing a Committee of Stakeholders that represents R&I actors' interests in market and technological terms to prioritize Green Energy R&I cooperation projects. This is also in accordance to WP 4 that foresees the strengthening of cooperation amongst different stakeholders from BR and EU beyond H2020.		
	Consider the interconnections between the time period of research activities and the development of new goods and services, including time to market constraints.		
	Give preference to projects that engage strategic stakeholders beyond the research domain, including private sector and regulatory and policy organizations.		
	To promote a few high-density projects in biofuels to contribute to the social economic and development of local, rural and indiginoues peoples and communites	Having biofuels, wind and solar projects built and developed in a participatory processes that involve all relevant stakeholders in each value chain	
	Being extremally selective to promote R&I cooperation that put citizens at its core in EU and BR. Citizens should be able to participate in renewable energy markets, see reductions in their energy bills, produce and consume their own green energy along with actions in food security and climate changes		
	Foster EU-BR pioneering coalitions and developing ongoing agreements amongst Brazilian and European companies in Green Energy		

Figure 3.5. Roadmap layers and actions for Green Energy for short and medium to long-term

Layers	Actions		
	Short-term	Mid-Term	Long-Term
	2020	2025	2030
Knowledge Bases	Developing a Monitoring System for innovative trends in Green Energy		
	Having biofuels projects focused on in a significative reduce greenhouse gas emissions (GHG benefits)	Having a few high-density projects in solar PV and wind to develop learning and technologies allowing transmission and smart system grid integration and to reach the relevant role of solar PV and wind in enegery matrix, and also due the potential to be climate-friendly and affordable power supply	Having a few high density R&I projects in solar PV to fill - technologically - the gap of different seasonality in solar production (solar cell efficiency) in EU-BR countries (a complementary model of productions considering where the sun shine)
	Having few high-density projects in each one of the prioritized energy sources: biofuels, wind and solar power, and avoiding fragmentation of resources over broader scopes	To promote research and incentives only for feedstocks systems which increase overall productivity of energy and food/feed/fiber on same land; consolidate the sustainability certification process	Establish a EU-BR long term R&I program for integrated use of biofuels in all transportation modes in EU-BR to neutralize the cost difference of producing a drop-in fuel versus a product for biofuel-adapted engines
	To promote energy efficiency as an opportunity to deliver more services for the same energy input, or the same amount of services for less energy output (reduction of losses)	Integrating Green Energy in EV charging infrastructure	Building common indicators (EU-BR) for both sides to reach sustainable perspectives for long term along with actions for bioresources and food security and climate changes applications
		Awarding prizes for the best practice or methodologies connecting different categories of stakeholders for biofuels, wind and solar power	
Competences and Resources	Developing a Monitoring System for long term financial sources in Green Energy, particularly to Biofuels, Wind and Solar. This indeed is an action to be developed along with WP 3.		
	Developing a Monitoring System for long term competences and resources capabilites in Green Energy, particularly to Biofuels, Wind and Solar. This is another action to be developed in WP 3.		
	Bilateral Brazil/EU commitment to long-range funding		
			Prioritizing R&I EU-BR projects to reach supporting a transition of the labor force to incorporate greener skills and address skill shortages, including energy efficiency to the labor force from both sides
		Bringing 3 specific research networks: one for biofuels, one for wind and one for solar for exchange/mobility between researchers and to develop common research	
		Prioritizing funding for R&I projects that will be key to reach 2030 decarbonisation and climate changes along with actions for bioresources and food security and climate	Maintain investment in lower TRL projects in order to continuously build resources and competences for medium and long term R&I cooperation in Green Energy.

Figure 3.5. Roadmap layers and actions for Green Energy for short and medium to long term (cont.)

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4 | Action Plan for Sustainable Use of Sustainable Use of Bioresources

4.1 | Background and Focus

This topic area is closely related to the development of the Bioeconomy - a priority research area for the EU and Brazil.[40] The Bioeconomy broadly refers to the exploitation of biological processes and organisms across a great many fields and industries including: Bio-Fuels, Bio-Plastics, Health and Medical Applications, Pharmaceuticals, Industrial use of Enzymes and Organisms, Agricultural Industry, GHG reduction systems, and Aquaculture. Due to its present and anticipated importance, the Bioeconomy was one of the five primary Research Areas highlighted in the initial INCOBRA project proposal, and has played a central role through all of the forward looking activities in WP1. As our survey of past foresight studies demonstrated, both Brazil and the EU have a long-standing commitment to science, technology, and innovation within the Bioeconomy, and a shared concern for maintaining biodiversity as a valuable resource. The present and future value of Bio-resources is further evidenced by both the publication and co-patent analysis (WP1.1), which showed an upward trend of value-add EU/BR partnerships over the last decade. Furthermore, nearly 25% of participants in the INCOBRA open consultation identify Bioeconomy as a promising field for STI-Cooperation for Brazil and Europe. This is especially interesting as many of the respondents advocating this area stated that Horizon 2020 was their first experience with bi-lateral project proposals which implies that this cooperation area is indeed taking of through H2020. During the Strategic Foresight Workshop process, it became clear through expert surveys, discussion, and critical vision development that within the broader bioeconomy context the Brazil-EU cooperation should focus on **sustainable use and management of bio-resources** including all types of bio-resources and uses from industrial use of enzymes to medical use of bioactive compounds from plants. Recent developments in Brazilian policy (explicitly the Biodiversity Access Law of 2016), and Brazil's role in COP21 Biofuture Program shaped dialogue and creative visioning during both of the workshops – clearly elevating practices and policies that reduce the environmental footprint of production and consumption patterns, while preserving biodiversity and environmental health especially as industrial use of biology intensifies. This focus was deemed particular well in line with the overall INCOBRA vision which is stating:

"*Given the results of this successful cooperation, societies feel that Brazil-EU collaboration contributes to their balanced social, environmental, and economic development*."

[40] European Commission (2016). Priorities for international cooperation in research and innovation. {COM(2016) 657 final}. 13/10/2016.

4.2 | Prioritized Items

The focus area **sustainable use and management of bio-resources** integrates the following key aspects all of which were highly prioritised by participants in both workshops[41]:

- Sustainable industrial biotechnology especially future generations of sustainable bio-refineries
- Rational and effective use of industrial and agricultural waste/effluent
- Conservation and sustainable use of biodiversity for new therapies
- Rational and effective discovery and screening of bioactive compounds from the Brazilian biodiversity
- Plant biotechnology.

For the sustainable use of bio-resources the following aspects of a desirable EU/Brazil 2030 future were emphasised:

- A coordinated Bioeconomy Strategy between Brazil and the EU is in place
- Both countries jointly commit to a joint long-term research and innovation strategy of sustainable use of bio-resources
- A Bio-pharmaceuticals Innovation Partnership between Brazil and EU is established
- Bioeconomy jobs increase overall employment opportunities both in EU and Brazil
- The COP21 Decarbonization goals are fulfilled with contribution from Brazil/EU bioeconomy research and innovation
- The Bioeconomy is fully circular and waste free through joint efforts of EU and Brazil
- Fictive news from 2030 "Europe and Brazil Breakthrough in Bio-Economy. Advances in the production of bio-based feedstock has earned one transatlantic Brazil-EU partnership the Nobel Prize. Research results in a 10 times increase in the amount of bio-based feedstock being used, which results in a reduced ecological footprint, food security, and greatly improved land-use efficiency."

4.3 | Concise Scenarios

4.3.1 Objective

To create more robust and resilient action plans, simplified alternative scenarios on the sustainable use of bio-resources were derived based on standard two-by-

[41] INCOBRA (2017). SFW Campinas and Frankfurt Reports (Deliverable 1.2).

two scenario development methodology. Though simple scenario models have their drawbacks, this method was deemed effective for the development of these Action Plans. These scenarios serve as a background for identifying promising opportunities for cooperation between Brazil and the EU - in regards to research and innovation for bio-resource management. The scenario analysis allows us to identify those actions that are beneficial in several possible future situations.

4.3.2 Critical Variables

In order to generate the scenarios we need to identify two critical variables i.e. variables that make a critical difference for the possibilities of setting up strategic R & I cooperation for sustainable use of bio-resources between Brazil and the EU. In addition, the development of the critical variable should be highly uncertain so meaningful variants can be developed. Using these criteria we identified the critical variables by analysing the material from the Strategic Foresight Workshop report (Deliverable 1.2), supporting documents and materials, and the detailed discussions that took place during group work at both SFW I & II. Through this analysis, we identified the following two critical variables:

Variable 1: The overall supportive nature of bi-lateral policies and regulation for sustainable use of bio-resources; and

Variable 2: The price of oil on the global market.

4.3.3 What is inside the Variables?

A more detailed view of the complex structures, entities, and flows that compose each of the two variables, can facilitate an understanding as to how such variables account for some of the complexity in play.

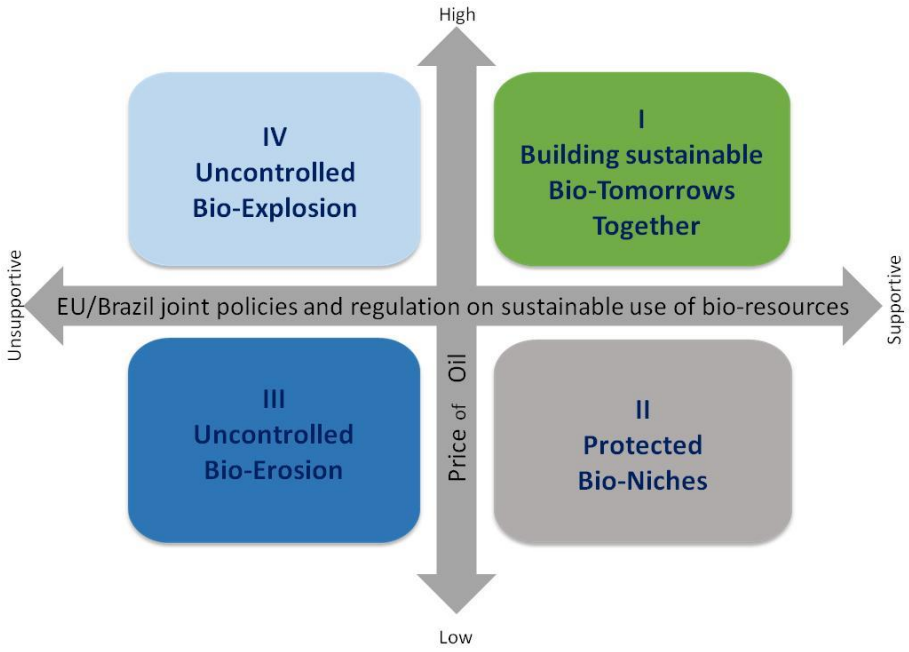


Figure 4.1: Crossing variables and scenario designation

VARIABLE 1:

"The overall supportive nature of bi-lateral policies and funding programs for Research and Innovation."

The research and innovation policy environment in which collaborative efforts between Brazil and the EU are developed will play a critical role in shaping the research agenda and results. With bi-lateral and broad ranging support for funding policies, IP agreements, and other critical policy areas, we can expect joint R & I activities to flourish across a number of fields related to the sustainable use of bio-resources. A non-supportive policy environment does not preclude excellent research or cooperation, but it does suggest that results will be less robust and unevenly distributed. Another important element is the overall stability of R&I policy on both sides. Functioning well-coordinated policies in support to sustainable use of bio-resources imply well-organised R&I policy settings in both Brazil and EU whereas a lack of coordination is likely to follow from weakening governance processes in at least one of the regions. It is important to note that EU and BR stakeholders can exert a certain amount of influence on the direction of this variable.

VARIABLE 2:

“The price of oil on the global market.”

The global price of oil is also a critical cross cutting variable, and as opposed to the first variable, represents a critical dynamic over which stakeholders can exert far less agency. The fluctuating oil prices of the past 10 years serve as a good indicator of the importance of this variable - with higher oil prices, numerous fiscal incentives emerged for increased research into bioeconomy industrial sectors. This influx of funding and research programs led to new breakthrough, and raised awareness of the vast potential of continued bioeconomic related R & I. The status of global oil prices has unwound some of the fiscal incentives, and curtailed the scope of biotechnological research in some industrial sectors. This variable's contingency on numerous global factors underscores the uncertainty of global oil prices going forward, and emphasizes the impact of this variable on all potential future scenarios.

In the following sections, we describe the four scenarios in general terms stressing implications for R & I cooperation in regards to the sustainable use of bio-resources. The simplified nature of these scenarios is meant to maximize the open nature of the context in which future INCOBRA actions and initiatives will take place. Results from the Strategic Foresight Workshops are integrated into each of the scenarios with alternative developments mapped according to the different conditions set forth by the variables.

Scenario I: Building Sustainable Bio-Tomorrows Together

This scenario develops along the assumption that both supportive, well-coordinated policy and funding for sustainable use of bio-resources exist, and the global price of oil raises significantly – conditions that, according to participant input, would benefit the general state of the bioeconomy and lend increased emphasis on sustainable management of bio-resources in general. High oil prices create the conditions for increased biotechnological research from both private and public sectors by creating financial incentives to invest. The ubiquity of oil-based products (plastics, fuel, base polymers, etc.) creates opportunities for R & I for both in-line replacements, as well as new entirely bio-based processes across many major industrial sectors. While increased bio-fuels research is obvious, the healthcare and pharmaceutical industries may become premier investors in the bioeconomy

and foster research into biopharmaceuticals and plant biotechnology independent of the high oil price.

Further bolstering bi-lateral R & I ecosystems, strong measures may be put in place to both financially and legislatively incentivize bi-lateral cooperative projects. Common protocols for research and data access for any partially or fully publicly funded project will create a wealth of new scientific knowledge for use in projects ranging from citizen science, to advanced commercial work. An agreed upon licensing and IP law regarding the use of Biodiversity might become the basis for reinforced incentives for joint private/public partnership and long term funding projects. The bi-lateral R&I ecosystem will ensure the focus on the BR/EU cooperation compared to other nations such as the US or China who might also be interested to explore and exploit the Brazilian bio-resources since the high oil price will foster a global movement towards the replacement of fossil resources by bio-resources.

Initially at least, this renewed interest and investment into biotechnologies might threaten to overwhelm the diverse bio-resources that are suddenly being explored and exploited in a much more intensive way. With so many R & I projects online, the importance of common managerial methods, measurements, and practices will became immediately apparent. With the potential of a common R & I research platform, and social and fiscal incentives at work, this scenario provides optimal conditions for collaborative R & I, but sustainable use of bio-resources relies on the social, political, and economic actions that can regulate and manage their use.

In this scenario, both state and industry in the EU and in Brazil are active players in R&I in Bioeconomy. Substantial employment benefits in the Bioeconomy are likely to appear both in the EU and Brazil. Also, health benefits from the biopharmaceutical research can be expected. There is a good chance to realise also wider visible societal benefits through sustainable use of bio-resources as outlined in the INCOBRA vision. To unlock this potential, actors in both regions need to launch activities that ensure a sustainability orientation of the Bioeconomy boom. This entails inclusion of citizens and civil society actors in developing localised solutions for sustainable bio-resource use.

These actions need to set in early, fast and very well coordinated to avoid being overwhelmed by the massive onset of activities for bio-resource exploitation and at the same time to ensure that citizens and civil society feel that the BR/EU-cooperation is designed and developed as cooperation between equal partners at eye level.

Within INCOBRA’s framework, key elements of such actions could be the further promotion of:

- EU-BR shared and strict legislative frameworks for sustainable use of bio-resources,
- EU-BR shared long-term funding priorities for the funding of public private partnerships towards sustainable use of bio-resources embracing as many of the active companies as possible,
- EU-BR joint use of bio-economy research facilities by consortia of public and private actors from both countries,
- EU-BR shared educational curriculum in sustainable use of bio-resources,
- EU-BR shared protocols and data management procedures that reach across the very diverse biotechnology development sectors, from plant biotechnology to next generation bio-refineries and emphasise capture of sustainability parameters,
- EU-BR pioneering procedures for optimising waste collection and utilization processes to maximize utility of bio-resources at each stage of their application on a local level together with key stakeholders,
- EU-BR shared efforts to integrate also civil society actors and ordinary citizens on local level into the sustainable use of bio-resources.

Scenario II: Sustainable Niches

If global oil prices were to remain relatively low for a sustained period, the broader Bioeconomy R & I sector would be a theater of prolonged struggle amongst various stakeholders. EU/Brazil joint bio-economy activities would most likely focus on the use of the biodiversity for biopharmaceutical research and plant biotechnology. Thanks to the supportive legislative and policy framework this domain may well flourish with a strong sustainability orientation. In the area of industrial biotechnology however, even with a policy and funding regime that is supportive of R & I in bioeconomy and sustainable Bio-resources management, there will be fewer market incentives to move away from traditional, fossil-based, industrial processes. If there is little market push for R & I activities, incentives for research will be more limited and this will likely lead to marginal gains for industrial biotechnology, and significant but small scale developments in general research and niche product developments. Especially the further development of future generation bio-refineries and concepts for rational and effective use of industrial and agricultural waste/effluent would suffer. Nevertheless, due to the currency

advantage Brazil may be one of the few actors who is still able to draw economic benefit from exploring also biofuels and biomaterial. While the joint development of a common bio-resource management professionalization curriculum may be agreed upon, its progress would be slowed due to fewer job market opportunities to attract students and promote a faster timetable for university adoption.

Concerning the sustainable use of bio-resources, this set of conditions might be optimal from the perspective of governing biotechnological development and the large-scale use of bio-resources. The relatively stable (if not declining) consumption of bio-resources would allow governing institutions more time to test and deploy appropriate measures for joint sustainable management of bio-resources. However, with little political or economic pressure to carefully monitor and sustainably exploit bio-resources, time alone does not guarantee better policies, practices, or protocols.

The lack of economic drive in the industrial biotechnology and biofuels limits private sectors investments. State actors need to use the scarce financial resources in a very efficient manner. Shared and intensified use of research facilities between Brazil and Europe may be one of the strategies adopted.

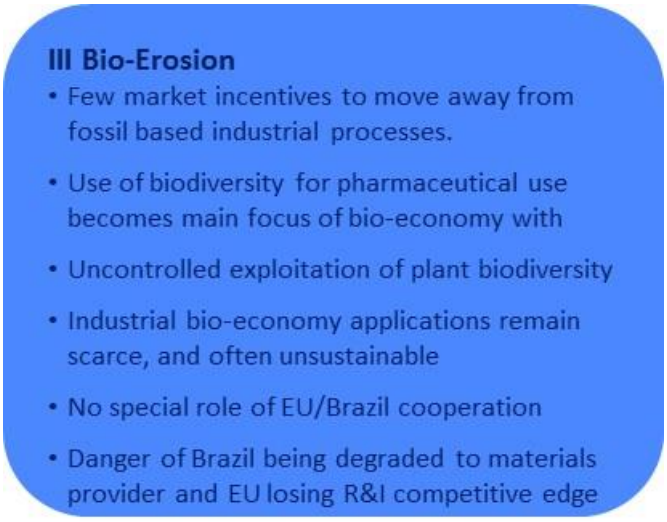
In this scenario, the booming BR-EU biopharmaceutical research is likely to create health benefits and a modest boost in employment in both regions in line with the expectations voiced in the vision. In the realm of biomaterials and bio fuels the relative stagnation and lack of private resources and market incentives challenges public actors to rationalise spending. The "hold on" situation provides an opportunity to prepare the ground for a sustainable use of bio-resources in the long-term future when oil prices again surge. This calls for a joint EU/Brazil "strategic niche management" approach where potential future breakthrough solutions for sustainable use of bio-resources are nurtured in protected niches.

Within INCOBRA’s framework, typical key actions would be:

- Launch joint studies exploring the conditions enabling a future industrial bioeconomy boom to be mutually beneficial and sustainable
- Jointly test and deploy appropriate measures for joint Brazil-EU sustainable management of Bio-resources
- Jointly launch small scale experiments such as advanced bio-refinery pilots that can quickly be scaled up when demand rises
- Support pioneering networks of actors willing to engage in R&I towards sustainable use of bio-resources even in the face of only few market incentives. These networks may e.g. be formed between pioneering regions in Europe and Brazil with similar interests in bio-resource use but also between complementary users and producers of bio-resources such as e.g. automotive companies and biofuel producers.

- Involve civil society in Brazil and EU in generating awareness for the potential benefits of sustainable use of bio-resources to create pioneering niche markets.
- Maximise shared and intensified use of costly research facilities
- Foster EU-Brazil cooperation making the most of the Brazilian currency advantage but with a clear sustainability focus.

Scenario III: Bio-Erosion



With a continuation of low oil prices, and unsupportive, bilateral policy and funding programs, a scenario emerges that could seriously derail the Bioeconomy. Though such conditions imply little public support for collaborative research, they also denote little economic incentive to develop biotechnologies at the expense of bio-resources. Instead of bio-resources coming under duress from an advancing Bioeconomy and biotechnological R & I, it could be that business as usual for global oil, and the systems it already supports, becomes a larger threat to biodiversity and the recognition of its potential.

Historically speaking, the global price of oil is comparatively low today (2016-2017), and there are many experts who think fracking and other fossil-fuel extraction methods will enable this state to persist for decades. If this condition were to persist, the continued development of bio-fuels and bioplastics will have to be incentivized through policy changes, as most large-scale industrial consumers of fossil fuels would have little reason to seek alternatives. Even though, due to currency benefits Brazil may be among the few players globally being able to profit from exploitation of bulk bio-resources, it is unlikely that advanced bio-refinery concepts and integrated waste management procedures are being developed and even applied within the country or together with Europe.

For R & I efforts into the Bioeconomy, products and services would have to be rooted in technological breakthroughs independent from the fossil-fuel market. In this version biopharmaceuticals and plant biotechnology still provide opportunities for the expansion of the Bioeconomy. However, without strong, bilateral, public support, R & I is likely to be funded primarily by private (and profit seeking) organizations. This undermines efforts at developing more collaborative efforts in STI fields, except among those incumbent organizations that maintain business

entities in both the EU and Brazil. Even so, any research results and IP is likely to remain trade secrets and thus limited its use for follow up research, or development of public goods. Moreover, without regulating frameworks for R&I in place sustainability of bio-resource use would have little priority. Exploitation of plant based resources for health applications may well proceed in an uncontrolled, inefficient and non-sustainable manner.

If most R & I research will be privately funded, and many of the traditional research vectors (biofuels and bioplastics) are non-economical regarding return on investment it is likely that exploration and experimentation remain the primary research vectors and bio-resource use within the Bioeconomy will be relatively light. While it is still important to establish policies for extraction and waste utilization, bio-resource management will be primarily driven by a lack of market demand. Similarly, activities towards common knowledge bases and core professionalization curriculum would have little political strength under such conditions. Shared use of Bio-economy Research Facilities between Brazil and EU would at best be occasional and rest on initiatives of individual actors with a special interest such as RTOs. In the face of lacking policy support, the role of science diplomacy may rise.

In this scenario health benefits from biopharmaceutical and plant biotech research would likely arise along with moderate employment benefits in this sector. The lack of regulation for sustainable resource management would lead to unsustainable strain on biodiversity from these activities. Fostering a sustainability orientation without concerted action of public actors would be left to a few pioneering private and civil society actors who would struggle due to lack of supporting regulatory framework and lack of market incentives. For biomaterials and bio-fuels the lack of engagement from both the public and private sector in industrial bioeconomy makes action towards the INCOBRA vision very difficult. Similar to the situation in scenario II it would certainly make sense to experiment in protected niches to prepare for future bio-booms. Without public support and regulation options this will be extremely difficult and left to non-state actors. Actions would possibly need to concentrate on campaigning for a shift towards stronger sustainability orientation and better coordination of EU and Brazil R&I policies.

Guidelines for actions regarding R&I cooperation within INCOBRA’s framework could include:

- Campaign on a political level for EU-BR shared and strict legislative and R&I policy support frameworks for sustainable use of bio-resources especially for biopharmaceutical and plant biotechnology
- Mobilise coalitions of pioneers from civil society, industry and research community willing to invest into a sustainable pathway of industrial biotechnology in spite of the unfavorable conditions.

- Identify "low hanging fruits" i.e. small showcase projects with high benefits for sustainable use of bio-resources and drive them forward.
- Foster Brazil-EU cooperation towards sustainable use of bio-resources within a global framework (e.g. International Bioeconomy Forum, World Business Council for Sustainable Development, UNEP, OECD ...)
- Foster the forming of lasting personal relationships through informal shared curriculum in sustainable use of bio-resources, personal contacts between Brazil-EU universities (e.g. shared summer schools on sustainable use of bio-resources, staff exchange)
- Use alternative funding sources such as crowdfunding campaigns.

Scenario IV: Uncontrolled Bio-Explosion

In this scenario, the price of oil on the global market rises dramatically with respect to current prices (2017). However, between Brazil and the EU there are little bi-lateral agreements on joint funding programs, strict policies concerning IP and licensing, or other institutions that would otherwise look to promote biotechnological R & I. Regarding the sustainable use of bio-resources, such conditions could easily develop into a scenario that lends its self to unregulated environmental exploitation, the loss of biodiversity, and the degradation of unique and valuable ecologies.

With market forces aligned to incentivize biotechnology R & I across a range of industrial sectors, private-side investment into various STI projects is quite likely to increase substantially. Industrial processes that utilize oil- and fossil-based byproducts will begin looking to replace these costly ingredients or processes with biotechnology. While this might be good for the overall state of the Bioeconomy - increasing the number of jobs, revenue streams, and research-funding sources - such conditions present some possible problems.

If bilateral EU-BR support for research does not also materialize, it is likely that research will focus on efforts that only increase the single bottom line. With profit becoming the primary motivation for the estimation and utilization for bio-resources (through R & I and industrial use-cases), it is likely that social, political, and cultural governing measures will be limited in both scope and effectiveness. This represents a transfer of potential wealth within biodiverse ecologies, and

does little to incentivize the sustainable use of bio-resources more generally. Without effective policy measures that regulate the management of bio-resource waste and its reutilization, inefficient industrial bio-economy solutions prevail. In general, it can be expected that highly diverse, suboptimal solutions fiercely compete on the global market. Global cooperation between bio-economy players is driven by profit and chance and joint activities between actors from EU and Brazil are in no way privileged. With little previous investment into joint competence building, Brazil faces the danger of being degraded to materials provider with low R&I contributions while EU countries may lose any special driving role in the bioeconomy boom. As an exception it is thinkable that some pioneering regions in Brazil and Europe align efforts to advance sustainable use of bio-resources together.

From and R & I institutional standpoint, such conditions favor large scale private research organizations, and the more established SMEs that have developed relationships with major industry players. These conditions do not preclude the emergence of start-ups and new businesses, but it could limit their numbers, research trajectories, and business development. This indicates that incumbent industrial powers within R & I would remain so, as would their relationship to society and its governance.

Lastly, the closed nature of private sector research and results would limit the applicability of new developments and the potential becomes limited by the agendas of existing needs. Furthermore, data and results become proprietary, and thus their successes will be limited in how new technologies are deployed and benefited from.

With little intervention and coordination from public sector actors, the private sector advances remain secretive, proprietary, and non-standardized. This limits participation by smaller scale research teams who cannot afford IP licenses for hardware, data and software. Sharing of research facilities is driven by the choices of oligopolistic consortia and highly selective. Bioeconomy related research groups at public universities are becoming mere workbenches for carrying out research agendas of large industrial players. State assets and common goods like the biodiversity are in danger of being sold out gradually. Proprietary knowledge would discount political will towards open databases. Joint EU/Brazil curricula would find little resonance as private institutions would likely prefer streamlined, agile, in-house training modules for their research staff.

In this scenario, health benefits from biopharmaceutical research and employment benefits in the wider bioeconomy are likely to materialise. Due to the lack of stimulation of basic research and radical innovation however, the bio-boom could be rather short lived. The use of bio-resources may well be largely short-term profit driven and unsustainable. Brazil-EU co-operations in the bioeconomy field are likely to be patchy. Realising the INCOBRA vision under these circumstances

is a continuous uphill struggle. As R&I governance is weak in both regions, actors from civil society, pioneering responsible companies and engaged research groups would need to join forces to drive the vision. While the lack of a supportive policy and legislative framework will hamper progress, some pioneering players may be able to mobilise resources due to the rather favorable economic situation of the sector.

Guidelines for actions regarding R&I cooperation within INCOBRA's framework could include:

- Mobilise coalitions of pioneers from civil society, consumers, industry and research community willing to invest into a sustainable pathway with voluntary shared standards protocols in spite of the lacking policy support.
- Strengthen alignment of efforts for sustainable use of bio-resources between EU and Brazil on a regional level.
- Use some of the bio-boom profits to drive forward joint EU-Brazil showcase projects with high benefits for sustainable use of bio-resources and high visibility.
- Foster Brazil-EU cooperation towards sustainable use of bio-resources within a global framework (e.g. world business council for sustainable development, UNEP, OECD ...)
- Foster the forming of lasting personal relationships through direct contacts between Brazil-EU research groups (e.g. shared summer schools on sustainable use of bio-resources, staff exchange, shared use of research infrastructures)
- Establish shared EU-Brazil curricula in sustainable use of bio-resources in an informal manner
- Campaign on a political level for EU-BR shared and strict legislative and R&I policy underpinning the sustainable use of bio-resources.

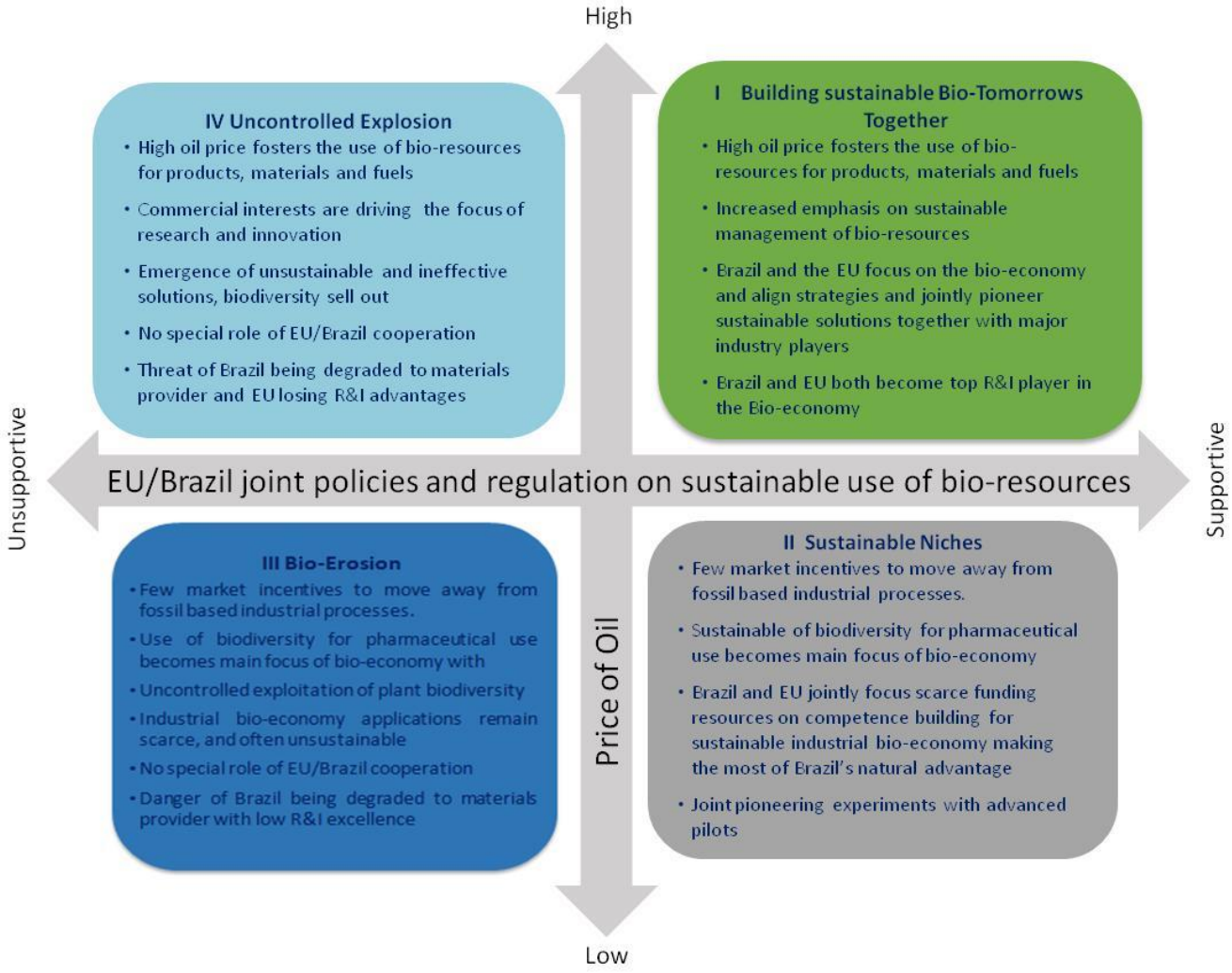


Figure 4.2. Scenarios overview based on scenario designation

4.4 | Robust Trajectories

Robust trajectories are the pathways towards preferable strategic end states for various social, economic, and governing factors. While uncertainty and change will often shape the details of the journey to achieving these goals, the basic approach remains valid to achieve the vision goals across scenarios. Below we discuss the ten main robust strategic options identified through the analysis of the four scenarios.

1. Brazil/EU supportive regulatory framework for sustainable use of bio-resources

The establishment of a regulatory framework for ensuring sustainability in the exploration of bioeconomy pathways emerged as a key strategy towards the vision. One important aspect that will greatly facilitate collaborative efforts in R & I is the distribution of IP rights and licensing royalties. Bi-lateral agreement in this regard will shape the circumstances for research projects and the status of partners, and contributes to the achievement of commercially successful product development across biopharmaceuticals, bioprocesses, and other sectors. In the two scenarios where such a framework was lacking the success of the chances of achieving the vision were substantially lower. In this situation, political campaigning for such a framework becomes a key strategy.

2. Brazil/EU common knowledge base and research protocols on sustainable use of bio-resources

A shared knowledge base is viewed as an essential component to improving and expanding collaborative efforts in R & I concerning the sustainable management and use of Bio-resources. Best practices in the collection of raw samples, database creation, and research results dissemination are needed in a manner that is general enough to apply across the diverse fields already outlined, while remaining unambiguous so as to avoid abuses. Critical to these best practices will be the co-development and wide dissemination for open access database standards and common protocols for research that help to ensure that results are verifiable and replicable across the EU and Brazil, and lend efficiency to the transition from scientific knowledge formation to intellectual property for industrial applications.

3. Bilateral Brazil/EU commitment to long-range funding

This was a core element of the INCOBRA visions. At the same time, it is also a robust strategy to support the second element of the vision: The generation of visible benefits for society. The scenario discussion showed that only such a shared agenda between EU and Brazil can yield the true benefits of sustainable use of bio-resources and thereby the wider bioeconomy.

4. Involving civil society in the development of bioeconomy

Especially important in the two scenarios where the states are less active but also when industry shows little interest due to lack of short-term profit expectations. Also in the scenario with both state and industry active, involvement of civil society stakeholders is key for developing the diverse range of locally adapted solutions required for a truly sustainable management of bio-resources.

5. EU/Brazil sharing of bioeconomy research facilities

This strategy was emphasized at the SFW I proceedings, as an effort to increase efficiency in research and replicability of results. Funding for infrastructure could be publicly or privately provided, or the result of public-private partnerships. The scenarios show that this action holds also in the face of difficult framework conditions as it may enable sufficient use of scarce resources especially in difficult circumstances.

6. EU-BR shared educational curriculum in sustainable use of bio-resources

By co-developing a core curriculum towards professionalization within the area of Sustainable use of Bio-resources, both the EU and Brazil will be providing shared channels of communication and understanding across their respective research communities. With a common knowledge background, research can become more focused and effective in regards to the challenges of managing Bio-resources in all their diversity. This strategy is especially successful in scenario I where bioeconomy jobs are soaring and interest in industry as well as state support are high. It emerged however that also in less favorable scenarios implementing this measure even on a lower level makes sense to foster the vision.

7. Create durable personal relationships between Brazilian and European researchers and innovators in sustainable use of bio-resources

Foster the forming of lasting personal relationships through personal contacts between Brazilian and European research groups (e.g. joint summer schools on sustainable use of bio-resources, staff exchange, shared use of research infrastructures). In difficult situations, these relationships will provide a resilience by enabling distributed activities even in the face of lacking official support. But also in favourable conditions such relationships will greatly increase the chances of Brazil and Europe advancing together.

8. Foster EU/Brazil pioneering coalitions

Identifying and mobilising potential coalitions of pioneers from civil society, industry and research community willing to invest into a sustainable pathway even

in difficult circumstances. These networks may e.g. be formed between pioneering regions in Europe and Brazil with similar interests in bio-resource use but also between complementary users and producers of bio-resources such as e.g. automotive companies and biofuel producers.

9. Experimenting breakthrough solutions in protected niches

This strategy of strategic niche management proved especially prevalent in scenario II to bridge where a "on hold" situation due to low oil prices allows careful preparation of steering a possible future bio-boom in sustainable directions. A large variety of diverse niches will enlarge the chances to take advantage of future business opportunities that might appear later on under changes framework conditions. As long as these future framework conditions remain unclear a diversified strategy will be most robust.

10. Optimising bio-waste collection and utilization processes through bi-lateral development of policies, partnerships, and technologies

The strategy aims to maximize utility of bio-resources at each stage of their application on a local level together with key stakeholders. This strategy is especially important for the cooperation between EU and Brazil since the two regions represent supplementary contributions along the value chain. The benefits for an optimization of bio-waste collection and utilization processes could ensure efficiency, approval of civil society and a competitive advantage compared to other actors.

As a domain, the Sustainable use of Bioresources includes important policy creation, community formation, and incentive programs alongside technological development. In seeking to outline the sequential component of the action plan, we have arranged different components along a general timeline. These time frame suggest a false linearity to some of the suggested actions, and many of the actions can be taken up in parallel given enough resources (Table 4.1).

Table 4.1. Robust Trajectories and Actions for Sustainable Use of Bioresouces for short and mid to long-term

	Actions		
Robust Trajectories	**Short-term**	**Mid-term**	**Long-term**
	2020	**2025**	**2030**
1. Brazil/EU supportive regulatory framework for sustainable use of bio-resources	Joint Biodiverstiy Legislation (fast track)	MoU for sustainable and fair exploration of biodiverstiy	Fully fledged supportive regulatory framework for joint sustainable exploration of biodiversity
2. Brazil/EU common knowledge base and research protocols on sustainable use of bio-resources.	Mapping bio-resource research programs, activities, and actors in Europe and Brazil	Building pilots for shared protocols and knowledge bases	Fully fledged joint research programme for building a shared knowledge base for all relevant aspects of bio-resource use
	Mapping and disseminating good practices of knowledge sharing between Europe and Brazil	Joint funding schemes and calls for biodiverstiy screening for bio-active compounds using the shared protocol and building pilots of joint knowledge bases	
	Identify opportunities for building shared knowledge bases and protocols		
3. Bilateral Brazil/EU commitment to long-range funding in the field	Mapping bio-resource research programs, activities, and actors	Adoption of shared priorities and joint long-term funding roadmaps	Routines for continuous joint programme development
	Joint Foresight activities and long-term strategy development involving key funders from both sides	Establish Innovation Partnerships e.g. on Sustainable Bio-pharmaceuticals or Next generation sustainable biorefineries	Sustainable Bio-pharmaceuticals Innovation Partnerships

Table 4.1. Robust Trajectories and Actions for Sustainable Use of Bioresouces for short and mid to long-term (cont.)

Robust Trajectories	Actions		
	Short-term	Mid-term	Long-term
	2020	2025	2030
4. Involving civil society in the development of bioeconomy	Mapping of civil society activities and fostering of exchange between matching initiatives	Joint EU/Brazil citizens' discourses on biotransformation processes	Continuous bioeconomy citizen dialogues in both regions with regular exchange of findings and experiences as well as bilateral dialogues
		Regional Bio-resource partnerships	
5. EU/Brazil sharing of bioeconomy research facilities	Mapping exiting research facilities in bioeconomy	Launching joint experiments with mixed research teams in slected pilot facilities	Roll out into fully fledged sharing scheme for all bioeconomy infrastructure
	Mapping best practices of sharing in other fields		
6. EU-BR shared educational curriculum in sustainable use of bio-resources	Joint Teaching Courses & Summer School Programs		
7. Create durable personal relationships between Brazilian and European researchers and innovators in sustainable use of bio-resources	Mapping research programs, activities, and actors including teaching programmes dedicated to sustainable use of bio-resources.	Develop joint teaching courses & summer school programs	Roll out into regular exchange programme on all levels
	Identify potential for alignment/mutual interest	Foster researcher exchange programme for the identified topics (building on the already established cooperation on Skłodowska-Curie Actions)	
		Organise matching events (e.g. symposia, conferences) for innovators, business developers, policy actors, think tanks, regulators and civil society actors from both regions active in the field.	

Table 4.1. Robust Trajectories and Actions for Sustainable Use of Bioresouces for short and mid to long-term (cont.)

	Actions		
Robust Trajectories	**Short-term**	**Mid-term**	**Long-term**
	2020	**2025**	**2030**
8. Foster EU/Brazil pioneering coalitions	Identify pioneering ecosystems of research, innovation and societal actors around sustainable use of bio-resources	Support the identified ecosystems in joint competence building, strategy building and market exploration	Full establishment of new joint value networks
	Establish regional bio-resource partnerships		
9. Experimenting breakthrough solutions in protected niches.	Identify potential breakthrough solutions for sustainable use of bio-resources which benefit in particular from joint development between Brazilian and European R&I actors.	Support experimenting e.g. through joint pilots and demonstrators around the identified solutions	Support the niche coalitions to embark into the wider landscape
10. Joining efforts for establishing cutting-edge procedures for optimising bio-waste collection and utilization processes	Mapping bio-waste streams in a few selected typical settings relevant for both EU and Brazil	Development of EU/Brazil Next Gen Zero Waste Biorefinery Demonstrator for efficient processing of diverse feedstock	A jointly developed bioplastics recycling scheme is activated in both Brazil and EU

4.5 | **Components of a Roadmap**

The robust strategic options outlined above can underpin the achievement of the INCOBRA vision of a sustainable use of bio-resources pioneered in a well functioning Brazil/EU cooperation with visible benefits that are appreciated by societies in Brazil and the EU alike. In order to generate a more concrete roadmap towards the realisation of the vision in 2030 we have broken down these robust strategic action lines into actionable items that support these measures stretching from the present to 2030. Roughly, we distinguish short-term actions (next 3 years) midterm actions (next 3-8 years) and long-term actions (2015-2030).

Regulation and Policies

Definition: This layer refers to bi-lateral governance initiatives that will facilitate the achievement of the Grand Vision in regards to managing the growth of the Bioeconomy in a sustainable fashion.

Main variables:

- The exploitation of biodiversity for the Bioeconomy will have impacts on ecologies, but the existence of a strong, bilateral regulatory framework can limit the extent of such impacts and bolster the development of sustainable practices and technologies;

- Understanding the long-term impacts and processes that bioeconomic research and exploitation can have is essential to Sustainable management of Bioresources. This requires joint commitment to funding of long-term research projects in regards to complex ecosystems and the impact of human contact.

- Establishing fair and sustainable standards for the utilization of biodiversity fosters the long-term management of Bioresources.

Timing: Short-, medium-, and long-term actions towards these goals are detailed in the following section.

Market

Definition: Monitoring critical market developments will inform the strategies deployed to achieve each element of the action plan. Cooperation opportunities, funding and prioritization are critically linked to markets outside of strict biotechnological fields.

Main variables:

- Monitoring demand for industrial applications of biotechnology can identify stakeholder groups and actors for R & I partnerships and novel collaborations.

- Demand for bio-based alternatives to petroleum-based products and components. Broad monitoring is necessary as this demand might be spurred by the pursuit of alternative fuels, biopharmaceuticals, and bio-plastics.

- Biologically derived Intellectual Property (IP) can spur investment in research and facilities in pursuit of the exploitation of biodiversity.

- In Brazil and Europe, diverse niche markets have developed due to targeted regulation (e.g. for specific applications only biodegradable products can be used) and by growing public demand.

- Emerging markets for waste products given the development of collection and utilization technologies.

- Tracking the financial impact of increased investment in Bioeconomic research and development

Timing: Market monitoring is to be conducted on a continuous basis, with particular attention given to specified indicators.

Knowledge Bases

Definition: The development of particular knowledge bases will facilitate the capacities for both Brazil and the EU to collaborate with efficiency and effectiveness across the domain of Sustainable use of Bioresources.

Main variables:

- Encouraging the development of cutting-edge procedures for optimising bio-waste collection and utilization processes can be achieved through various policy and funding incentives.

- The development of a huge diversity of technological solutions that are specifically focused on niche applications.

- Identifying technological branches that directly impact the Sustainable management of Bioresources (sensors, data analytics, etc.) can focus R & I efforts.

Timing: Short-, medium-, and long-term actions towards these goals are detailed in the following section.

Competencies and resources

Definition: This layer refers to the coordination of shared knowledge and various resources (facilities, personnel, financial) between actor groups within Brazil and the EU. This includes both support actions for existing collaboration programs, and the planning and implementation of new programs in line with actions towards the achievement of the Grand Vision regarding Sustainable use of Bioresources.

Main variables:

- Ensuring Brazilian and EU collaborators have access to the best available technologies and facilities to conduct their research in an effective and efficient manner.

- Citizen input is a critical resource for ensuring successful research and collaboration in the Sustainable Use of Bioresources. Developing and maintaining channels for the involvement of civil society, and monitoring if and how those inputs are used, is essential to ongoing R & I strategic development.

- Collaboration is more efficient, effective given a common foundational knowledge and training across participants. The development of a shared educational platform and curricula can facilitate more effective R & I.

- Understanding essential commonalities and differences in research methods and protocols will foster more opportunities for collaboration.

- Fostering diverse win-win partnerships and mutually beneficial collaborations across Brazil and EU stakeholders. Creating conditions through funding and policy for novel coalitions to form can generate new opportunities.

- Creating and maintaining spaces and channels for the strengthening of social and professional relationships, will facilitate long-term, successful R & I collaboration.

Timing: Short-, medium-, and long-term actions towards these goals are detailed in the following section.

Take into considerations the description of this layers, the Figure 4.3 presents the actions which rose up from robust trajectories by layer for short, medium and long term.

Layers	Actions		
	Short-term	Mid-Term	Long-Term
	2020	2025	2030
Regulation and Policies	Understanding the long-term impacts and processes that bioeconomic research and exploitation can have is essential to Sustainable management of Bioresources. This requires joint commitment to funding of long-term research projects in regards to complex ecosystems and the impact of human contact.		
	The exploitation of biodiversity for the Bioeconomy will have impacts on ecologies, but the existence of a strong, bilateral regulatory framework can limit the extent of such impacts and bolster the development of sustainable practices and technologies.		
	Establishing fair and sustainable standards for the utilization of biodiversity fosters the long-term management of Bioresources.		
Market	In Brazil and Europe, diverse niche markets have developed due to targeted regulation (e.g. for specific applications only biodegradable products can be used) and by growing public demand.		
	Monitoring demand for industrial applications of biotechnology can identify stakeholder groups and actors for R & I partnerships and novel collaborations.		
	Demand for bio-based alternatives to petroleum-based products and components. Broad monitoring is necessary as this demand might be spurred by the pursuit of alternative fuels, biopharmaceuticals, and bio-plastics.		
	Biologically derived Intellectual Property (IP) can spur investment in research and facilities in pursuit of the exploitation of biodiversity.		
		Tracking the financial impact of increased investment in Bioeconomic research and development	
		Emerging markets for waste products given the development of collection and utilization technologies.	

Figure 4.3. Roadmap layers and actions for Sustainable Use of Bioresources for short and medium to long term

Layers	Actions		
	Short-Term	Mid-Term	Long-Term
	2020	2025	2030
Knowledge Bases	The development of a huge diversity of technological solutions that are specifically focused on niche applications.		
	Identifying technological branches that directly impact the Sustainable management of Bioresources (sensors, data analytics, etc.) can focus R & I efforts.		
		Encouraging the development of cutting-edge procedures for optimising bio-waste collection and utilization processes can be achieved through various policy and funding incentives.	
Competences and Resources	Ensuring Brazilian and EU collaborators have access to the best available technologies and facilities to conduct their research in an effective and efficient manner.		
	Citizen input is a critical resource for ensuring successful research and collaboration in the Sustainable Use of Bioresources. Developing and maintaining channels for the involvement of civil society, and monitoring if and how those inputs are used, is essential to ongoing R & I strategic development.		
	Collaboration is more efficient, effective given a common foundational knowledge and training across participants. The development of a shared educational platform and curricula can facilitate more effective R & I.		
	Understanding essential commonalities and differences in research methods and protocols will foster more opportunities for collaboration.		
		Fostering diverse win-win partnerships and mutually beneficial collaborations across Brazil and EU stakeholders. Creating conditions through funding and policy for novel coalitions to form can generate new opportunities.	
	Creating and maintaining spaces and channels for the strengthening of social and professional relationships, will facilitate long-term, successful R & I collaboration.		

Figure 4.3. Roadmap layers and actions for Sustainable Use of Bioresources for short and medium to long term (cont.)

4.6 | Supporting Documents

INCOBRA (2017). Strategic Foresight Workshops Report (Deliverable D1.2 (WP1).

INCOBRA (2016). Co-Patent Report (Included in D1.2).

INCOBRA (2016) Open Consultation Results (Included in D 1.1).

INCOBRA (2016). Survey of Existing Foresight Studies (Included in D 1.1).

EC (2016). Implementation of the strategy for international cooperation in research and innovation {COM(2016) 657 final} and Accompanying Commission Staff Working document. Report from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions.

5 | Action Plan for Food Security and Adaptation of Agriculture to Climate Change

5.1 | Background and Focus

Food Security and Adaptation of Agriculture to Climate Change is a clear domain where both Brazil and the European Union show mutual interest, as these areas are considered priority areas for cooperation between Brazil and EU within the STI dialogue. Moreover, Brazil is a global producer and exporter of agricultural and food products[42]. It is ranked among the biggest producers of soybeans, corn, cattle beef, poultry, citrus, sugarcane, and eucalyptus, among others. It is also the country possessing the biggest ready-to-cultivate land area in the world, with more than 150 million hectares available without cutting down forests[43]. On the other hand, Brazil is also a major consumer of pesticides and other hazardous products, and agriculture is among the most polluting activities in this country, particularly for GHG emissions[44].

On the European side, Food Security and Adaptation of Agriculture to Climate Change is a major and long-term topic of interest whether headed to health and environmental safety or to strategic food supply and these has a pivotal place in both internal and external policies[45]. Food security and sustainable are among EU´s top development priorities for the coming years Common challenges faced by both Brazil and the EU in developing their research and development capabilities for Food Security and Adaptation of Agriculture to Climate Change include the development of technologies that enable the adaptation of crops to climate change, particularly to higher temperatures, and reducing environmental impacts of agri-food systems without compromising the long-term supply of food.

The outline in the development of the Roadmap focus on cooperation for mutual benefits among stakeholders related to Food Security and Adaptation of Agriculture to Climate Change. This Action Plan envisages a scenario in which policies and regulations combined with food chain sustainability lead to an Integrated Food System. The central aim of this scenario planning is to organize a structured framework able to build a forward look of possible futures, based on highly critical

42 Source: The World Bank Group. 2006 World Development Indicators. http://nationalaglawcenter.org/wp-content/uploads/assets/crs/RL33699.pdf
43 http://www.fao.org/ag/agp/agpc/doc/counprof/brazil/brazil.html
44 http://www.scidev.net/global/policy-brief/brazil-climate-change-a-country-profile.html
45 At the core of EU Development Policy is the investment in sustainable and inclusive agriculture and the development of supportive policies.

variables that will shape the future of the prioritized areas between Brazil and the European Union.

Analyzing the current Brazilian scenario, the growth, development and improvement of technologies through R&I cooperation may increase knowledge generation, which in turn drives market demands. This cooperation provides bilateral benefits for the stakeholders themselves, since investment reflects the results of the cooperation. It is possible to envisage that R&I cooperation will play for making Integrated Food Systems more sustainable, resilient, diverse and competitive. Research only cannot solve alone challenges of Food Security and Adaptation of Agriculture to Climate Change, strategic and multi-stakeholder approach are key ingredients to future reforms of Food Security and Adaptation of Agriculture to Climate Change.

5.2 | **Prioritized Items**

Based on the critical variables that comprise this Action Plan (Food Security and Adaptation of Agriculture to Climate Change), two specific dimensions were defined, taking the current Brazilian scenario as inspiration. Such dimensions were revealed based on experts' consultation, roundtable discussions with stakeholders in the field and secondary data provided by the referees (ex: reports, websites, academic documents, etc.). They strongly represent the current situation and dilemmas faced by the country. Yet, this dimensions could be applied to any country, especially those locate in developing areas, but not exclusively to them.

The ongoing growth on demand for agricultural products – specifically organic products and improvements in food nutrition – leads to effective raise in future development within this area. Changes on consumer behavior within the chain of Food Security and Adaptation of Agriculture to Climate Change are currently a trend which should be observed in both regions in future scenarios. The critical variables have been classified into the following two dimensions: **Food Chain Sustainability and Policies and Regulations.**

For Food Security and Adaptation of Agriculture to Climate Change the following aspects of a desirable EU/Brazil 2030 future are emphasized:

- A coordination between Brazil and the EU is in place;
- Brazil and EU are highly committed to a joint long-term research and innovation strategy aiming to increase Food Security and Adaptation of Agriculture to Climate Change;
- A partnership to increase resilience in agriculture is established between Brazil and EU;
- Food security is guaranteed to the population of both partners and actions are in place to prevent climate change hazards;
- The development of agriculture and related technologies provides jobs and economic development through trade among partners;

- Fictive news from 2030 "Europe and Brazil managed to reduce global hunger by expanding food production without compromising the environment. Demand for food products is guaranteed through integrated food systems".

5.3 | Concise Scneario

5.3.1 Objective

In order to create a more robust and resilient action plan, simplified alternative scenarios on Food Security and Adaptation of Agriculture to Climate Change were derived based on standard two-by-two scenario development methodology. Despite simple scenario models have their drawbacks, this method was deemed effective for the development of these Action Plans. These scenarios serve as a background for identifying promising opportunities for cooperation between Brazil and the EU - in regards to R&I. The scenario analysis allows us to identify those actions that are beneficial in several possible future situations.

5.3.2 Critical Variables

Below are the defined variables that make a critical difference for the possibilities of setting up strategic R&I cooperation for Food Security and Adaptation of Agriculture to Climate Change between Brazil and the EU. Critical variables were selected by multiple sources: Analyzing the material from the Strategic Foresight Workshop report (Deliverable 1.2), supporting documents, interviews and materials, and the detailed discussions that took place during group work at both SFW I&II. Through this analysis, we identified the following two critical variables:

- Food Chain Sustainability;
- Policies and regulations.

5.3.3 What is inside the Critical Variables

It is important to understand the priorities needed to achieve these critical variables and allow the development of R&I programmes.

VARIABLE 1: Food Chain Sustainability

Brazil and EU are large, continental sized with different food systems and productive realities. For achieving Food Chain Sustainability, technological and innovation, priorities should include:

- A sustainable strategic orientation from different stakeholders;
- Improving the supply and demand:

- Large companies can upright their production to ensure adequate supply and quality of the final product. Large scale production for global markets, compliance with sustainable production.
- Small decentralized producers, represented by family farmers. Production concentrated in local/regional markets. Potential for added value-niche products, short circuits. Terroir, authenticity, agro ecological and organics. Social and rural development.
- Product and process improvement, qualification and education for end-users and consumers of the food chains. Development of sustainable mindsets;
- Improving traceability and labelling regulation in the food supply chain: information about the origin, production methods, processes, environmental impacts, use of disruptive technologies, information flow, trust;
- Involving stakeholders within the same supply chain (producers, processors, distributors, consumers and outside stakeholders (institutions and research).

VARIABLE 2: Policies and Regulations

Policies are rules that are made by organizations, to achieve their aims and goals and regulations are made to make individuals, groups and organizations comply and behave in a certain manner. Priorities for R&I must acknowledge this dimension. In special:

- State policy for the development of real and long-term programs aiming for Food Security and Adaptation of Agriculture to Climate Change;
- Updates on local and national legislation;
- Strong support for investments in research and technological development (RTD);
- Transparency and consensus among all the actors in the chain;
- Concentrating efforts on conducting research on food security and sustainability enabling inclusive and efficient agricultural and food system.

Further on, the combination of such variables in quadrants will show different scenarios for Food Security and Adaptation of Agriculture to Climate Change. The scenario analysis is essential for better understanding our critical variables Food Security and Adaptation of Agriculture to Climate Change in the context of the proposed Action Plan. Therefore, by describing each scenario and identifying the conditions for characterizing quadrants we can foresee the influences and implications for R&I cooperation.

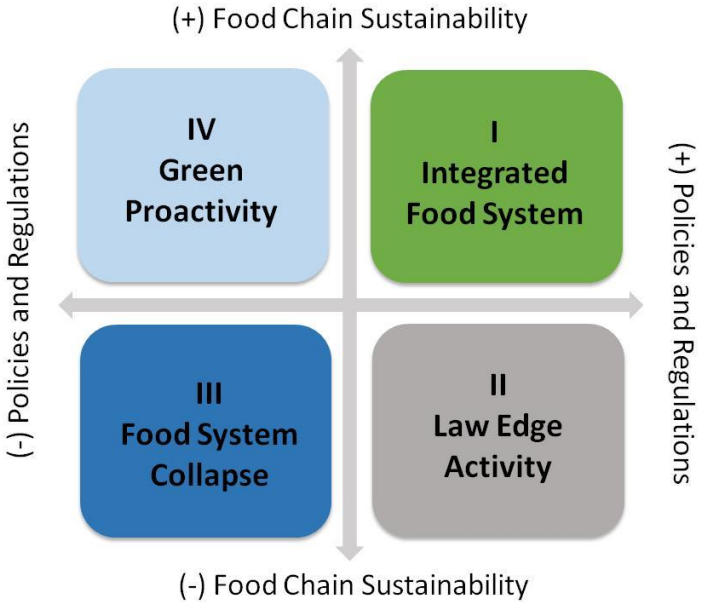


Figure 5.1: Crossing variables and scenario designation

Figure 5.1 presents the four scenarios based on previously defined Critical Variables: **Policies and Regulations**; and **Food Chain Sustainability**. With the two critical variables in mind, it is possible to create a justification for the scenarios mentioned on the previous topic prioritized items inside.

Scenario I: Integrated Food System

Figure 5.1 shows the ideal scenario, described by a favorable development of policies and regulations bounded to a food chain system concerned and committed with the economic, social and environmental sustainability. Here, some critical points for integrated food system are: *Higher quality and food security demands*, *new or updated sustainable agriculture system*, *precision agriculture* and *growing demand for sustainable products*:

- The food chain is mainly guided by the nutritional potential of the final product. Instead of consuming empty calories, consumers focus on good calories;

I - INTEGRATED FOOD SYSTEM

- Food chain guided by the nutritional potential final product.
- Adaptive research tailors solutions to particular agro-ecological solutions, productions systems, consumer demands and preferences, and socio economic circumstances;
- Governmental focus is efficient-oriented mitigating corruption, reducing bureaucracy, among others. Improvements in this area guide the development of a transparent food system.
- Multidimensional system including environmental, social, institutional and economical support and recognized by consumers.

- Qualification and development of dynamic capabilities for small suppliers, integrated into vertical food chains, clusters or local productive arrangements; Strategic research is in place to keep up with the emerging challenges. Adaptive research tailors solutions to particular agro-ecological solutions, productions systems, consumer demands and preferences, and socio economic circumstances;
- Governmental focus is on more efficient actions plans, mitigating corruption, reducing bureaucracy, among others. Improvements in this area guide the development of a transparent food system;
- Food sustainability is enriched with new significance, acquiring along the way even more dimensions (environmental, social, institutional and economic), with growing recognition on the part of consumers;
- This cultural change would be boosted by governmental incentives to increase organic farming and local "healthy" suppliers. Trust consumer education and raising public awareness is also crucial;
- This integration movement should be supported by available public research foundations, universities and research centers, who could educate and qualify local family farmers;
- Space for public-private partnerships, public policies focused on R&I and international collaboration, as the role of research becomes crucial to enable the most appropriate solutions to be identified.

Scenario II: Law Edge Activity

In this scenario, policies and regulations are effective, while the food chain develops a minimal activity effort to follow sustainable results. This scenario is positively influenced by the critical variables: *Higher quality and Food security demands* and negatively influenced by the critical variable *Low standardization of small producers*. Consequently, it is characterized by:

II- LAW EDGE ACTIVITY

- Producers follows the requirements of local policies and regulations with little or no stimulus for eco-innovations;
- Surveillance improvements pushes a sustainable behavior of both local farmers and large vertically integrated companies;
- Many small producers will run out of business, driving a new discussion about the social and economic impact of environmental policies and regulations.

- Producers guide their activities following the requirements of national policies and regulations. No stimulus for eco-innovations;
- The improvement of regulatory inspections encourages a sustainable behavior of both local farmers and large vertically integrated companies;
- Many small producers will run out of business, driving a new discussion about the social and economic impact of environmental policies and regulations.

Guidelines for actions regarding R&I cooperation within INCOBRA's framework could include:

- Foster the forming of lasting personal relationships through direct contacts between Brazil-EU research groups (e.g. shared summer schools on sustainable use of bio-resources, staff exchange, shared use of research infrastructures);
- Establish shared EU-Brazil project in sustainable food production systems;
- Campaign on a political level for EU-BR shared R&I policy for developing and financing projects.

Scenario III: Food System Collapse

This scenario "food system collapse" represents an environment that lacks not only a strong effort from government towards policies and regulations, but also a lack of sustainable culture among food chain members. According to Figure 5.1, this is the most negative scenario, influenced mainly by the critical variables *Bureaucracy*, *Restricted funding for research and innovation (R&I)*, *Few governmental initiatives (active delay)* and *Corruption*.

III FOOD SYSTEM COLLAPSE

- Weak food chain with small producers dissociated from the top issues on global food production
- Absence of policies and regulations towards sustainable food chains not leading to environmental preservation.
- Fraud and lack of transparency leads to opportunistic behavior and lack of integration among food chain agents and stakeholders;
- Quality products not available to most consumers, bringing negative effects on nutritional diet.

The main characteristics of this scenario are:

- There is a weak food chain, where small producers are dissociated from the main discussions on global food production and only focused at their own production and local problems, without broader concerns for environmental issues and climate change impacts;
- The absence of policies and regulations towards sustainable food chains ended up into reduced environmental preservation. Fraud and lack of transparency. Opportunistic behavior, lack of integration among the food chain agents and stakeholders;
- Consumers do not have quality products available, bringing negative effects on nutritional diet.

Guidelines for actions regarding R&I cooperation within INCOBRA's vision could include:

- Foster Brazil-EU cooperation towards Food Security and Adaptation of Agriculture to Climate Change within a global framework and looking for international agency cooperation;
- Identify benchmarks and fund eco-innovative projects to act as role models for entrepreneurs;

- Mobilize coalitions of pioneers from civil society, industry and research community willing to invest into a sustainable pathway in spite of the unfavorable scenario.
- Mobilize coalitions of pioneers from civil society, industry and research community willing to invest into a sustainable pathway in spite of the unfavorable scenario.

Scenario IV: Green Proactivity

This scenario reflects a situation in which policies and regulations are weak, but at the same time the food chain seeks quality development and international markets. On the one hand, it is mostly influenced by the critical points *Bureaucracy* and *Corruption*. Governmental support is scarce and almost impossible to achieve. On the other hand, the food chain sustainability would present a positive perspective, where the influential critical points are: *Higher quality and food security demand*, *growing demand for sustainable products* and *New or updated sustainable agriculture system*:

IV - GREEN PROACTIVITY

- First movers are prominent and seek potential high quality standards markets to establish more robust practices than local demands;
- Open scenario for entrepreneurs and big companies looking forward to expand activities;
- Research plays a important role in exploring niches of new exploitation.

- First movers are prominent. They seek potential markets that have higher quality standards, establishing more rigorous practices than the ones demanded by local legislators;
- Open scenario for entrepreneurs and big companies which are looking for possibilities for the expansion of their activities;
- Research plays a role in exploring niches of new exploitation.

Guidelines for actions regarding R&I cooperation within INCOBRA's vision could include:

- Stimulate the creation of startups and foster entrepreneurship initiatives;
- Mobility between researchers between BR and EU, aiming for brainstorming and shared founded projects;
- Help in the establishment of a quality and green mindset, where standards should be higher and consumers should increase their awareness towards production systems.

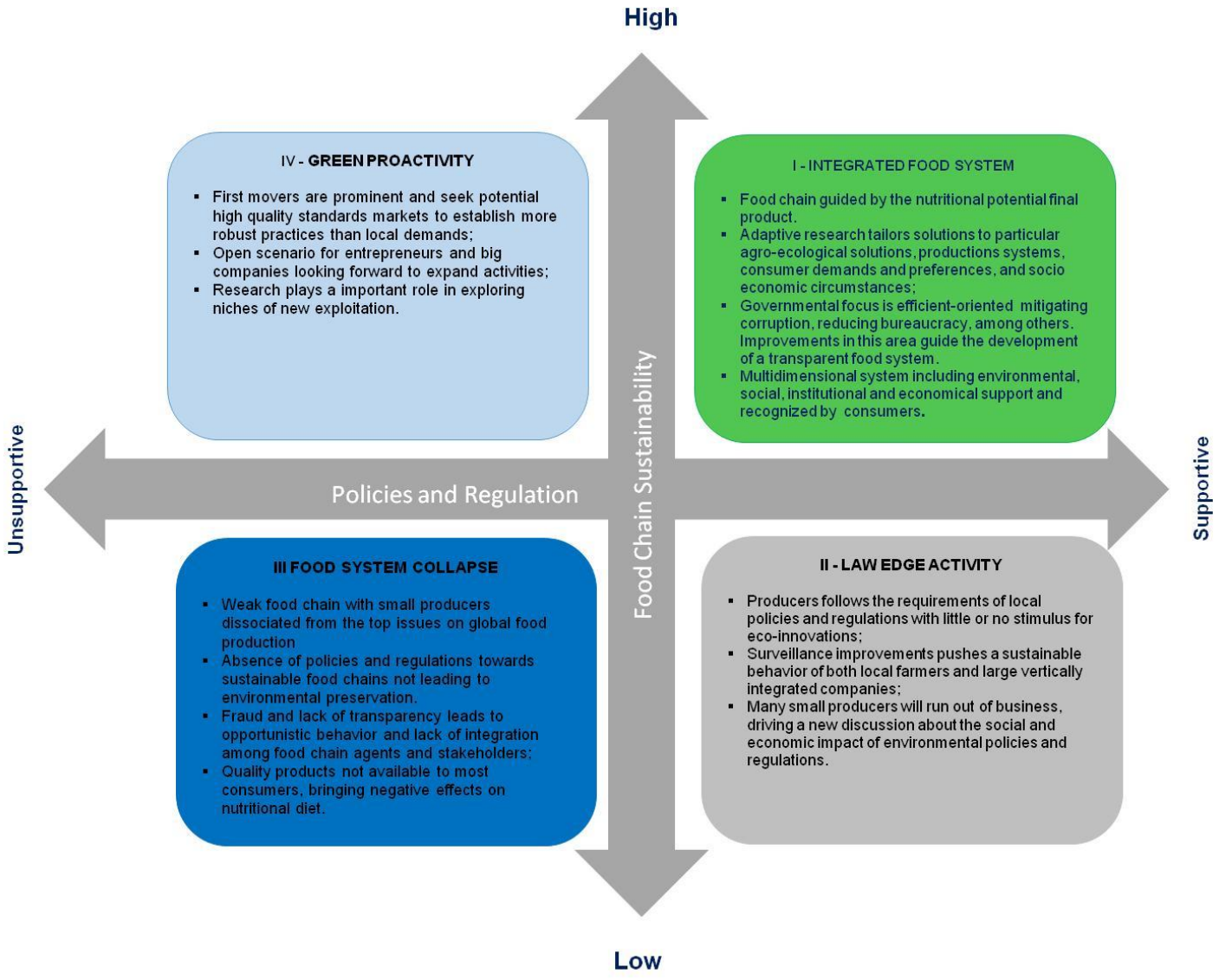


Figure 5.2. Scenarios overview based on scenarios descriptions

By analyzing the main trends over knowledge-based development, two priority areas emerged as mainstreams (Figure 5.3). The first related to GLOBAL FOOD SUPPLY and encompasses the main challenges on food production and supply. The second is ADAPTATION TO CLIMATE CHANGE and can be described as the main issues facing global warming and sustainability. Researchers and experts consulted, as well workshops held in Brazil and EU for this Action Plan, agreed that these two interrelated clusters compose the main trends in Food Security and Adaptation of Agriculture to Climate Change.

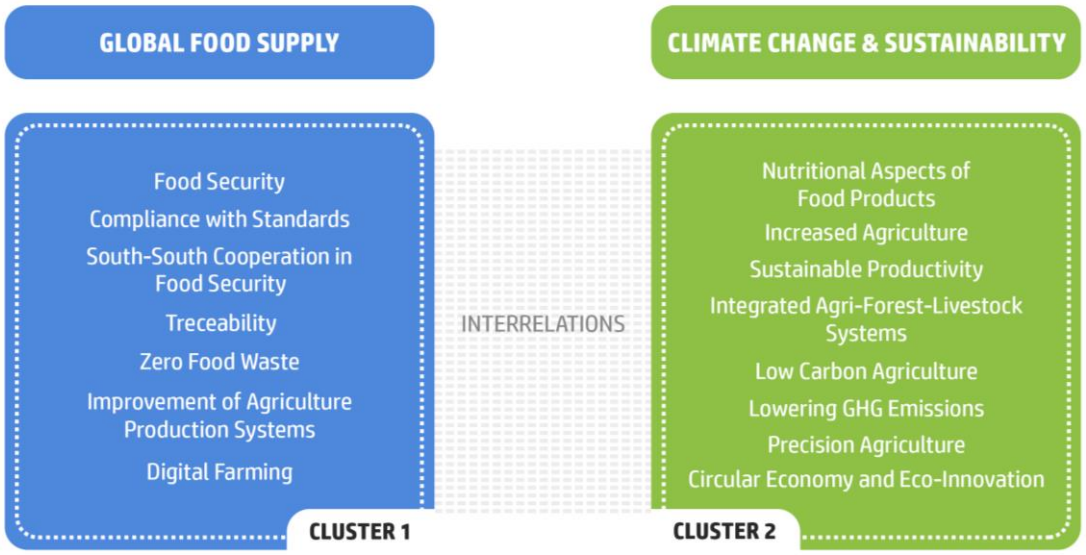


Figure 5.3: Mainstream priority areas within Food Security and Adaptation of Agriculture to Climate Change.

Our results are aligned with FAO[46], that highlight that high-input, resource-intensive farming systems, which have caused massive deforestation, water scarcities, soil depletion and high levels of greenhouse gas emissions, cannot deliver sustainable food and agricultural production. Innovative and integrative systems are needed, aiming to protect and enhance the natural resource base, while increasing productivity. Transformative process towards "holistic" approaches, such as agroecology, agro-forestry, climate-smart agriculture and conservation agriculture, which also build upon indigenous and traditional knowledge must be stimulated all over the world. Technological improvements, along with drastic cuts in economy-wide and agricultural fossil fuel use, would help address climate change and the intensification of natural hazards, which affect all ecosystems and every aspect of human life. For FAO, greater international collaboration is needed to help tackle those challenges.

[46] http://www.fao.org/publications/fofa/en/

Clearly, EU-Brazil cooperation has deepened and widened, now covering a range of issues far beyond the scope of the initial 1992 agreement.[47] R&I cooperation between Brazil and the EU is strategic. It can not only improve market accessibility from both sides for products and services, but also stimulate other countries to move towards Integrated Food Systems, enabling Food Security and Adaptation of Agriculture to Climate Change for the benefit of present and future generations.

5.4 | **Robust Trajectories**

As described, Brazil and the European Union face common challenges in developing their research and development capabilities for Food Security and Adaptation of Agriculture to Climate Change. However, while S&T development are in similar stages of development in BR and EU, the application of these technologies are still jeopardized in Brazil. The low educational level of Brazilian farmers, adding to the usual gap between knowledge developers and technology appliers, end up restraining the use of new technologies in the field. Consequently, while in EU is moving towards sustainable agriculture, as the European Commission and the European Parliament had highlighted the need to preserve the EU's food production potential, "so as to guarantee long-term food security for European citizens"[48]. In the case of the Brazilian scenario, aspects related to regulation, regulatory inspections and corruption are major sources of concern. Brazil is also a giant in commodity production, yet sustainable food production is still embryonic, with great potential to develop. Figure 5.4 provides an overview of the four scenarios which, in the following sections will be explored.

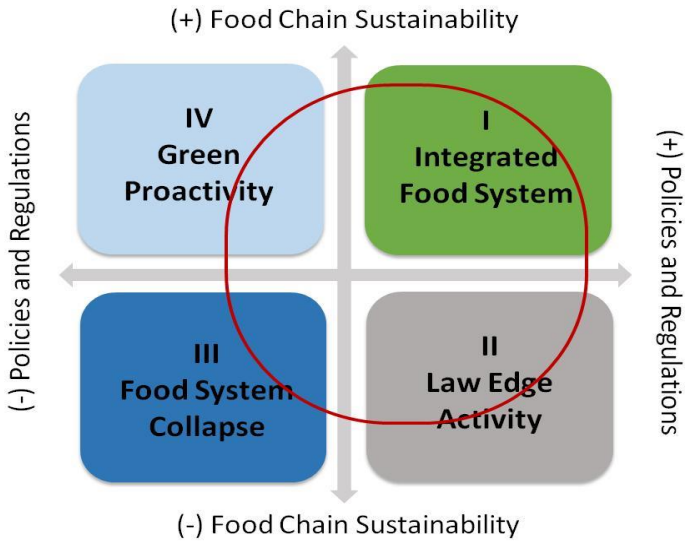


Figure 5.4: Area for Robust Trajectories

[47] https://ghum.kuleuven.be/ggs/events/2012/05_2012/eubrazilconferencereportfinalv-1.pdf
[48] http://www.reformthecap.eu/sites/default/files/Food%20Security%20Zahrnt.pdf

Figure 5.4 shows the mix of scenarios of Food Security and Adaptation of Agriculture to Climate Change. Through to red circle it can be noticed the present global situation for both parties (the EU and BR).

The Integrated Food System scenario is the most likely one to emulate the nearest future, even though is not yet clear.

Our Action Plan is ambitious, as current R&I policies in Brazil lack a holistic food system approach and are scattered across different sectors and stakeholders, with weak coherence and coordination across our priorities. We hope INCOBRA can contribute to change this reality. Suggestions to facilitate assertive cooperation in any of the four selected scenarios:

1. **Use of interdisciplinary or transdisciplinary teams**

This is absolutely crucial to deal with the challenges of future agro 4.0. Knowledge creation and sharing, development of new skills and use of digital platforms to communicate.

2. **Stimulate transformative and systemic projects to satisfy consumers' needs**

Traditional models have proven to be incomplete and obsolete to face growing population and the need to support food (with nutritional and sustainable attributes) for future generations. Projects combining people, profit and planet need to be in the agenda.

3. **Develop collaborative networks to strengthen learning and strategic goals**

Involve stakeholders within the same supply chain (producers, processors, distributors, consumers) and other external members (institutions and research). It is not only a single agent way of thinking or acting. Members from all the links of the supply chain need to be involved and committed to guarantee the change towards more green and integrated food systems.

4. **Different agricultural models**

Assurance of the coexistence of different agricultural models, including small-scale agriculture, which is suitable for the creation of jobs in the rural areas, ecological agriculture and sustainable agriculture, but also large scale operations, driven by eco-innovations.

5. **Creation of a new food-quality policy**

Creation of a new food-quality policy, which will have a significant impact on sustainable and competitive European and Brazilian agriculture. For instance, the development of labelling and quality assurance schemes can guarantee quality and safety for different food productions systems and consumers must be educated to recognize such cues. Governments need to provide technical and financial support for eco-innovative solutions and organizations.

6. **Use of different tools and co-creation methods at some stage of the research/production process**

The trajectory towards integrated food systems would much benefit from including citizens and consumers and other agents in the R&I process, as legitimacy is improved. Transparency is fundamental for cooperation. For instance, to organize proposals as multi-actor approaches including practice partners such as industry and retail, government representatives and community members, as well as consumer and environmental organizations and NGO.

7. **Monitor efficient supply chains and benchmark best technological practices**

Softwares can provide Supply Chain Event Monitoring, enabling the transformation of a supply chain into a real-time adaptive network that optimizes productivity and efficiency by proactively notifying key agents when operational or system-related events occur across the supply chain. Apply precision tools and systems to increase resilience and manage risks. In terms of benchmarking, the EU uses the concept of ‘Best available techniques’ (BAT), which are the best for preventing or minimizing emissions and impacts on the environment. Techniques include both the technology used and the way installations are designed, built, maintained, operated and decommissioned. For installing an intensive farm, for instance, EU producers need to follow specific BATs. Knowledge is therefore shared within different EU industrial sectors. 1) Stimulate the development of Observatories 2) Create and share Books of Knowledge.

8. **Monitor and benchmark for financial support for Food Security and Adpatation of Agriculture to Climate Changes**

Establish governance and strong institutional and financial support to tackle food security and adaptation to climate change, continuously, and guided by science. Public policies and regulations aiming to facilitate the achievement of objectives and

targets, reducing bureaucracy and increasing accessibility for small and medium food enterprises.

Based on scenarios and critical issues raised up to this moment, the robust trajectories which better represent the path Brazil and EU should follow to foster R&I collaborative projects and actions are now presented (Table 4.1).

Table 5.1. Robust Trajectories and Actions for Food Security and Adaptation to Climate Changes for short and mid to long-term

Trajectory	Actions		
	Short-term	Mid-term	Long-term
	2020	2025	2030
1. Use of interdisciplinary or transdisciplinary teams	Promoting human resources and people management facing the challenges of a growing multidimensional food chain.		
2. Transformative and Systemic Projects	Strengthening relations between EU-BRAZIL to promote ways of adaptation and improvement of technology, information systems and communications.	Developing common research agendas to incorporate technology agro 4.0 (future trends) and big data to the emerging integrated food systems.	
3. Develop Collaborative Networks to Strengthen Learning and Strategic Goals	Establishing a Committee of Stakeholders as R&I actors' representatives to put forward Food Security and adaptation of Agriculture to Climate Change cooperation projects.		
	Calling for projects aligned to strategic stakeholders, both private and public agents, and a growing niche connected to customer´s demand for sustainable and nutritional valuable products.		
4. Different Agricultural Models	Observatory for innovative trends in Food Security and adaptation of Agriculture to Climate Change.		
	Developing strategic policies to allow public procurement of food products coming from sustainable agriculture and with guaranteed nutritional value.		
5. Food Quality Policies	Designing a Monitoring and Evaluation System (M&E) for policies and regulations in Food Security and Adaptation of Agriculture to Climate Change in cooperation EU-BRAZIL for an efficient implementation of estimated targets and Objectives.		
	Interconnecting research activities with development of new products and services taking into consideration a multidimensional view including customers, producers, service providers, organizations, etc.		
	Calling for projects aligned to strategic stakeholders, both private and public agents, and a growing niche connected to customer´s demand for sustainable and nutritional valuable products.		
6. Use of Different Tools and Co-Creation Methods	Promoting public-private partnership to develop strategies to support consumer demand for sustainable products.	Promoting along with EU-BRAZIL R&I partners market development through homogenization of quality products aligned with sustainable agriculture. Benchmarking high standard levels.	

Table 5.1. Robust Trajectories and Actions for Food Security and Adaptation to Climate Changes for short and mid to long-term (cont.)

Trajectory	Actions		
	Short-term	Mid-term	Long-term
	2020	2025	2030
7. Monitor and Benchmark	Bilateral Brazil/EU commitment to long-range technology transfer sharing and funding; Stimulating the development of Observatories; Creating and sharing Books of Knowledge.		
8. Governance, Institutional and Financial Support	Foster EU-BR pioneering coalitions and developing ongoing agreements between Brazilian and European companies in Food Security and Adaptation of Agriculture to Climate Change.		
	Promoting a joint Committee of R&I projects (with members from EU and BR) in order to proactively act towards pro Food Security and Adaptation of Agriculture to Climate Change research policies.		
	Establishing a strong legal framework to support innovations that can foster Food Security and Adaptation of Agriculture to Climate Change.		

In order to achieve the Integrated Food Systems scenario, some conditions are not only desired, but mandatory. Food systems are quite complex and a way to tackle such challenge is to breakdown the Action Plans into manageable parts. In this regard, the layers that will guide our framework for the roadmaps are Regulation and Policies, Market, Knowledge-based and Competences and Resources.

5.5 | **Components of a Roadmap**

We built our roadmap based on four different layers (Regulations and policies, Markets, Knowledge Bases and Competences and Resources), each one composed by its own explaining variables. We analyzed the conditions for achieving our desired scenario, taking into account Technology Readiness Level.

Specific R&I collaborative projects can promote multidisciplinary and integrated approaches and improve the impact of innovation for Food Safety and Sustainable Agriculture. Those will be next presented. A schematic representation of the proposed roadmap is in Figure 5 so that to achieve Food Security and Adaptation of Agriculture to Climate Change through and Integrated Food System.

Regulations and Policies

This layer refers to public-private agents initiatives as governance facilitators for the achievement of the Grand Vision in regards to managing the sustainable growth of an Integrated Food System.

Concentrating efforts on conducting researches on food security and adaptation of agriculture on climate change should enable inclusive and efficient agricultural and food system. The existence of a strong coordination between private and public for a regulatory framework can support the extent of such impacts and bolster the development of sustainable practices and technologies.

Understanding the long-term impacts will bring transparency and consensus among all agents is a substantial achievement for an Integrated Food System taking care of food security and climate change. This joint commitment should raise support for investments in research and technological development (RTD) and establish high standards for an integrated food system.

Market

Markets are absolutely necessary to achieve Integrated Food Systems, since consumers and the overall economic status of societies are the driving motors for development and further innovation. **Quality products and sustainable agriculture** are yet only part of that reality in Brazil. The market is still very heterogeneous, but in the medium run the forecast is that social media and global communication platforms can boost benchmarking and evolution. *Collaborative projects aiming to educate*

consumers and increase information access would be advisable (traceability, for instance).

In the same trajectory, the demand for **sustainable products** is small. Green products supply a niche market nowadays, but in the short/medium run we expect this to grow. Take for instance the example of green energy in Brazil, where records on Eolic energy are achieved every month. The same applies to organic production. For instance, data from the Brazilian Ministry of Agriculture (2017)[49] indicated that the number of organic production units tripled from 2013 to 2016, growing from 6.700 mil to 15.700. In 2017, 750.000 hectares are being used for organic production, and the system is present in 22.5% of the cities. *Collaborative R&I projects could involve the development of Intelligence Centers to gather and share information – for producers and consumers. Consumers need to be informed about the benefits of a healthy diet: for themselves and the planet. Other projects could empower and engage communities, civil society and consumers in sustainable food systems (ex: Smart cities and urban agriculture, food waste initiatives, etc.)*.

Finally, economy is the thermometer of development. If the country faces an economic crisis, business players and societies retreat. Yet, the medium-long run perspective is positive and there is a need to boost the Integrated Food Systems. From an EU perspective, it is crucial to guarantee quality food supply and stimulate the development of third countries on a global scale. *Collaborative projects might involve, for instance, the offering of grants and training for researchers, students and future farmers, in key-areas, such as circular economy, eco-innovation, food safety, etc.*

The European Union has in its tradition developed strong policies and initiatives in the field of food security and sustainability. Currently, as a matter of fact, the main objective of the Common Agricultural Policy (PAC) is not only providing enough food, but also the high-quality food produced in a sustainable way and in accordance with the requirements in the fields of environmental protection, water resources, the health and well-being of animals, the health of plants and public health, which simultaneously guarantee stable agricultural incomes.

Moreover, The Common Agricultural Policy, having in mind 2020 horizon, is been directed towards raising the competitiveness of European agriculture and the guarantee of food security, simultaneously promoting high-quality food products, environmental protection and the development of rural areas.

[49] http://www.mda.gov.br/sitemda/noticias/mais-org%C3%A2nicos-na-mesa-do-brasileiro-em-2017

Indeed, according to several analysis[50], the pursuit of higher quality constitutes an important element of the strategy of the agriculture and food sector of the EU on the global market, in order to maintain the high level of competitiveness.

Knowledge Bases

For planning, producing and consuming you need people, but you certainly need infra-structure and machinery to achieve an ideal Integrated Food System. Today, many farmers, SMEs and even larger companies need to adapt foreign technologies to our productive reality. *Platforms to accelerate the development of joint investment/technological projects by encouraging and supporting interregional/international cooperation could be developed (Ex: ferti-irrigation, precision agriculture, bio-economy, and food technology).*

Finally, in the era of the internet-of-things, apps and mobile solutions, the development and implementation of **software**, cloud-based services and world-class data infrastructures to ensure science, business and public services urges in Brazil. The benefits of the "big data" revolution for Food Security and Adaptation of Agriculture to Climate Change are yet to be discovered and explored. *Collaboration in this area is absolutely crucial.*

Competences and Resources

The development of **public-private partnerships** is still timid and incipient in Brazil. Bureaucracy and lack of expertise are the main barriers. While the EU has a vast experience in this field. Take for instance the successive Framework Programs, the amount of resources involved and the massive network created, bringing such positive outcomes for the European society as whole. Numerous established capacity building pan European R&I networks were created, bringing together governments, science, industry and other stakeholders to exploit new and emerging research opportunities. *Workshops to stimulate information exchange and benchmarking with EU Excellence Programs could be a strategic action.*

As capability represents the intersection of capacity and ability, projects that have the goal to train **human resources** and deal with management of people are crucial for the development of our ideal scenario. A path leading to this broad holistic and systematic view should be pursued. *One could envisage projects aiming to qualify producers towards better production practices (ex: the development of a Book of Knowledge – BoK – containing information about the legislation, best practices, etc.), for example. Knowledge transfers, especially for farmers and SMEs.*

Financing is almost inexistent in the current Brazilian economic situation. Yet, absolutely necessary for stimulating new business models, eco-innovations and

[50] http://ageconsearch.umn.edu/bitstream/143167/2/10%20EP%204%202012-11.pdf

circular economy. In a short run, it can be expected the country to recover, opening new windows for growth of Integrated Food Systems in the future. Agribusiness is the driving force of Brazilian economy. *Here, we suggest EU to keep collaboration with Brazil for Food 2030 projects. Currently, the scope of direct scientific interactions carried out by the European Commission's Joint Research Centre with partners in Brazil include the areas of disaster prevention and crisis management; sustainable management of natural resources; energy with a focus on smart grids; food security; bio-economy; Information and Communication Technologies (ICT), including geo-information and space applications; nanotechnologies. We suggest to keep focusing on those areas and include some for specific Calls, as presented in our cluster's definition.*

The Figure 5.5 shows the Actions distributed in this four layers of de roadmap.

Layers	Actions		
	Short-term	Mid-Term	Long-Term
	2020	2025	2030
Regulation and Policies		Promoting a joint Committee of R&I projects (with members from EU and BR) in order to proactively act towards pro Food Security and Adaptation of Agriculture to Climate Change research policies.	
	Designing a Monitoring and Evaluation System (M&E) for policies and regulations in Food Security and Adaptation of Agriculture to Climate Change in cooperation EU-BRAZIL for an efficient implementation of estimated targets and Objectives.		
	Establishing a strong legal framework to support innovations that can foster Food Security and Adaptation of Agriculture to Climate Change.		Developing strategic policies to allow public procurement of food products coming from sustainable agriculture and with guaranteed nutritional value.
Market	Promoting along with EU-BRAZIL R&I partners market development through homogenization of quality products aligned with sustainable agriculture. Benchmarking high standard levels.	Improving the quality of products in a sustainable and integrated food chain.	
	Establishing a Committee of Stakeholders as R&I actors' representatives to put forward Food Security and adaptation of Agriculture to Climate Change cooperation projects.		
	Interconnecting research activities with development of new products and services taking into consideration a multidimensional view including customers, producers, service providers, organizations, etc.		
	Foster EU-BR pioneering coalitions and developing ongoing agreements between Brazilian and European companies in Food Security and Adaptation of Agriculture to Climate Change.		
Competences and Resources	Developing a Monitoring System for long term financial sources in Food Security and adaptation of Agriculture to Climate Change.		
	Promoting public-private partnership to develop strategies to support consumer demand for sustainable products.	Calling for projects aligned to strategic stakeholders, both private and public agents, and a growing niche connected to customer´s demand for sustainable and nutritional valuable products.	
	Developing a Monitoring System for long term competences and training in Food Security and adaptation of Agriculture to Climate Change		
		Promoting human resources and people management facing the challenges of a growing multidimensional food chain.	Maintaining investments in lower TRL projects in order to continuously build resources and competences for medium and long-term R&I cooperation in Food Security and Adaptation of Agriculture to Climate Change.
Knowledge Based	Observatory for innovative trends in Food Security and adaptation of Agriculture to Climate Change.		
	Developing a Monitoring System for long term competences and resources capabilities in Food Security and adaptation of Agriculture to Climate Change.		
	Bilateral Brazil/EU commitment to long-range technology transfer sharing and funding; Stimulating the development of Observatories; Creating and sharing Books of Knowledge.		
	Strengthening relations between EU-BRAZIL to promote ways of adaptation and improvement of technology, information systems and communications.	Developing common research agendas to incorporate technology agro 4.0 (future trends) and big data to the emerging integrated food systems.	

Figure 5.5. Roadmap for Food Security and Adaptation to Climate Changes: actions versus layers for short and medium to long-term

Additional Comments

Clearly, EU-Brazil cooperation has deepened and widened, now covering a range of issues far beyond the scope of the initial 1992 agreement.51 R&I cooperation between Brazil and the EU is strategic. It cannot only improve market accessibility from both sides for products and services, but also stimulate other countries to move towards Integrated Food Systems, enabling Food Security and Adaptation of Agriculture to Climate Change for the benefit of present and future generations.

Whether on the sea, the land, or in the factory, the actors responsible for our food systems are also the largest group of natural resource managers in the world and thus critical agents of change in any transformation of current consumption and production systems. This complexity and diversity of responsibility is one of the major challenges to the future-proofing of our food systems.

Our Action Plan is ambitious, as current R&I policies in Brazil lack a holistic food system approach and are scattered across different sectors and stakeholders, with weak coherence and coordination across our priorities. We hope INCOBRA can contribute to change this reality.

[51] https://ghum.kuleuven.be/ggs/events/2012/05_2012/eubrazilconferencereportfinalv-1.pdf

6 | Action Plan for Advanced Manufacturing and Nanomaterial

6.1 | Background and Focus

Advanced manufacturing, understood as the use of innovative technologies and methodologies to improve products or processes or to develop new ones while improving the resource efficiency and competitiveness in the manufacturing sector, is a priority research area for both the EU and Brazil,[52] due to its huge potential to generate wealth, to create high-quality jobs and to address global societal challenges. In fact, the Europe 2020 strategy underlines its critical role in making key enabling technologies (KETs) and new products competitive, affordable and accessible, multiplying their societal and economic benefits. Consequently, the launching of dedicated calls for proposals in the areas of LEIT-Nanotechnologies, Advanced Materials, Advanced Manufacturing and Processing have been announced in the EU Work Programme 2018-2020[53]. Moreover, the Brazilian Government put together in 2015 a Task-Force that established a set of short, medium and long term actions, which culminated with the announcement of an Advanced Manufacturing National Policy for the second half of 2017[54].

During the first INCOBRA Strategic Foresight Workshop held in Campinas Nanomaterials and their industrial applications was identified as a priority cross-cutting topic common to most research and innovation fields within the focus area of Nanoscience and Nanotechnology, including Environment & Energy, Nanobiotechnology, Pharmaceuticals, Electronics, Agriculture & Food Security, among others. The importance of safety regulations in relation to nanoscale materials and products was also stressed by the experts. A subsequent co-publication analysis, aimed to determine the evolution and current state of EU-BR joint publications indexed in the Web of Science (WoS) on the prioritized research topics identified in the SFW I, showed a significant increase in the publication rate from 2012 onwards and revealed that nanomaterials for Electronics was the topic where the Brazil-EU has been more productive, followed by Nanobiotechnology, Pharmaceuticals and Energy & Environment, in good agreement with the opinion expressed by the experts. To corroborate the results of the first workshop, Advanced Manufacturing and Nanomaterials were unanimously chosen as

52 European Commission. Priorities for international cooperation in research and innovation. {COM(2016) 657 final}. 13/10/2016.
53 European Commission. Factories of the Future. Multi-annual roadmap for the contractual PPP under Horizon 2020, 2013, doi: 10.2777/29815; European Commission. Work Programme 2018-2020. Nanotechnologies, Advanced Materials, Biotechnology and Advanced Manufacturing and Processing, v3.6, 31/05/2017.
54 Brasil Governo Federal. Perspectives of Brazilian specialists over Advanced Manufacturing in Brazil. Brasília, Nov 2016.

essential topics for the cooperation between Brazil and the EU by the participants of the second Strategic Foresight Workshop held in Frankfurt.

6.2 | Prioritized Items

The focus research and innovation area on Advanced Manufacturing and Nanomaterials integrates the following key aspects, all of which were highly prioritized by participants in both workshops:

- Strategic nanomaterials for applications in (i) energy and environment, (ii) consumer and security electronics, (iii) biotechnology, (iv) health and pharmaceutics, (v) agriculture and food security and (iv) textiles;
- Advanced manufacturing of innovative nanoscale materials, sensors and devices;
- Nanoscale metrology;
- Toxicity of nanomaterials, specific to each application field.

Inside the INCOBRA vision, a simple, transparent, and trust based project governance allows for the orchestration of work teams.

- Governance instruments and actors are synchronized, harmonized, and aligned to complement each other;
- On both sides there is a long-term commitment to funding policies;
- Diverse partners interact like an open and flexible research and innovation network;
- There is a clear and stable framework for cooperation that guides the research agenda while accommodating creativity and original ideas in a flexible manner.

For the particular area of Advanced Manufacturing and Nanomaterials the following aspects of a desirable EU/Brazil 2030 future were stressed:

- A coordinated strategy between Brazil and the EU for Advanced Manufacturing and Nanomaterials is well established
- A long-term commitment to support R&I in Nanomaterials is reached by Brazil and the EU
- A network of infrastructures with state-of-the-art facilities, open to academia and industrial stakeholders, enables the joint development of emerging nanomaterials and the training of young technologists in advanced nanofabrication with contribution from both Brazil and the EU
- Successful technology transfer models for the advanced manufacturing of nanomaterials are implemented through the joint efforts of Brazil and the EU
- Advanced Manufacturing jobs increase overall employment opportunities

both in Brazil and the EU
- Protection of intellectual and industrial property of new nanomaterials and advanced fabrication processes is properly addressed through the joint cooperation of Brazil and the EU
- Timely production and commercialization of high value nanomaterials-based technologies at competitive and affordable prices achieved by BR/EU spin-off companies
- Fictive news from 2030 "*A Flying Automated People Mover Made Real: A network of Brazilian and European research institutions and industries announced the first "FAPM" at the last INCOBRA meeting in Vienna. This highly innovative product takes advantage of advanced manufacturing techniques, based on modular and reconfigurable components that can be customized by the end user. The production process is zero-waste, and environmentally friendly. This is due to the digitalization of manufacturing and production. This new technology will alleviate mobility problems in big cities as Sao Paulo or Madrid. People with special needs will benefit from this advanced technology."*

6.3 | **Concise Scenarios**

6.3.1 Objective

In this section we describe alternative scenarios on the implementation of an advanced manufacturing of high-value products, such as nanomaterials, derived from a standard two-by-two scenario development methodology. These scenarios will then serve as a basis for the subsequent definition of an action plan with robust trajectories that enable an effective and successful R&I cooperation between Brazil and the EU in this particular area. Our starting point was the evaluation of the present situation of the principal aspects that may pose a challenge for the realization of a sustainable advanced manufacturing, particularly those related to human and financial resources, R&I infrastructures, regulations and technology, which then allowed us to propose four possible situations that could arise in the future, once the most critical variables were identified. Analysis of the four scenarios then allowed us to propose actions to be taken to achieve an advanced manufacturing that enables not only the turning of R&I achievements into high-value products, but also cost-effective, resource-efficient and timely production and commercialization.

6.3.2 Critical Variables

As mentioned above, the identification of two critical variables is necessary in order to define the different scenarios that could arise in the R&I cooperation of Brazil and the EU in Advanced Manufacturing and Nanomaterials. Our decision

was based on the information gathered in the Strategic Foresight Workshop Report (Deliverable 1.2) and the discussions held by experts during SFW I and II as well as supporting documents containing the vision of policy makers and industrial stakeholders on Advanced Manufacturing and Nanomaterials from both Brazil and the EU, following these three criteria:

- The intensity and frequency with which the variable came up during the workshops, particularly during the debates about prioritization.
- The pervasiveness of the variable to define the future of the priority topic.
- The degree of impact the variable may have on the practicability of R&I cooperation.

Accordingly, the two critical variables chosen for Advanced Manufacturing and Nanomaterials are:

> Variable 1: Joint public and private investment in advanced manufacturing and nanomaterials R&I
>
> Variable 2: Evolution of EU/Brazil joint policies and regulations relative to advanced manufacturing and nanomaterials

6.3.3 What is inside the Variables?

VARIABLE 1:

Joint public and private investment in R&I on advanced manufacturing and nanomaterials

For advanced manufacturing to contribute significantly to the realization of grand societal challenges it is essential to have a joint government-industry investment in cross-disciplinary manufacture-related R&I programs.[2,3] Moreover, the creation of public-private partnerships for the timely deployment of new technologies in the EU and Brazil is of maximum importance. Joint collaboration can take place in Open Innovation Hubs, which bring materials facilities within reach of companies and facilitate pilot experiments and technology transfer by moving from a *laboratory tested* to an *industrially proven* status. They can also play a fundamental role in training the engineers, doctorates and technicians in the STEM disciplines required in advanced manufacturing jobs[55].

[55]Technology Hubs. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Federal Republic of Germany, 2013; Advanced Manufacturing Plan. Dow Brazil, The Dow Chemical Company, May 2014.; Technology roadmap, SMART-Advanced manufacturing program, Spain, January 2017.

VARIABLE 2:

Evolution of EU/Brazil joint policies and regulations relative to advanced manufacturing and nanomaterials

This variable addresses the effect that public policies have on the manufacturing system by setting the rules on labor laws specific to advanced manufacturing, taxes on technology equipment, software, etc, educational policies, fiscal incentives for companies investing in nanomaterials and advanced manufacturing-related R&D or protection of the intellectual property. It also includes Brazil-EU collaboration in nanosafety issues; Although much progress has been achieved through joint research relative to the safety of nanomaterials and the transfer of this knowledge into regulations, further measures need to be taken as nanotechnology reaches the market. At this point, Brazil-EU joint cooperation to build a database for risk assessment, hazard and exposure, human health and environment and risk mitigation, including all regulatory aspects would be most beneficial for society[56].

Figure 6.1 depicts the four scenarios proposed by intercrossing of the two critical variables. Description of these scenarios and the implications for the Brazil-EU collaboration in advanced manufacturing- and nanomaterials-related R&I can be found in the following section.

[56]CEO Policy recommendations for emerging economy nations: Brazil, http://reports.weforum.org/manufacturing-growth/brazil/; Analysis of Science, Technology and Innovation opportunities in Nanotechnologies in Brazil for Dutch institutes and companies. NanoBusiness Informação e Inovação Ltda, November 2016.

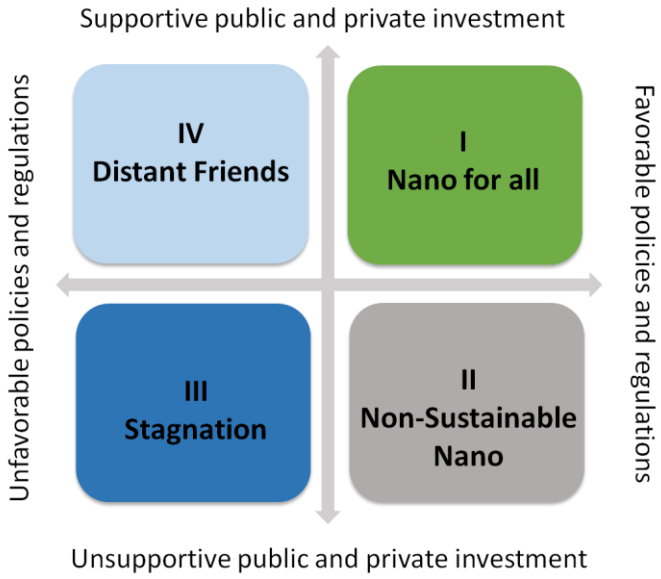
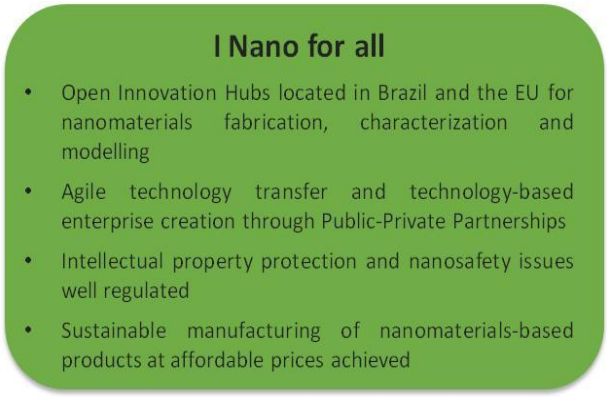


Figure 6.1: Crossing variables and scenario designation

Scenario I: Nano for all



As shown in Figure 6.1, this scenario corresponds to a situation in which Brazil and EU policy makers and industry jointly decide to booster Advance Manufacturing as a pathway to increase competitiveness, supporting the creation of new or the upgrade of already existing state-of-the-art infrastructures for the design, fabrication, testing and upscaling of emerging nanomaterials, in Open Innovation Hubs located on both sides of the Atlantic, combined with the existence of fiscal incentives for companies investing in R&I, favourable labour laws for manufacturing and well-established regulations relative to intellectual property protection and patent licensing policies. Moreover, compliance with health, safety and environmental regulations is followed at advanced manufacturing premises on a regular basis. Industrial stakeholders have open access to Innovation Hubs at fair prices, where they collaborate with researchers in pilot experiments to evaluate technological risk prior to investment. Public-Private partnerships proliferate to drive innovation and contribute to build a solid advanced manufacturing base in Brazil and Europe. This, in turn, offers excellent employment opportunities to doctorates and engineers trained in advanced manufacturing at the Innovation Hubs. The result of

this scenario is the consecution of sustainable manufacturing of nanomaterials-based products and services at affordable prices.

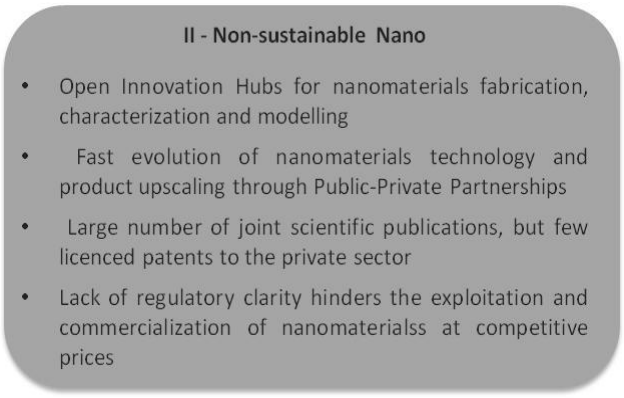
The “Nano for all” scenario presents an ideal situation for the realization of an effective and fruitful R&I cooperation in Advanced Manufacturing and Nanomaterials.

Guidelines for actions regarding R&I cooperation within INCOBRA’s vision could include:

- Project calls to be focused on the upscaling of a limited number nanomaterials-based technology domains, prioritized by policy makers with the participation of industrial stakeholders;
- Project calls that include updating of infrastructures for their continuous adaptation to new advanced manufacturing technologies, processes and nanoscale metrology procedures;
- Close monitoring of project results, including publications and patent licensing as well as time-to-market of materials research outputs;

- Special monitoring of adequate quality and safety control of developed processes and products across Innovation Hubs;
- Fostering of training activities in advanced manufacturing in all relevant R&I programmes, including mobility actions to technology centres located in other countries.

Scenario II: Non-sustainable Nano



This second scenario describes a situation characterized by a high public and private investment in advanced manufacturing infrastructures and human resources, similar to the first scenario, but without a joint effort from Brazil-EU policy makers to comply with safety, to improve labour law regulations, or to offer fiscal incentives for companies that invest in advanced manufacturing-related R&I. In this case Open Innovation Hubs, networking and public-private partnerships also lead to a fast development of nanomaterials science and technology accompanied by a proliferation of high-quality publications and, to a lesser extent, patents. The lack of specific education policies focusing on STEM disciplines results in shortage of qualified graduates to cover certain

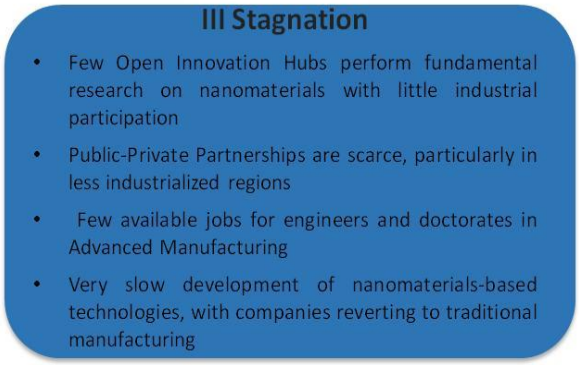
manufacturing jobs, but acquisition of skills is made possible through training of young doctorates at the Open Innovation Hubs or through requalification of experienced professionals. In addition, production costs in the advanced manufacturing sectors increase, due to the tax burden in technology equipment/ software and the lack of advantageous fiscal and energy costs associated to R&D activities. The lack of an adequate regulatory framework hinders the exploitation and commercialization of nanomaterials-based products at competitive prices, inhibiting the realization of a sustainable advanced manufacturing.

While R&I funding opportunities are numerous in this scenario, the unfavourable regulatory framework hinders the sustainability of an Advanced Manufacturing of innovative nanomaterials-based products due to non-competitive production costs, which calls for the following actions towards the realization of the INCOBRA framework:

- Project calls to be specifically focused on the upscaling of innovative nanomaterials R&D with applications in those sectors, e.g. automotive, textile, footwear, that have been negatively affected by the appreciation of Brazilian currency with the aim of reducing time-to-market and production costs of new products
- Reinforcement of training activities in STEM disciplines relevant for advanced manufacturing in prioritized R&I programmes, through partnerships and collaborations between the public and private sector to promote mobility actions to first class universities and technology centres worldwide
- Incentives for research and technology centres and universities participating in joint R&I Brazil-EU collaboration programmes for successful technology transfer activities, patent licensing and creation of technology-based enterprises
- Increase of fiscal incentives for companies participating in joint R&I Brazil-EU collaboration programmes dedicated to Advanced Manufacturing and Nanomaterials, aiming at their market commercialization at reduced costs

Scenario III: Stagnation

The third scenario depicts the situation derived from a low EU/Brazil joint public and private investment in R&I united with a poor support of joint policies and regulations relative to advanced manufacturing and nanomaterials. The availability of public funding for R&I programmes, open-access to technology infrastructures and training of specialized personnel is

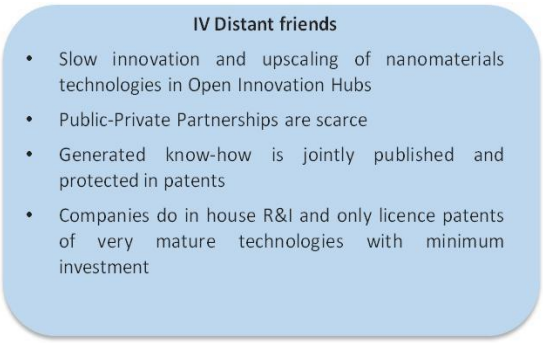


low and, consequently, Public-Private Partnerships in structural projects, where business opportunities and risks can be evaluated, do not proliferate. The interaction between academia and industrial stakeholders worsens in less industrialized regions of Brazil and the EU. The implementation of automated equipment and robots, sensors and actuators, or big data management in Open Innovation Hubs, which are essential for the development of an advanced manufacturing, occurs at a slow pace, while project activities concentrate on fundamental research on nanomaterials with little industrial participation. Consequently, the supply of jobs in Advanced Manufacturing is quite low. Furthermore, without the update of Brazilian legislation to favour the access of companies to financial incentives and resources, the development of an advanced manufacturing system in this scenario is at risk. The global result is a very slow development of nanomaterials-based technologies that reach the market only at high prices, with a large number of companies reverting their activity to traditional manufacturing.

The scenario “Stagnation” combines the worst conditions for the achievement of the INCOBRA vision. However, scientific activity under such circumstances does not decay, but rather continues with strength to face the difficult times. Actions to improve all relevant aspects of the Brazil-EU cooperation in Advanced Manufacturing and Nanomaterials would be necessary to revert the situation, including the following:

- Highly targeted project calls looking for more efficient and sustainable advanced manufacturing of innovative nanomaterials through the creation of customised solutions or by adding new materials functionalities to existing solutions;
- Identify and implement effective and well-coordinated standardized regulations and compliance protocols;
- Promote Advanced Manufacturing as the destination for new creative, high-skilled and interdisciplinary jobs to induce a positive public perception and attract skilled labour;
- Provide training to researchers to enhance their skills in presenting their work to a business audience in order to enhance collaboration and uptake of new nanomaterials-based technologies;
- Encourage research centres to use intelligent robotics, IoT and data analysis in manufacturing for the improvement of operational flexibility and efficiency, quality and safety assurance, management of resources and productivity.

Scenario IV: Distant Friends



This last scenario corresponds to a favourable evolution of EU/Brazil joint policies and regulations relative to advanced manufacturing and nanomaterials coexisting with a low public and private investment in in joint R&I in these areas. Under these conditions manufacturing related R&I follow different paths for academia and industrial stakeholders. On the one hand, innovation in nanomaterials is mainly carried out at R&D institutes and Open Innovation Hubs with a low budget, which imposes restrictions on the acquisition of automated equipment and implementation of sophisticated software and IoT technologies. While the generated know-how is published and protected by patents, products are rarely scaled to a pre-industrial stage. On the other hand, private companies have access to advantageous tax exemptions and carry out most of their advanced manufacturing R&D activities in-house, engaging only in Public-Private Partnerships to access very mature advanced technologies through pilot experiments and demonstrators in Open Innovation Hubs and patent licensing with minimum investment. Another consequence is the increase of job opportunities for doctorate holders and engineers in advanced manufacturing enterprises. Relying on their compliance with environment protection regulations, the private sector becomes under this scenario the main driver of the economic, social and environmental sustainability of Advanced Manufacturing R&I in Brazil and the EU.

While a sustainable Advanced Manufacturing is led by industry in this scenario, its long-term survival would not be possible unless it is based on R&I, in good agreement with the INCOBRA vision. In order to realize this transition several actions could be implemented, including:

- Identify synergies across research organizations to avoid unnecessary duplication of projects and advanced manufacturing equipment
- Encourage the creation of few competitive innovation hubs or clusters of aligned capabilities in Advanced Manufacturing of high added value nanomaterials to enhance knowledge sharing and reduce collaboration costs. Bringing multiple businesses and research teams together geographically can be of mutual benefit, as researchers can offer solutions to business problems while businesses can identify markets for the technology being developed by researchers
- Develop training courses for the requalification of employees of traditional manufacturing industries, who have a wealth of knowledge and experience that can be leveraged in emerging advanced manufacturing R&I

- Encourage researchers to develop or acquire skills in digital literacy, leadership and strategic management, customer interface and STEM disciplines to remain competitive

An overview of the four scenarios outlined above can be seen in Figure 6.2.

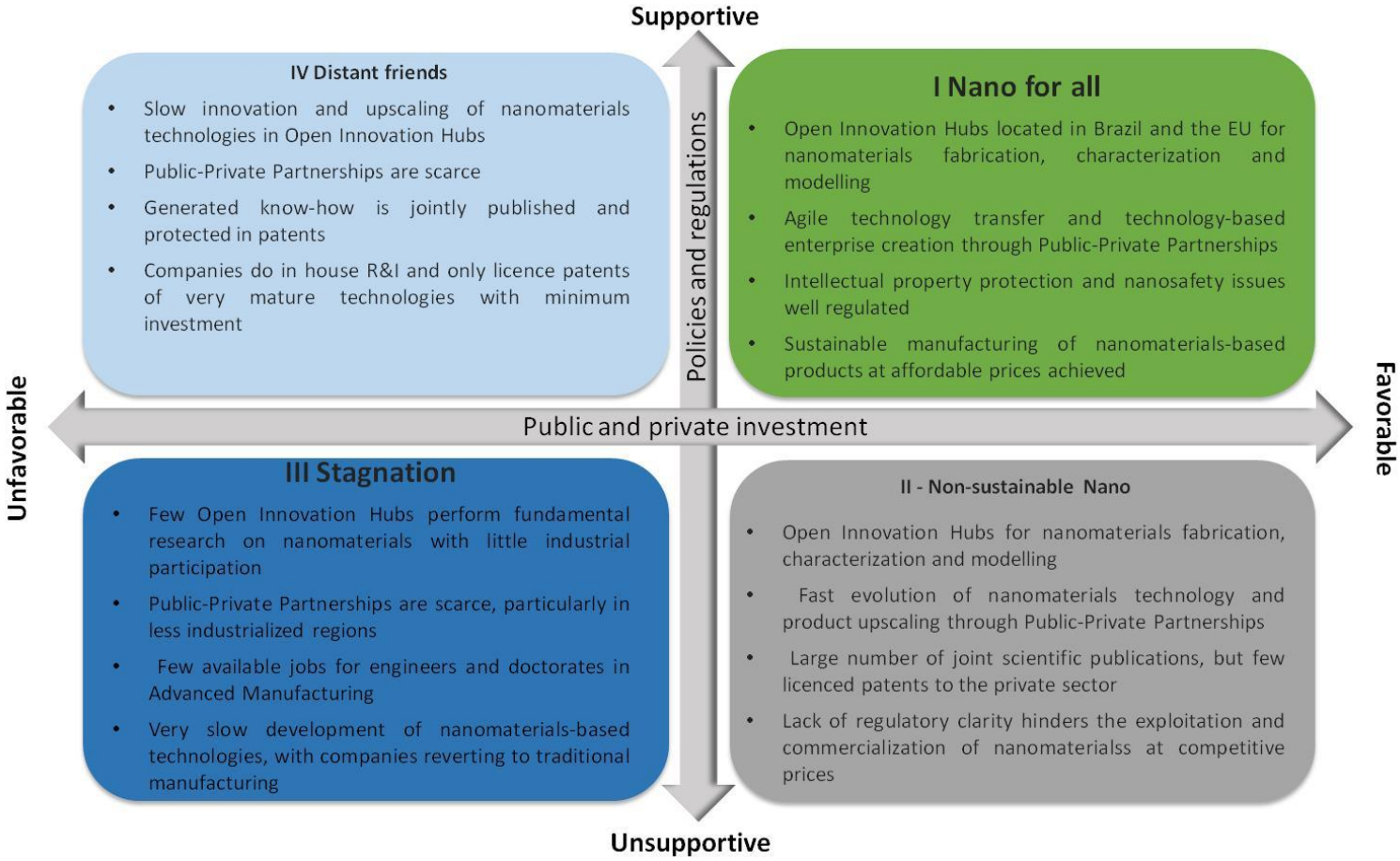


Figure 6.2. Scenario overview based on secnario description

6.4 | **Robust Trajectories**

The analysis made of the challenges and opportunities that could arise under different boundary conditions allow us to envisage a series of measures and actions that would be essential to establish a long-lasting and productive Brazil-EU cooperation in Advanced Manufacturing and Nanomaterials R&I according to the INCOBRA vision. Bearing in mind that both Brazil and the EU have excellent research infrastructures, which places them in a unique position to capture profitable stages of the value chain, and that both governments have manifested their commitments to boost Advanced Manufacturing and Nanomaterial technologies, the most probable situation in future years would be that described by the so-called “Nano for all” scenario. But the fact that certain public policies having a critical effect on manufacturing are still to be addressed, or the cyclical nature of some advanced manufacturing industries that entail uncertainties with respect to private investment in R&D, are just but a few of possible circumstances that would make the situation shift towards any of the two adjacent scenarios, “Non-sustainable Nano” or “Distant friends”. Consequently, a robust trajectory for Brazil-EU cooperation in Advanced Manufacturing and Nanomaterials should take into account a mix of possible scenarios, as depicted by the red line shown in Figure 6.3.

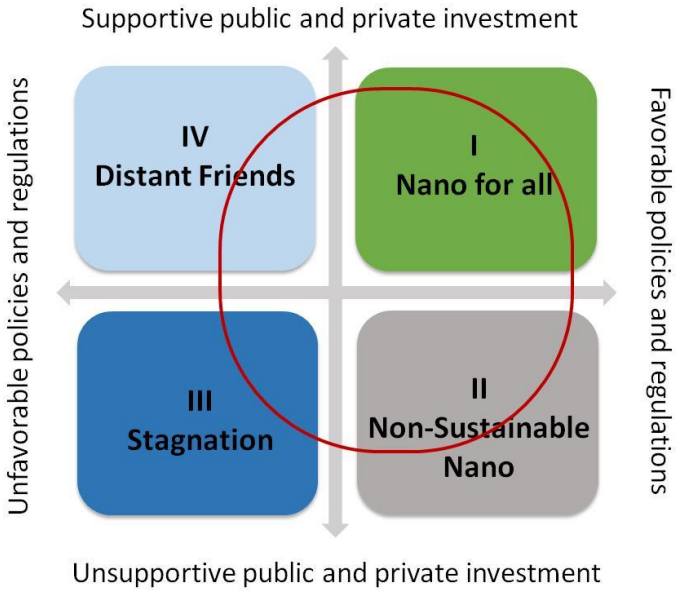


Figure 6.3. Area for robust trajectories

Based on the above we propose here the following measures as robust trajectories for a long-lasting and productive Brazil-EU cooperation:

1. **Establishment of a legal framework for the Brazil-EU collaboration in Advanced Manufacturing and Nanomaterials R&I**

Signing of a Memorandum of Understanding between Brazil and the EU is an indispensable first step to establish the aims and terms of the joint collaboration in Advanced Manufacturing and Nanomaterials R&I, and to highlight the key role of this strategic area in the development of tomorrow´s industry and the creation of high quality jobs and economic growth in both regions.

2. **Development of a joint Brazil-EU multi-annual work Program in Advanced Manufacturing and Nanomaterials R&I**

The multi-annual work program will have clear thematic focus and a pre-defined budget to ensure long term continuity in the implementation of manufacturing research strategies and to raise confidence in the private sector investors. It should include dedicated calls on advanced manufacturing-related R&I topics decided previously by mutual agreement and having synchronized timelines and simplified application procedures, as described in the vision. The envisioned program will include fundamental and applied research through industrial pilots and large–scale demonstration activities, bringing research outputs closer to the market.

3. **Brazil-EU industry participation in the definition of collaboration priorities in Advanced Manufacturing and Nanomaterials R&I**

In order to guarantee that available human and materials resources are harnessed, the participation of industrial stakeholders in programming and project execution will be encouraged, helping with decision-making and technology implementation management, based on their first-hand knowledge of new challenges and opportunities in manufacturing. Favorable fiscal incentives for companies investing in R&D and flexible regulations in Brazil for multinational companies entering consortia with national laboratories will contribute to the realization of this action line

4. **Joint Brazil-EU establishment of Open Innovation Hubs for strategic Nanomaterials Advanced Manufacturing R&I**

Open Innovation Hubs, envisaged as technological networks for advanced manufacturing of high added value products, like Nanomaterials, at state-of-the-art facilities with participation of all relevant stakeholders (Companies, ICTs, Government) will be the most important mechanism for technology transfer to industry. Public-Private Partnerships will be at the core of nanomaterials-based technology up-scaling and demonstration in relevant industrial environments, carrying out proof of concept and pilot tests joint experiments, while providing technical training to young graduates and serving as consulting body.

5. **Joint Brazil-EU commitment to develop a continuous training program in Advanced Manufacturing for science and engineering graduates and technicians**

Having a talented workforce in Brazil and the EU is key to support the diverse advanced manufacturing sector, improve its competitiveness and attract new investment. Collaborations via public-private partnerships in Open Innovation Hubs offer the best environment for the training of young doctorate holders and engineers, thereby fostering the “manufacturing ecosystem” that drives research and innovation in emerging materials and technologies.

6. **Design of a common evaluation protocol for BR-EU collaboration R&I programs in Advanced Manufacturing and Nanomaterials**

A common follow up of project activities and results is important to determine the effectiveness of actions taken to improve the Brazil-EU collaboration and to allow for budgetary and research priority readjustments, when necessary. It should include the deployment of indicators to monitor innovation performance, particularly through scientific publications and licensed patents, achievement of technology milestones related to specific priorities of the cooperation between Brazil and the EU, the environmental and socioeconomic impact of the developed technology as well as an analysis of the networking efficiency between research and industry stakeholders through Open Innovation Hubs.

7. **Joint Brazil-EU development of a science-based risk governance of Nanomaterials .**

The aim of this initiative is the development of appropriate regulations to promote the safety of strategic nanomaterials that are expected to enter the market in the near future and to ensure their acceptance by society, industry and governments. Besides identifying emerging nanotechnologies, it involves the translation of a sound scientific knowledge on materials toxicity into an appropriate regulatory framework and the management of risks and safety in the advanced manufacturing sector. In Table 1 we show the strategic actions to be implemented in the short (2020), mid (2025) and long term (2030) for each of the robust trajectories described above.

Table 6.1. Robust Trajectories and Actions for Advanced Manufacturing and Nanomaterials for short and mid to long-Term

Trajectories	Actions		
	Short-term	Mid-term	Long-term
	2020	2025	2030
1. Establishment of a legal framework for the Brazil-EU collaboration in Advanced Manufacturing and Nanomaterials R&I	Signing of a Framework Agreement between Brazil and the EU	Renewal of Agreement after revision of aims and terms	Renewal of Agreement after revision of aims and terms
2. Development of a joint Brazil-EU multi-annual work Program in Advanced Manufacturing and Nanomaterials R&I	Identification of strategic advanced manufacturing sectors and emerging nanomaterials technologies of common interest and design of aligned R&I initiatives	Implementation of aligned R&I initiatives through projects focused on product design, proof of concept, prototyping, pilot scaling and regulations	
		Proactive investment in state-of-the-art manufacturing infrastructures with participation of public and private actors	
3. Brazil-EU industry participation in the definition of collaboration priorities	Co-identification of global trends and emerging technologies	Industry involvement in programming and project execution	Development of efficient technology transfer models Improvement of time-to-market for jointly developed nanomaterials
	Co-definition of strategic research priorities, technology requirement and timelines	Joint technology risk assessment	
		Industry commitment to long-term R&I investment	
4. Joint Brazil-EU establishment of Open Innovation Hubs	Identification of excellence research and technology centres involved in Advanced Manufacturing/Nanomaterials	Co-location of research centres, universities and business	Creation of spin-off companies originated from open innovation hubs
	Envisage incentives to promote collaborations through public-private partnerships	Creation of 3-4 innovation hubs with focus on strategic nanomaterials advanced manufacturing	
5. Joint Brazil-EU commitment to develop a continuous training program	Identification of required skills, capabilities and resources in R&I projects	Development of tailored training programs in advanced information and manufacturing technologies, STEM disciplines and entrepreneurship	Development of MSc and Doctorate courses in Advanced Manufacturing and Nanomaterials involving industrial stakeholders
6. Design of a common evaluation protocol for BR-EU collaboration R&I programs	Elaboration of evaluation protocol to monitor key technology and innovation indicators	Implementation of protocol to evaluate R&I project results and adjustment of specific program focus and participation requisites	Creation of “Innovator of the Year” award
7. Joint Brazil-EU development of a science-based risk governance of Nanomaterials	Develop understanding of connection between physical-chemical, exposure and hazard characteristics of nanomaterials	Implementation of standardised regulations and compliance protocols	Implementation of optimized science-based regulation and compliance protocols
	Identification of standardised regulations and compliance protocols		

6.5 | **Components of a Roadmap**

The seven robust strategies proposed in the previous section ought to be implemented to realize the INCOBRA vision for a successful Advanced Manufacturing of nanomaterials-based products that will bring enormous social and economic benefits to both regions. In order to generate a roadmap based on these trajectories, we have grouped the strategic key actions to be implemented in the short (2020), mid (2025) and long term (2030) into four main categories, each one focusing on: i) Regulations and Policies, ii) Market, iii) Technology and iv) Competences and Resources.

Regulation and Policies

Definition: This layer addresses all joint Brazil-EU governance initiatives undertaken to create the policies and the regulations to be complied with, which would be needed to attain a high value-added, sustainable and safe advanced manufacturing, specially that aiming at the timely development of close-to-market nanomaterials technologies.

Main challenges:

- Policies affecting manufacturing costs, e.g. energy costs, labor laws, tax burden on technology equipment and software;
- Policies affecting long-term talent and human capital developmentPolicies supporting the participacion of industrial stakeholders in advanced manufacturing R&I activities to collaborate with researchers in the seek for innovative technologies;
- Policies to ensure adequate intellectual property protection and technology transfer to the production sector;
- Safety regulations relative to nanomaterials automated manufacturing and handling.

Timing: Short, medium, and long term.

Market

Definition: This layer encompasses all reliable data regarding nanomaterials local and global markets to be continously monitored and analyzed to achive the timely and competitive manufacturing of strategic nanomaterials-based products through the joint Brazil-EU R&I programs on Advanced Manufacturing.

Main variables:

- Market trends, opportunities and challenges for each relevant application segment, e.g., electronics & consumer goods, pharmaceuticals, etc.;

- Market size calculated on the basis of the revenue generated through sales in all related nanomaterials application segments;

- Factors that drive market growth, e.g., increasing R&D investment of major companies and Brazil-EU governments along with consumer acceptance, increasing applications of nanoparticles in different fields, excellent physico-chemical properties of nanomaterials, etc.;

- Factors that hamper nanomaterials market growth, e.g.,stringent environmental and health regulations, high cost of nanomaterials, lack of research, etc.;

- Business strategies of key players in Brazil and the EU to remain competitive in the global nanomaterials market, such as partnerships, mergers and acquisitions, business expansion and products & applications developments[57].

Timing: Short, medium, and long term.

Technology

Definition: This layer refers to all key enabling technologies to be jointly developed through Brazil-EU R&I collaboration to achieve a sustainable and competitive advanced manufacturing of high added-value products, e.g., nanomaterials.

Main challenges:

- Nanomaterials technology R&I less based on addressing specific product limitations, but rather on increasing materials functionality, thus enhancing manufacturing flexibility. R&I on nanomaterials directed towards applications in electronics, biotechnologies, environment, energy, health, agriculture and food security.

- Implementation of advanced tools for testing and selecting the best materials science solutions: computer modelling, visualization tools, advanced analytical metrology with nanoscale resolution;

[57] Nanomaterials Market: Global Industry Analysis and Opportunity Assessment 2015-2025, https://www.futuremarketinsights.com/reports/nanomaterials-market, 2017.

- Implementation of repeatable and scalable manufacturing processes and parameters to facilitate the rapid adoption of materials with exceptional properties;

- Implementation of advanced processing technologies across the vaue chain, including smart robotics, sensors and data analytics, additive manufacturing tools, etc.;

- Implementation of advanced information technologies across the production chain: Big Data and IoT for data collecting, simulation, inspection, operation, improvement, supply chain management and reduction of energy usage[58].

Timing: Short, medium, and long term.

Competences and resources

Definition: This layer encompasses all human and finantial resources as well as R&D infrastructures necessary to carry out those joint research activities between Brazil and the EU that will enable the Grand Vision on advanced manufacturing and nanomaterials.

Main challenges:

- Identify strategic advanced manufacturing sectors and emerging nanomaterials technologies of common interest for Brazil-EU collaboration, followed by implementation of aligned R&I initiatives through projects focused on product design, proof of concept, prototyping, and pilot scaling;

- Identify skills, capabilities and resources needed in R&I projects. Develop tailored training courses to improve or acquire skills in STEM disciplines, digital literacy, and entrepreneurship, among others;

- Identify excellence research and technology centres involved in advanced manufacturing in Brazil and the EU to become part of specialized joint open innovation hubs/labs that would enable collaborations via public-private partnerships;

- Proactive investment in state-of-the-art manufacturing infrastructures and new technologies with participation of public and private actors.

Timing: Short, medium, and long term.

[58] Advanced Manufacturing, www.csiro.au, November 2016.

Figure 6.4 shows the resulting Roadmap for a successful Brazil-EU cooperation on Advanced Manufacturing and Nanomaterials:

Layers	Actions		
	Short-term	Mid-Term	Long-Term
	2020	2025	2030
Regulation and Policies	Signing of a Framework Agreement between Brazil and the EU	Periodical revision and renewal of Framework Agreement	
	Development of standardised safety regulations and compliance protocols for nanomaterials	Implementation of standardised safety regulations and compliancen protocols for nanomaterials	Implementation of optimised science-based safety regulations and compliance protocols for nanomaterials
Market	Identification of stratefic advanced manufacturing sectors and nanomaterials		
	Monitoring of nanomaterials market trends and dynamics for each relevant application segment		
		Prioritize R&I projects on multifuncional nanomaterials for increased number of product market segments	
	Foster industrial stakeholders access to pilot scaling and risk assessment experiments		
			Establishing strategic public-private partnership with key leading companies fortimely production of innovative nanomaterials

Figure 6.4. Roadmap for Advanced Manufacturing and Nanomaterials: actions versus layers for short, medium and long term

Layers	Actions		
	Short-term	Mid-Term	Long-Term
	2020	2025	2030
Knowledge Bases	Identification of strategic advanced manufacturing sectors and nanomaterials	Nanomaterials technology R&I focused on increasing materials funcionality for enhanced manufacturing flexibility	
		Implementation of advanced tools for nanoscale testing and selecting the best materials science solutions in R&I projects	
		Implementation of repeatable and scalable manufacturing processes and parameters in R&I projects to facilitate the rapid adoption of nanomaterials with exceptional properties	
		Implementation of automated manufacturing tools in R&I projects including smart robotics, sensors and data analytics, etc.	
		Implementation of advanced information technologies in R&I projects like Big Data and IoT	
Competences and Resources	Identification of execellence research and technology centres involved in Advanced Manufacturing and Nanomaterials	Implementation of aligned R&I initiatives through projects focused on product design, proof of concept, prototyping, and pilot scaling	
		Proactive investiment in state-of-the-art manufacturing infrastructures with participation of public and private actors	
		Creation of 3-4 innovation hubs	Creation of spin-off companies originated from open innovation hubs
	Identification of required skills, capabilities and resources in R&I projects	Development of tailored training programs in advanced information and manufacturing technologies, STEM skills and entrepreneurship	Development of MSc and Doctorate courses in advanced manufacturing and nanomaterials
			Creation of "innovator of the year" award

Figure 6.4. Roadmap for Advanced Manufacturing and Nanomaterials: actions versus layers for short, medium and long term (cont.)

6.6 | Supporting Documents

Strategic Foresight Workshops Report (Deliverable D1.2 (WP1).

Strategic Foresight Workshops Report (Deliverable D1.2 (WP2).

Co-Patent Report (Included in D1.2).

Open Consultation Results (Included in D 1.1).

Survey of Existing Foresight Studies (Included in D 1.1).

7 | Action Plans for Smart Cities and Smart Systems

7.1 | Background and Focus

Smart Cities and Smart Systems were a priority topic present in both Strategic Foresight Workshops (SFW) conducted in Brazil and the European Union. But the topic was not originally part of collaboration's scope and emerged as a more focused, practical aspect of Information and Communication Technologies (ICT) - one of the original Research Areas highlighted in the initial INCOBRA project proposal.

But during the workshops, it became clear that every innovation, technology, research and cooperation goal converged to applications connected to urban problems and their solutions.

And not only that. All the other Research Areas had impacts on urban dynamics or were highly impacted by how cities will work in the future. More precisely, the SFW showed that connected urban environments would influence and be influenced by other priority sectors such as food, energy, environment, health, electronics, etc.

A cross-impact analysis between information technology and cities showed its influences on policies, decisions and strategies in other Research areas, and how cities are influenced by moves in these same areas as well. In particular, the following combinations were taken into consideration for the development of this action plan:

- ICT x food, energy, and environment;
- ICT x health and wellness;
- ICT x Nanotech and electronics.

The topic Smart Cities & Smart Systems, then, involves the use of integrated digital systems, many of them autonomous, to enable efficiency, sustainability and wellness, especially in cities taking into consideration aspects of energy, environment, health, wellness and electronic systems.

Since Smart Cities and Smart Systems is a broad and complex theme that can't be isolated from other topics and their policies this plan focuses on the centrality of cities and smart systems for the cooperation as a whole.

7.2 | Prioritized Items

As previously discussed, Smart Cities and Smart Systems is a very complex, interconnected theme that demands inclusive and integral approaches. It is also known that culture, social and physical infrastructure, and especially political

differences between EU and Brazil play a major role in any discussion or action determined by this cooperation.

Brazil is quite well-known for its engagement with technology. Brazilians spend several hours a week in social networks, incorporated e-commerce faster than other developing countries and has one of the most advance internet banking systems in the world. But cities in Brazil lack the necessary infrastructure to make them deliver better citizen experiences.

That being said, the following priorities are suggested for consideration by INCOBRA. All of them are focused on the development of new businesses, entrepreneurship and collaboration with private and public actors.

- Citizen engagement - including distributed governance sharing economy;
- Ecosystems of wellbeing - including urban environment, health and social security;
- Privacy and Security - including Blockchain, data policies and analytics;
- New economies - including fintech, cryptocurrencies and collaborative economy;
- Internet of Everything - including autonomous systems, sensors, big data and analytics;
- Entrepreneurship - including innovation ecosystems, urban solutions and social.

Based on INCOBRA framework, we can add:

- A simple, transparent, and trust based project governance allows for the orchestration of work teams;
- Governance instruments and actors are synchronized, harmonized, and aligned to complement each other;
- On both sides there is a long-term commitment to funding policies;
- Diverse partners interact like an open and flexible research and innovation network;
- There is a clear and stable framework for cooperation that guides the research agenda while accommodating creativity and original ideas in a flexible manner.

For the development of Smart Cities & Smart Systems research and innovation strategies, as well as the inclusion and wellness of its citizens, the following aspects of a desirable EU/Brazil 2030 future were emphasized:

- A coordinated Smart Cities & Smart Systems Strategy between Brazil and the EU is in place;

- Both countries jointly commit to a joint long-term research and innovation strategy for developing Smart Cities & Smart Systems;
- A Smart Cities & Smart Systems Innovation Partnership between Brazil and EU is established;
- Smart Cities & Smart Systems ventures increase in both countries. Bi-national startups and solutions are developed to address urban problems using AI, Blockchain and social networks;
- Citizens, local governments and businesses cooperate in seamlessly to increase wellness, urban development and shared governance; Cooperation between cities and citizens in both countries is dynamic and permanent;
- Cooperation between Brazil and EU accelerates the increasing role of cities as platforms for innovation and human wellness. A pilot program for extreme governance automation and extreme citizen participation is launched in 2030. Program happens simultaneously in one Brazilian and one EU city;
- Cooperation between Brazil and EU develop radically new forms of governance and citizen participation through a combination of open data, open networks and algorithms;
- *Fictive news from 2030 "Brazilian island disrupts city governance" "A Brazilian city is going mayor-less thanks to algorithms and extreme citizen participation. Fernando de Noronha, an Atlantic island part of the state of Pernambuco, just implemented a combination of artificial intelligence, smart contracts and MESH networks to distribute local governance. Part of if will be in the hands of every citizen, but a good part will be driven solely by algorithms. The solution, developed by a startup based in Recife, is part of Incobra, a long-standing cooperation between Brazil and the European Union."*

7.3 | **Concise Scenarios**

7.3.1 Objective

The development of a robust action plan demanded a clearer vision on the impacts and challenges present in the theme of Smart Cities & Smart Systems. For that, four alternative scenarios were developed using a variation of the standard two-by-two scenario development methodology.

The four scenarios take into consideration the two main variables in a scale of low to high human-centric policies and systems, and low to high pervasiveness of autonomous systems. The ream responsible for this Action Plan took the liberty of adding a layer of alternative futures, as proposed by the Manoa School, to the original approach. Each scenario meshes the two factors with other key drivers to represent stories of growth, collapse, stability and transformation of Smart Cities & Smart Systems.

The scenarios, then, serve as a basis for identifying challenges, dilemmas and opportunities for research and innovation for Smart Cities & Smart Systems.

7.3.2 Critical Variables

According to the SFW reports, there are several variables that may critically interfere in setting up strategic R&I cooperation between Brazil and the EU. The criteria for the chosen variables took into consideration criteria such as:

- The intensity and frequency with which the variable came up during the workshops, particularly during the debates about prioritization;
- The pervasiveness of the variable to define the future of the priority topic;
- The degree of impact the variable may have on the practicability of R&I cooperation.

Considering these, the two critical variables chosen for Smart Cities & Smart Systems are:

- Design of policies and systems centered in human experience, inclusion and wellness;
- Penetration of autonomous, intelligent and connected things and systems.

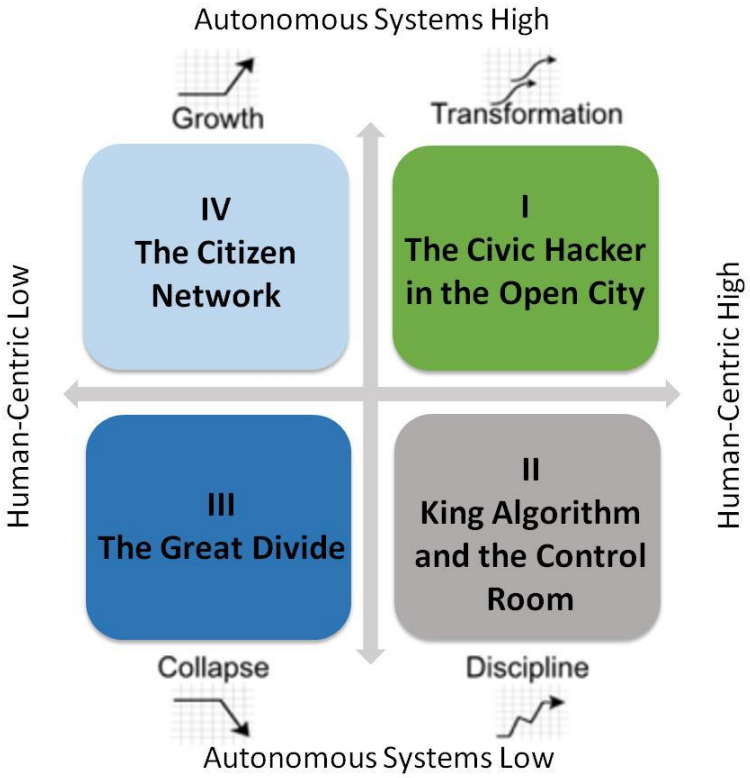


Figure 7.2: Crossing variables and scenario designation

7.3.3 What is inside the Variables?

The variables used to build the scenarios emerged from the analysis of priorities and concerns present in the two SFW. An apparent antagonism between what technology could provide and how humans would react and engage with it emerged from the discussions and became a clear inflection point. As such, the following variables were synthesized and crossed to build the scenarios:

VARIABLE 1

"Design of policies and systems centered in human experience, inclusion and wellness"

Human-Centered design of policies is a critical variable in the development of systems and innovations that impact citizen inclusion, health, wellness, privacy, security and the urban environment. During the SFWs there was an increasing concern on the role of citizens and the use of technology to improve not just city governance, but citizens participation and general wellbeing.

VARIABLE 2

"Penetration of autonomous, intelligent and connected things and systems"

Another critical variable is the pervasiveness of connectivity, autonomous systems, sensors, data and analytics of both people and city infrastructure. Disruptive technologies such as AI, Blockchain and advanced analytics were highlighted as very important during the workshops, but were positioned at lower priority in general, in a clear polarization of the theme.

In the following sections, we describe the four scenarios in general terms stressing implications for R & I cooperation in regards to Smart Cities & Smart Systems. Results from the SFWs are integrated into each of the scenarios, as well as narrative moods as a result of the use of the Alternative Scenarios methodology. Each scenario presents a simple, yet colorful setting as well as its implications to R&I cooperation between Brazil and the EU.

Scenario I: The Civic Hacker in the Open City

As can be seen in the figure, this scenario relates to the case where policies and systems whose design promote connectivity, inclusion, data privacy and other human-centered issues and is boosted by high pervasiveness of autonomous systems, data analytics, predictive systems and digital tools.

I – The Civic Hacker in the Open City

- Ubiquitous connectivity and systems disrupt traditional governance. Citizens can access data, create open public service apps;
- Rise of cryptocurrencies creates parallel currencies, disrupt traditional finance system. Everyone is a bank;
- Urban mobility is flexible, distributed, shared and smart. Everyone is a transportation provider;
- Completely new contracts and regulation must be invented.

This scenario envisions a city whose physical environment is blended with data, artificial intelligence, autonomous systems, and smart grids (energy or otherwise). This city is treated as an open-source cyberware to which citizens can freely access, feed and modify, like a WiKi, or hack in typical maker culture way. In this scenario, the citizen is its main sensor, data provider and actuator. Access happens via embedded systems in clothes, ambient objects and implants. The word for this is symbiosis.

This is a Transformation scenario, which brings many opportunities, but raises several critical issues.

Ubiquitous connectivity and systems challenge traditional governance. More than citizen participation, this scenario demands governance transformation towards horizontality, openness and participation. Traditional forms of governance (be that private or public-sector governance) will have to develop new ways of dealing with digitally empowered citizens. The pervasiveness of algorithms also challenges traditional governance and hierarchies, as well as the role of citizenship in providing security via coveillance and urban planning/management.

The rise of cryptocurrencies powered by Blockchain and new forms of connected, social trade, challenges current market and financial systems. New policies must be developed to deal with decentralized economy and currency.

Urban mobility is highly transformed by autonomous systems, Blockchain and smart energy grids. The benefits of autonomous vehicles for wellness, security and the environment must be balanced against current auto industry, city design and work.

Development of this scenario is extremely complex and depends on the confluence of indicatives in both private and public sectors, as well as citizen engagement. Over focus on either human-centric policies or automated systems

may change this scenario into either a more modest Citizen Network or a King Algorithm scenario.

Research in this scenario is extremely rich, precisely because it depends on the involvement of private initiatives, public policies, citizen engagement and innovation. Multiparty researches may benefit not just from the development and deployment of policies, products and services, but also from the learning process and interaction, which may open opportunities for more and better products, services and futures outcomes.

Guidelines for actions regarding R&I cooperation within INCOBRA's framework could include:

- Search for EU-BR short, mid and long-term funding opportunities;
- Establish interoperability protocols for IoT;
- Establish joint policies for cryptocurrencies and hyperlocal digital currencies
- EU-BR shared efforts to integrate also civil society actors and ordinary citizens;
- Jointly develop EU-BR data management, privacy and transparency protocols;
- Integrate food, bio-fuels, energy and electronics chains into Smart Cities infrastructure;
- Establish joint policies and protocols for automated and shared governance;
- Match startups and ventures to develop urban solutions;
- Jointly develop pilot programs for new governance models.

Scenario II: King Algorithm and the Control Room

In a second scenario, the interaction between high pervasiveness of autonomous systems with low efforts in developing human-centered solutions create a scenario of growth of current smart cities designs. In this scenario, command and control solutions become both cheap and common and are adopted by every major city in the next decade or two.

II – King Algorithm and the Control Room

- Command and control solutions become cheap;
-
- Public data turns into just in time actions;
- Anticipatory policies in secutirty, mobility, infrastructure, health and energy;
- Low citizen participation.

In this city, citizens are highly connected and rely on (and contribute to) high density databases, which are processed and transformed into both just in time actions and anticipatory policies in security, mobility, infrastructure, health and energy. But citizens have limited access to data and decision-making processes. The main

form of internet connection in this scenario are "invisible", non-invasive, AI-assisted, voice and gesture-enabled devices such as earbuds and necklaces.

In this Growth scenario, current trends in smart cities become the norm and raises several issues.

Citizen participation is low and data is abundant, which benefits top-down decision-making. Collaboration in governance and economy, though, are major drivers of change that may either challenge the fulfillment of this scenario or impose hard times for policy makers, companies and governments.

Though the scenario implies cheap and pervasive systems, the road to its fulfillment depends heavily on public investment in command and control centers, sensors and connectivity, which may be faced as a major financial challenge.

Connected cities, grids, sewer and waste systems, buildings, that is, ubiquitous sensory input plus command and control systems have the potential to promote huge impacts in environmental management. However, these initiatives are focused on long-term goals, which can be perceived as useless by citizens and deemed waste of resources by contrary politicians. On the short term, several of these initiatives failed to coordinate concrete actions to turn data into effective environmental policies.

Research in this scenario is the easiest, but poorest in terms of overall benefit. It basically involves the adoption of ready-made solutions from big providers. However, some solutions may need easy to use and fast deployment to achieve effectiveness.

Guidelines for actions regarding R&I cooperation within INCOBRA's framework could include:

- Search for EU-BR short, mid and long-term funding opportunities;
- Establish interoperability protocols for IoT;
- EU-BR shared efforts to integrate civil society actors and ordinary citizens
- Match startups and ventures to develop urban solutions;
- Jointly develop EU-BR data management, privacy and transparency protocols;
- Integrate food, bio-fuels, energy and electronics chains into Smart Cities infrastructure;
- EU-BR jointly attract major infrastructure and systems providers to collaborate with INCOBRA.

Scenario III: The Great Divide

The most contradictory scenario speaks of the great digital divide between highly developed, digital, well-connected urban centers and low autonomy, low human-centered systems and policies of suburbs and the countryside.

III – The Great Divide

- Automated systems are ill-distributed, generating a profound digital divide;
- Disenfranchised citizens will hack the system to gain access to its benefits;
- Next generation health, wellness and environment management are accessible to a priviledged few;
- Low citizen participation in governance and digital lifestyle.

This scenario assumes that connectivity and autonomous systems in richer, well-educated and white communities will highly contrast with ill-connected, disenfranchised, peripheral non-white communities within or outside cities. Even though it's expected that another billion people will enter the internet in the next decade, this scenario indicates a new, extended version of the digital divide. One that will not be based on connectivity, but mostly on speed, access to artificial intelligences and autonomous systems and digital mobility. For digitally excluded of the next decade, the primary form of connectivity is current state of the art smartphones.

A Collapse scenario, this story raises the following questions:

With the importance of the internet and autonomous systems in the future, how will ill-connected citizens bypass policies, systems and networks?

The new digital divide has the potential to generate a social divide even greater than the one faced today. These ill-connected citizens won't have access to freelance jobs, sharing economy opportunities and even access to cryptocurrencies and social security, both enabled by Blockchain technologies.

Environmental and health issues are critically harmed in this scenario. Without access to digital systems - adopted because of their clear benefits, but ill-distributed due to lack of policies or investment - citizens may revert to offline solutions and improvisation, adding entropy to the system, which may lead to societal collapse in microscale. This may also impact the wealthier societies, due to the rapid spread of epidemics and the rise of superbugs.

Research in this scenario is of extreme importance. It's the scenario to be avoided and reflects a real danger to the development of society. Its mitigation depends heavily on public policies in infrastructure and inclusion, as well as income, entrepreneurship and mutually beneficial digital platforms.

Guidelines for actions regarding R&I cooperation within INCOBRA's framework could include:

- Search for EU-BR short, mid and long-term funding opportunities;
- Jointly develop digital inclusion programs for a post-smartphone age;
- EU-BR shared efforts to integrate civil society actors and ordinary citizens;
- Match startups and ventures to develop citizen inclusion, “low-tech” internet access and systems;
- Integrate food, bio-fuels, energy and electronics chains into Smart Cities infrastructure focusing on disenfranchised communities;
- Jointly develop digital literacy, maker culture and entrepreneurship projects in disenfranchised communities.

Scenario IV: The Citizen Network

The final scenario focuses on the convergence of high human-centered policies, designs and systems with low adoption of algorithms and data analytics.

IV – The Citizen Network

- Ubiquitous internet for most citizens;
- Radical access to information is balanced with political, social and economic factors;
- Citizen participation is high, but limited;
- New policies for governance, cryptocurrencies and business must be designed.

This scenario considers that in the next decade internet will be ubiquitous to most citizens, via several technologies, and there will be a number of autonomous, predictive and analytical systems available to both people, things and organizations. However, the pervasiveness of these systems will be pushed back by political, social and economic factors. In this sense, citizen participation and collaboration will be high, decentralizing many aspects of governance, public services and commerce. Collaboration and connectivity are the norm and though centralized systems and environments do exist, these are deemed as antiquated and must be preserved because of its legacy systems. In this scenario, cryptocurrencies are common, but are highly regulated. In this scenario, people still use some kind of centralized device as its main form of accessing the internet, but every object has some form of computational power. The key here is that systems, devices and autonomous solutions are highly distributed and developed to enhance human experience, not substitute it.

This Stability scenario raises the following critical questions:

This is the most balanced scenario, and for that reason, the hardest to design. It considers society decided not to engage in command and control systems, but still rely on centralized systems. In it, society adopted autonomous systems, but managed to put humans on center-stage, which helped them deal with the digital divide.

Legacy systems versus autonomous systems will impose a great challenge to parties in both public and private sectors. Conflict between these two will raise confusion and slow down the implementation of actions.

Just as in the Citizen Hacker scenario, governance, commerce and many other aspects of society will need revision, adaptation and some new policies will have to be invented.

This balance is very fragile and any factor can develop into any of the other scenarios in partial or full form.

Research in this scenario is easy, rich, but hard to implement in full. It involves engagement with civic society, as well as policy makers and companies/entrepreneurs. But to make all parties agree in common actions is probably a hard task.

Guidelines for actions regarding R&I cooperation within INCOBRA's framework could include:

- Search for EU-BR short, mid and long-term funding opportunities;
- Establish interoperability protocols for IoT;
- Jointly develop digital inclusion programs for a post-smartphone age;
- Establish joint policies for cryptocurrencies and hyperlocal digital currencies;
- EU-BR shared efforts to integrate acivil society actors and ordinary citizens;
- Jointly develop EU-BR data management, privacy and transparency protocols;
- Integrate food, bio-fuels, energy and electronics chains into Smart Cities infrastructure;
- Establish joint policies and protocols for automated and shared governance
- Match startups and ventures to develop urban solutions;
- Jointly develop pilot programs for new governance models, new business models and new finance systems.

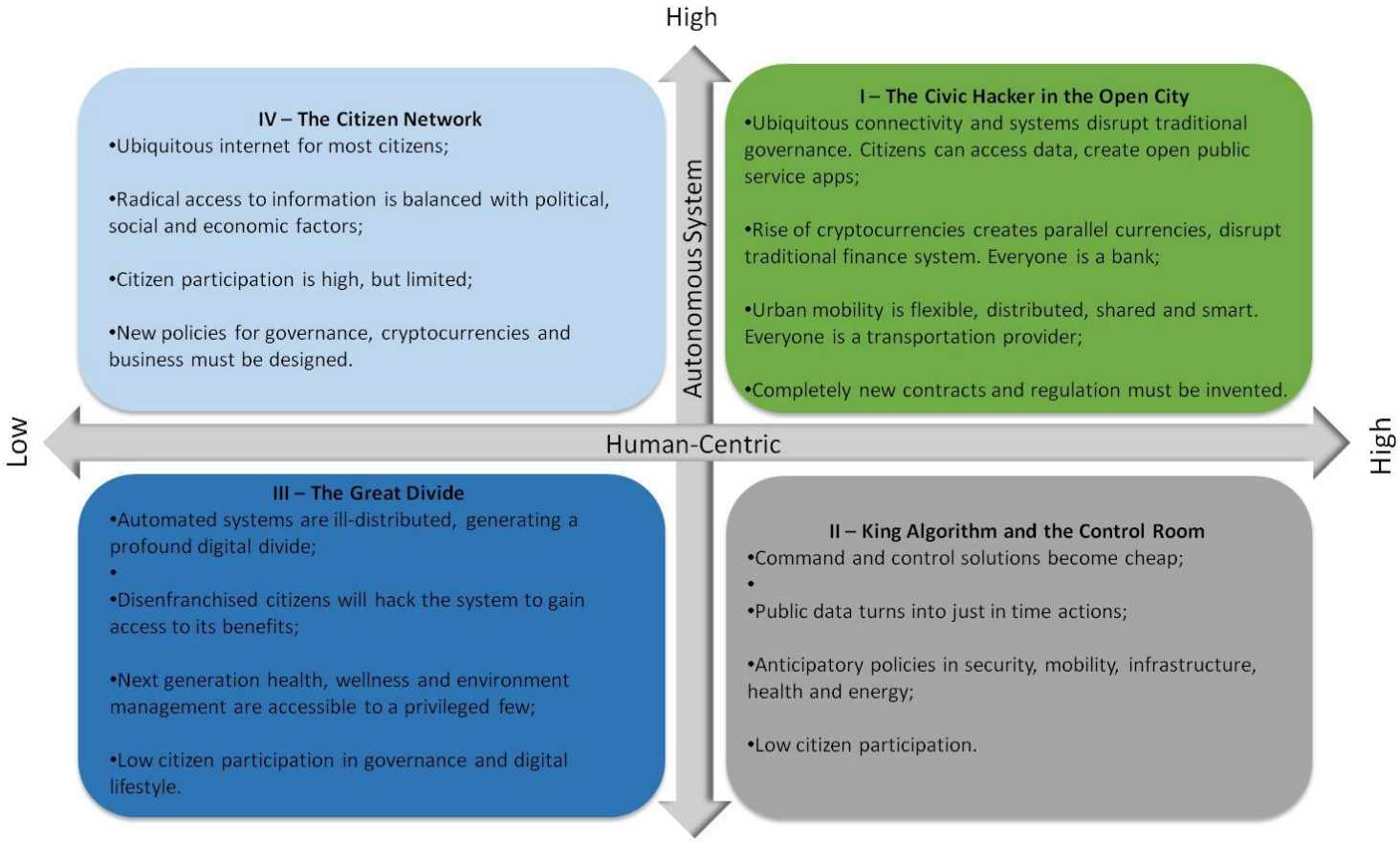


Figura 7.2. Scenarios overview based on scenarios desdription

7.4 | **Robust Trajectories**

Robust trajectories are the pathways towards preferable strategic end states for various social, economic, and governing factors. While uncertainty and change will often shape the details of the journey to achieving these goals, the basic approach remains valid to achieve the vision goals across scenarios. Below we discuss the the main robust strategic options identified through the analysis of the four scenarios.

1. Brazil/EU startup ecosystem for urban innovation

The problems and dilemmas derived from the exploration of ubiquitous connectivity, artificial intelligence, cryptocurrencies, smart contracts and citizen engagement in the SFWs open the opportunity for solutions using technology, social innovation and reinvention of public policies. Considering the accelerating rate of change in Smart Cities & Smart Systems, and considering the difficulty government agencies show to react to change, it's recommendable that INCOBRA promote the creation of a binational startup ecosystem and help new companies develop innovative solutions to urban challenges.

2. Bilateral Brazil/EU commitment to long-range funding

To fulfill INCOBRA's vision for Smart Cities & Smart Systems, it's fundamental that cities may have access to funding to invest in infraestructure, social innovation, startup programs, etc. Funding collaboration being one of the core elements in INCOBRA vision, a robust trajectory for this topic must include both monitoring opportunities as well as lobbying with local governments the creation of these funds. It's crucial that Brazil and EU develop a shared agenda and shared commitment to collaborate into developing funding opportunities.

3. Cross-research between priority areas

Analyzing unexpected consequences in the four scenarios, it became clear that robust trajectories for Smart Cities & Smart Systems had deep impact (and was deeply impacted by) developments, researches and outcomes present in all other research areas, namely bio-fuels, green energy, electronics and health/wellness. It is important, then, that robust trajectories in Smart Cities & Smart Systems include at least the highest impact trajectories from other research areas and vice-versa. Another key point is to connect these other trajectories in strategies for innovation and entrepreneurship.

4. Brazil/EU common knowledge, research and development of IoT protocols and solutions and next generation networks

One critical aspect emerging as a result of Smart Cities & Smart Cities vision is that Internet of Things (IoT) solutions still lack solid interoperability protocols.

Technologies and solutions developed by one provider in Europe may not operate with expected efficiency in Brazil and vice versa. On the other hand, ubiquitous next generation networks (5G, MESH, etc) are also essential in all four scenarios. It's fundamental that, to collaborate in this area, both countries must establish a common language for its solutions – and the solutions themselves. The exchange of experts, facilities, research groups, technologies and policies is fundamental for the vision.

5. Joint policy development for net neutrality, data security, privacy and management

All four scenarios show the importance and abundance of data. In some scenarios, data is open and "hackable". In others, data is closed and harvested. How cities, systems and citizens will have their data secured, their privacy guaranteed and their digital life properly managed is paramount for the fulfillment of INCOBRA's vision. And since data is transnational, it's fundamental that Brazil and the EU work together to establish common policies for these themes, as well as efforts for developing new protocols, commons data storage facilities, legal landmarks and, last but not least, net neutrality.

6. Development and sharing of Brazil/EU makerspaces and research facilities

As described in previous items, much of the innovations and solutions in Smart Cities & Smart Systems should come from startups, civil society and independent researchers. Also, it became clear in the scenarios that the impact of autonomous systems and human-centric designs will open a large space for maker culture. Even being very connected to "do it yourself" ethos, the development, sharing and access to distributed, networked makerspaces and open innovation research facilities, may accelerate the development of urban solutions and "open cities" strategies. This robust strategy includes education in digital skills/knowledge and learning by doing as research facilities.

7. Joint development of policies and new business models for work, health and mobility platforms

In the scenarios, work, health and mobility are deeply impacted by autonomous systems and human-centric designs. In the scenarios, services in these areas are accessed through platforms (either in invisible devices or "smart gadgets"). Platforms are already a major driving force in digital economy but with ubiquitous access to connectivity and data, platforms become the way in which people will connect to jobs, health and wellness services, transportation, etc. Disruption in this area will not wait for policy makers, but it's fundamental to both make sure platforms offer positive outcomes to citizens and to anticipate next generation platforms in more extreme, transformative scenarios. It's also fundamental that

Brazil and the EU jointly foster innovation in this area, especially with new business models.

8. Joint research and innovation in Blockchain technologies (cryptocurrencies and smart contracts)

During the SFWs, Blockchain appeared as both highly important/disruptive, but also not a priority. But according to the scenarios, Blockchain technologies, both in the form of cryptocurrencies or smart contracts, appear to be extremely important for INCOBRA's vision. In the most extreme scenarios, governance, finance, businesses, legal systems and jobs are impacted by ubiquitous access to networks and data. But even in controlled scenarios these issues remain critical. So, it's crucial that Brazil and the EU establish joint efforts to research and support innovation that use Blockchain technologies for smart contracts and cryptocurrencies.

9. Joint strategies for digital Inclusion & "smart slums"

As demonstrated in the scenarios, the nature of the internet is changing. From gadgets to ambient media, from operational systems to artificial intelligence. As previously mentioned, access to services happens via platforms and access to these platforms is crucial for INCOBRA's vision. To prevent a new digital divide scenario, it's important that Brazil and the EU focus on joint strategies and policies for digital inclusion. Also, it is extremely important that Smart Cities & Smart Systems infrastructures, technologies, strategies and innovations are distributed and reach impoverished areas – slums, shanty towns, etc.

10. Joint design of new city governance labs

All the scenarios and, therefore, all strategies lead to research, experimentation, design and implementation of innovations for new models for city governance and urban dynamics. To accomplish INCOBRA's vision, Brazil and the EU must jointly research, design and implement "living labs" for Smart Cities & Smart Systems. These labs must work as pilots and test fields for technologies, innovations, policies and strategies for citizenship participation, open city strategies, makerspaces, smart contracts, cryptofinance, wellness, privacy, data management and other themes.

Table 7.1. Robust Trajetories and Actions for Smart Cities and Smart Systems for short and medium to long-term

Trajectories	Actions		
	Short-term	Mid-term	Long-term
	2020	2025	2030
1. Brazil/EU startup ecosystem for urban innovation	Match BR/EU urban challenges and startups for collaboration	Resolve joint-venture regulations, funding and develop solutions	Deploy binational startups/solutions into BR/EU markets
2. Bilateral Brazil/EU commitment to long-range funding	Create BR/EU task force to map funding opportunities for urban solutions and tangential technologies	Create specific funds for in Brazil and EU, as well as binational funds, for urban solutions ventures Attract BR/EU venture capital to invest in startups focused on urban solutions	Permanent, self-sustained funding cycle for urban solutions startups via BR/EU public funds, as well as venture capitals
3. Cross-research between priority areas	Jointly map and include strategies that impact other priority areas as well as Smart Cities & Smart Systems strategies that impact other priority areas	Jointly implement strategies following synchronized timetables	Smart Cities & Smart Systems fully integrated with strategies for food, health, electronics, bio-fuels, green energy, etc.
4. Brazil/EU common knowledge, research and development of IoT protocols and solutions and next generation networks.	Jointly map current and emerging technologies in IoT and next generation networks Jointly create a research group, integrated with technology providers, to research interoperability protocols and best practices for Smart Cities & Smart Systems	Jointly develop interoperability protocols for Smart Cities & Smart Systems, as well as next generation network technologies	Fully interoperational IoT systems, artificial intelligence solutions and Blockchain technologies. Smart Cities & Smart Systems work seamlessly.

Table 7.1. Robust Trajetories and Actions for Smart Cities and Smart Systems for short and medium to long-term (cont.)

Trajectories	Actions		
	Short-term	Mid-term	Long-term
	2020	2025	2030
5. Joint policy development for net neutrality, data security, privacy and management	Develop and define BR/EU best parameters for net neutrality, data security, privacy and management.	Press countries into signing an agreement following INCOBRA's statement	Data bill of rights signed by BR/EU and under implementation
6. Development and sharing of Brazil/EU makerspaces and research facilities	Map research facilities and makerspaces in BR/EU focused on urban innovation.	Establish a network of BR/EU facilities and makerspaces researching, designing and developing urban solutions	BR/EU Urban Labs Network fully functional. Research and innovation database grows exponentially
	Develop sharing and collaboration terms between BR/EU research facilities and makerspaces	Build research facilities and makerspaces in BR/EU	
	Design new research facilities and makerspaces for BR/EU	Foster citizen engagement in maker culture in BR/EU	
7. Joint development of policies and new business models for work, health and mobility platforms	Map innovations in business models in work, health and mobility platforms in BR/EU	Test business models and policies in startups supported by INCOBRA	New rules and new business models for work, health and mobility platforms implemented and fully functional. Platforms benefit not only its owners, but the whole of their communities
	Jointly promote challenges to develop radically new business models in those		
	Map and propose policies to ensure wellness and fairness in work, health and mobility platforms		

Table 7.1. Robust Trajetories and Actions for Smart Cities and Smart Systems for short and medium to long-term (cont.)

Trajectories	Actions		
	Short-term	Mid-term	Long-term
	2020	2025	2030
8. Joint research and innovation in Blockchain technologies (cryptocurrencies and smart contracts)	Create BR/EU research and innovation groups to develop and prototype Blockchain technologies	Deploy INCOBRA's cryptocurrency in BR/EU and make it public	Citizens use INCOBRA's cryptocurrency. Smart contracts are used for a number of applications, from law cases to hyperlocal currencies
	Map current and emerging issues in cryptocurrencies in BR/EU	Deploy prototype smart contracts system for one of INCOBRA's the priority areas	
	Jointly map areas that potentially disrupted by smart contracts		
9. Joint strategies for digital Inclusion & "smart slums".	Map digital inclusion challenges in BR/EU	Develop and deploy a Smart Cities & Smart Systems digital inclusion strategic guide	Smart slums are the source of their own urban solutions and export their solutions to other urban areas in the world
	Jointly define common challenges and knowledge for digital inclusion in BR/EU	Implement strategies to prevent great divide scenarios	
		Integrate research facilities and makerspaces into impoverished areas	
10. Joint design of new city governance labs	Jointly map locations to establish and open, living urban lab in BR/EU	Choose location in BR/EU for the open, living lab	Two cities in Brazil and the EU are the first to test new forms of governance that discard mayors
	Jointly design a long-term experiment in disruptive governance solutions	Implement pilot for new governance and participatory citizenship solution	

7.5 | **Components of a Roadmap**

All robust strategies outlined in the previous section should be used to accomplish INCOBRA's vision of Smart Cities & Smart Systems, especially in the form of open cities with large citizen participation, innovation and inclusion. This vision, performed under a large and well-functioning collaboration between Brazil and the European Union will benefit both sites and help build new and better urban dynamics in both countries. To better visualize the scope and main challenges of this roadmap, we clustered the previous strategies in four major areas. These represent the key themes in our strategy up to 2030. Finally, to better coordinate this effort, we distinguish short-term actions (2020) midterm actions (2025) and long-term actions (2030).

Regulation and Policies

Definition: This layer refers to the development of joint strategies and policies that prevent digital divide scenarios, promote inclusion, diversity, citizen engagement and wellness.

Main challenges:

- Digital inclusion (and digital divide) might have different meanings in Brazil and the EU. Issues such as income, age, location and access to technologies, as well as culture and societal characteristics must be taken into consideration;

- Citizen engagement, especially in more radical scenario, might face strong resistance from the status quo. Politicians, local governments and political parties might feel threatened. On the other hand, make citizens engage in decision processes might be an even greater challenge;

- Wellness and health face regulatory challenges, depending on specialties and type of consultation. Also, data privacy and security is critical for the success of this layer.

Timing: Short, medium, and long term.

Market

Definition: This layer refers to new, private ventures (startups), that will research, develop, prototype and deploy solutions to urban problems using technologies such as AI, IoT, Blockchain, next generation networks, etc, to innovate in areas such as citizen engagement, wellness, health, governance, privacy, data security, cryptocurrencies, digital inclusion, etc.

Main challenges:

- Development and access to new technologies will impact the success or even the feasibility of solutions and startups;

- Funding is crucial for startup survival. Access (or lack of) to venture capital or public funding will determine rate of success in this line;

- Matching not just challenges common to Brazilian and EU cities, but also startups willing to collaborate and co-develop solutions is critical. Regulatory barriers preventing BR/EU joint-ventures are also critical to success.

Timing: Short, medium, and long term.

Knowledge Bases

Definition: This layer refers to sharing of knowledge and development of interoperability protocols for IoT, smart systems, artificial intelligences, cryptocurrencies and smart contracts, among others. It also refers to new policies that must be created in order to regulate (or de-regulate) urban innovations in order to benefit citizens and governance.

Main challenges:

- Local governments and policy makers must balance the benefits and impacts of either embracing the scenarios and their transformations, dealing with with change or even preventing change from happening;

- The IoT landscape is still very blurry in terms of interoperability. There are four or five groups designing different protocols of communication. There are even lone wolf companies who provide closed solutions. Choosing technologies and a starting point for protocols will have huge influence on the outcome;

- Disruption in some areas might face resistance from groups of interest. Cryptocurrencies and smart contracts will probably face suspicion and outright avoidance by banks, transportation and even government departments.

Timing: Short, medium, and long term.

Competences and Resources

Definition: This layer refers to the development of infrastructures for Smart Cities & Smart Systems strategies (network infrastructure, smart grids, datacenters, research facilities, makerspaces, etc), as well as the means for funding such ventures.

Main challenges:

- Monitoring, identifying and/or creating funding opportunities in both Brazil and the EU is critical to INCOBRA's collaboration;
- Timing is critical. Terms and scope of shared research facilities and makerspaces must be defined as quickly as possible;
- Citizen engagement in maker culture-style innovation might face resistance from both academic and business circles.

Timing: Short, medium, and long term.

Figure 7.4 shows the resulting Roadmap for a successful Brazil-EU cooperation on Smart Cities and Smart Systems:

Layers	Actions		
	Short-term	Mid-Term	Long-Term
	2020	2025	2030
Regulation and Policies	Map and propose policies to ensure wellness and fairness in work, health and mobility platforms	Resolve joint-venture regulations, funding and develop solutions	New rules and new business models for work, health and mobility platforms implemented and fully functional. Platforms benefit not only its owners, but the whole of their communities
		Press countries into signing an agreement following INCOBRA's statement	
Market	Match BR/EU urban challenges and startups for collaboration	Deploy binational startups/solutions into BR/EU markets	
		Build research facilities and makerspaces in BR/EU	
		Foster citizen engagement in maker culture in BR/EU	
		Test business models and policies in startups supported by INCOBRA	

Figure 7.3. Roadmap for Smart Cities and Smart Systems: actions versus layers for short, medium and long term

Layers	Actions		
	Short-term	Mid-Term	Long-Term
	2020	2025	2030
Knowledge Bases	Jointly map and include strategies that impact other priority areas as well as Smart Cities & Smart Systems strategies that impact other	Jointly implement strategies following synchronized timetables	Smart Cities & Smart Systems fully integrated with strategies for food, health, electronics, bio-fuels, green energy, etc.
	Jointly map current and emerging technologies in IoT and next generation networks	Jointly develop interoperability protocols for Smart Cities & Smart Systems, as well as next generation network technologies	Fully interoperational IoT systems, artificial intelligence solutions and Blockchain technologies. Smart Cities & Smart Systems work seamlessly.
	Jointly create a research group, integrated with technology providers, to research interoperability protocols and best practices for Smart Cities & Smart Systems	Build research facilities and makerspaces in BR/EU	BR/EU Urban Labs Network fully functional. Research and innovation database grows exponentially
	Develop and define BR/EU best parameters for net neutrality, data security, privacy and management	Deploy INCOBRA's cryptocurrency in BR/EU and make it public	Citizens use INCOBRA's cryptocurrency. Smart contracts are used for a number of applications, from law cases to hyperlocal currencies
	Design new research facilities and makerspaces for BR/EU	Deploy prototype smart contracts system for one of INCOBRA's the priority areas	Smart slums are the source of their own urban solutions and export their solutions to other urban areas in the world
	Map innovations in business models in work, health and mobility platforms in BR/EU	Develop and deploy a Smart Cities & Smart Systems digital inclusion strategic guide	Two cities in Brazil and the EU are the first to test new forms of governance that discard mayors
	Jointly promote challenges to develop radically new business models in those areas	Implement strategies to prevent great divide scenarios	
	Create BR/EU research and innovation groups to develop and prototype Blockchain technologies	Integrate research facilities and makerspaces into impoverished areas	
	Jointly map areas that potentially disrupted by smart contracts	Choose location in BR/EU for the open, living lab	
	Jointly map locations to establish and open, living urban lab in BR/EU	Implement pilot for new governance and participatory citizenship solution	
	Jointly design a long-term experiment in disruptive governance solutions		
Competences and Resources	Create BR/EU task force to map funding opportunities for urban solutions and tangential technologies	Create specific funds for in Brazil and EU, as well as binational funds, for urban solutions ventures	Permanent, self-sustained funding cycle for urban solutions startups via BR/EU public funds, as well as venture capitals

Figure 7.3. Roadmap for Smart Cities and Smart Systems: actions versus layers for short, medium and long term (cont.)

7.6 | Supporting Documents

Strategic Foresight Workshops Report (Deliverable D1.2 (WP1).

Strategic Foresight Workshops Report (Deliverable D1.2 (WP2).

Co-Patent Report (Included in D1.2).

Open Consultation Results (Included in D 1.1).

Survey of Existing Foresight Studies (Included in D 1.1).

8 | Conclusion

This report results from a joint collaboration amongst European and Brazilian partners of INCOBRA project. Its main objective is to present strategic Action Plans to foster R&I Cooperation in the five prioritized Areas.

It presents detailed Action Plans (hereafter APs) for R&I cooperation in five prioritized areas: Green Energy; Bio-resources; Food Security and Adaptation of Agriculture to Climate Change; Advanced Manufacturing and Nanomaterials; and Smart Cities and Smart Systems. These areas and respective contents were defined in the previous tasks and activities of INCOBRA.

This conclusion is structured in two parts: a) specific findings from APs; b) common findings under a cross cutting analysis.

8.1 | Specific findings from APs

8.1.1 Prioritized topics for R&I Cooperation

A number of specific hot topics for R&I cooperation were defined within each Priority Area. These topics may be seen in the boxes presented here bellow.

Green Energy

Green Energy focused on two main clusters of energy sources:

- **Sustainable biofuels and biorefineries; and**
- **wind, solar and mixes of renewables.**

Four cross-cutting themes have emerged as particularly interesting for R&I cooperation in these two groups:

- **Energy modeling/policy and regulation - benchmarking of best practices;**
- **Energy efficiency - applications, mobility, metering, data collection and treatment;**
- **Energy storage;**
- **Smart Grids.**

Sustainable Use of Bioresources

The following key aspects were highly prioritised for Bioresources:

- **Sustainable industrial biotechnology especially future generations of sustainable bio-refineries;**
- **Rational and effective use of industrial and agricultural waste/effluent;**
- **Conservation and sustainable use of biodiversity for new therapies;**
- **Rational and effective discovery and screening of bioactive compounds from the Brazilian biodiversity;**
- **Plant biotechnology.**

Food Security and Adaptation to Cimate Change

This Priority Area clustered priorities in two groups. Here bellow the main topics for each group:

Global Food Supply:

- **Food Security;**
- **Compliance with International Standards;**
- **South – South cooperation;**
- **Traceability;**
- **Zero Food Waste;**
- **Improvements in Agrifood Systems;**
- **Digital Farming.**

Climate Change and Sustainability:

- **Nutritional aspects of food products;**
- **Sustainble increase of productivity;**
- **Integrated Systems;**
- **Low Carbon and low GHG emissions;**
- **Precision Agriculture.**
- **Circular economy and Eco-innovation.**

Advanced Manufacturing and Nanomaterial

Priorities selected for Advanced Manufacturing and nanomaterial:

- **Strategic nanomaterials for applications in:**
  - **Energy and environment,**
  - **Consumer and security electronics,**
  - **Biotechnology,**
  - **Health and pharmaceutics,**
  - **Agriculture and food security and**
  - **Textiles**
- **Advanced manufacturing of innovative nanoscale materials, sensors and devices;**
- **Nanoscale metrology;**
- **Toxicity of nanomaterials, specific to each application field.**

Smart Cities and Smart Systems

The following topics summarize priorities set for Smart Cities and Smart Systems:

- **Citizen engagement - including distributed governance sharing economy;**
- **Ecosystems of wellbeing - including urban environment, health and social security;**
- **Privacy and Security - including Blockchain, data policies and analytics;**
- **New economies - including fintech, cryptocurrencies and collaborative economy;**
- **Internet of Everything - including autonomous systems, sensors, big data and analytics;**
- **Entrepreneurship - including innovation ecosystems, urban solutions and social.**

8.1.2 Robust Trajectories for R&I Cooperation in Prioritised Areas

Robust Trajectories (RTs) are defined as the strategies able to face uncertainties framed by the scenario analysis. They represent critical steps necessary to be considered in fostering R&I cooperation either for favourable or unfavourable scenarios.

A summary of RTs for each of the five Priority Areas is presented below.

Green Energy

1. **Incorporate into R&I cooperation a component of monitoring policies and regulatory frameworks that affect the future of Green Energy;**
2. **Focus on complementary niches/strategies for EU and BR in biofuels, solar and wind energy R&I themes;**
3. **Monitor/build long term financial strategy related to R&I cooperation among the EU, Brazil and others;**
4. **Monitor/build long-term competences and research capabilities related to Green Energy in the EU and BR;**
5. **Be extremely selective in setting priorities for collaborative R&I projects and activities with really high potential of technological cum market success;**
6. **Establish a minimum level of density for R&I cooperation to guarantee scale and scope economies;**
7. **Engage the private sector in both sides of R&I cooperation.**

Sustainable Use of Bioresource

1. Brazil/EU supportive regulatory framework for sustainable use of bio-resources;

2. Brazil/EU common knowledge base and research protocols on sustainable use of bio-resources;

3. Bilateral Brazil/EU commitment to long-range funding;

4. Involving civil society in the development of bioeconomy;

5. EU/Brazil sharing of bioeconomy research facilities;

6. EU-BR shared educational curriculum in sustainable use of bio-resources;

7. Create durable personal relationships between Brazilian and European researchers and innovators in sustainable use of bio-resources;

8. Foster EU/Brazil pioneering coalitions;

9. Experimenting breakthrough solutions in protected niches;

10. Optimising bio-waste collection and utilization processes through bi-lateral development of policies, partnerships, and technologies.

Food Security and Adaptation to Climate Change

1. **Use of interdisciplinary or transdisciplinary teams;**
2. **Stimulate transformative and systemic projects to satisfy consumers' needs;**
3. **Develop collaborative networks to strengthen learning and strategic goals;**
4. **Different agricultural models;**
5. **Creation of a new food-quality policy;**
6. **Use of different tools and co-creation methods at some stage of the research/production process;**
7. **Monitor efficient supply chains and benchmark best technological practices;**
8. **Monitor and benchmark for financial support for Food Security and Adpatation of Agriculture to Climate Changes.**

Advanced Manufacturing and Nanomaterials

1. **Establishment of a legal framework for the Brazil-EU collaboration in Advanced Manufacturing and Nanomaterials R&I**
2. **Development of a joint Brazil-EU multi-annual work Program in Advanced Manufacturing and Nanomaterials R&I**
3. **Brazil-EU industry participation in the definition of collaboration priorities in Advanced Manufacturing and Nanomaterials R&I**
4. **Joint Brazil-EU establishment of Open Innovation Hubs for strategic Nanomaterials Advanced Manufacturing R&I**
5. **Joint Brazil-EU commitment to develop a continuous training program in Advanced Manufacturing for science and engineering graduates and technicians**
6. **Design of a common evaluation protocol for BR-EU collaboration R&I programs in Advanced Manufacturing and Nanomaterials.**

Smart Cities and Smart System

1. Brazil/EU startup ecosystem for urban innovation;

2. Bilateral Brazil/EU commitment to long-range funding;

3. Cross-research between priority areas;

4. Brazil/EU common knowledge, research and development of IoT protocols and solutions and next generation networks;

5. Joint policy development for net neutrality, data security, privacy and management;

6. Development and sharing of Brazil/EU makerspaces and research facilities;

7. Joint development of policies and new business models for work, health and mobility platforms;

8. Joint research and innovation in Blockchain technologies (cryptocurrencies and smart contracts);

9. Joint strategies for digital Inclusion & "smart slums";

10. Joint design of new city governance labs.

As can be observed, RTs show both specific, and common measures. The latter may be taken as transversal and pervasive strategies across all Priority Areas.

A crosscutting analysis of the set of Robust Trajectories - and Actions referred in each of the Priority Areas - has shown eight major strategies that can be understood as of highly important to the endeavor of building up R&I cooperation between Brazilian and European stakeholders. Next item presents these findings.

8.2 | **Common findings across Priority Areas**

As mentioned, eight common strategies may be drawn from a transversal analysis of the five Priority Areas. These are the following (Figure 8.1):

Figura 8.1 – Common fidings across Priority Areas

1. **Monitoring of and contributing to regulation and policy**

Regulation and policies are of major relevance to promote bilateral R&I cooperation in the five Priority Areas. All Areas are particularly sensitive to legal definitions and to the political preferences. Even more important, those Areas have been increasingly subjected to international rules and agreements. Climate change -and other environmental issues; food production and land use; access to and use of natural resources; potential health risks associated with nanotechologies; policies towards energy production and consumption; just to mention a few, are critical domains deeply affected by regulation and political preferences. In this respect, R&I cooperation both at programme or project levels must take into account the regulatory and political perspectives surrounding the subjects and objectives of cooperation.

2. **Constant search for funding**

Funding is a natural major concern, particularly thinking in bi- or multilateral long-term cooperation. It is of core importance to prospect different sources and schemes for financing R&I cooperation beyond the regular and most obvious ones. APs are aligned with recent priorities set by the EU and Brazil. However, priorities are expected to change, depending on the new scientific, technological and societal drivers.

In order to implement the set of priorities defined in the APs a constant flow of funding has to be immediately identified. Of course in its initial steps this will probably be strongly dependent on the regular sources from Brazilian and European sides.

That is why an institutional initiative from INCOBRA is here needed. INCOBRA must negotiate financial support within regular funding agencies in order to assure the necessary resources to implement R&I cooperation for the selected priorities. Moreover, it also needs to start looking for alternative and complementary financial sources.

3. **Sharing common knowledge and facilities**

This strategy points to two main issues: exploring scale and scope economies, and assuring reciprocity in R&I cooperation between Brazil and EU. A win-win strategy over research and innovation shall combine different interests and asymmetries amongst stakeholders.

It is important to notice the double advantage of exploring complementary competences in R&I cooperation: it entails conditions to reduce transaction costs and to increase potential impacts for both sides.

4. **Selecting common R&I topics across the five Priority Areas that leverage the complementary knowledge, framework conditions and longstanding cultural linkages between Brazil and EU**

This also refers to taking advantage of scope economies since many hot topics selected along the five Priority Areas may be seen as of mutual interest. For instance, “sustainability” is an ubiquitous word that could drive R&I projects and programmes. An immediate example would be a project focusing on nanotech applied to bio-resources and biofuels for promoting smart cities and contributing to the reduction of GHG emissions.

5. **Identifying pioneering coalitions for R&I cooperation**

This strategy aims to committing key stakeholders in the process of R&I cooperation. Industry, civil society, research community, to mention the most known, may be connected in resilient coalitions based on subjects of common interested. For instance, specific regional ecosystems in areas of mutual interest (nanotech, smart cities, biofuels, climate change etc.) or even complementary arrangements over value chains (transport/mobility, food security, bio-based products etc.) could constitute pioneering coalitions for medium- and long-term cooperation.

6. **Engagement of the business sector as a core contributor in R&I cooperation**

Whatever the programme or project, if innovation is expected as an outcome of R&I cooperation, business sector must be a main contributor. Depending on the TRL of a project companies are supposed to be involved since the designing phase until the deliver of outputs and outcomes. Higher TRL’s projects urge for having business sector on board.

7. **Involving Civil Society as a constant stakeholder**

Citizen engagement is an increasing concern of R&I activities for many complementary reasons. Whether for evaluating impacts of R&I outcomes over civil society or for prospecting priorities or even for establishing translacional research, this is a core issue to build up a culture of responsibility in R&I activities. Engagement of civil society also contributes to increase social legitimacy of science and technology, and by extension contributes to the advocacy of R&I within different segments of society.

8. **Establishing best governance practices for R&I cooperation**

Last but not least, there is an operational cross cutting strategy critical to succeed in R&I cooperation. Governance and best practices for R&I projects and programmes are a cornerstone for the success of EU Brazil R&I cooperation. Harmonizing rules and management tools and practices may make the difference for any TRL level.

Each time more scientific and technical merit has been complemented by managerial elements of merit.

9 | Annex

9.1 | Technical Justification of five areas for EC

Green Energy

Introduction

At the time of inception the INCOBRA Project had pointed out six primary areas of R&I to be tackled by tasks 1.1[59] and 1.2[60]: Energy, Information and Communication Technology (ICT), Nanoscience and Nanotechnology, Food Security and Sustainability Agriculture, Marine Research and the Bioeconomy.

Task 1.1 and 1.2 have gathered and analyzed information about those primary topics from a variety of source in order to prepare a background document as a basis of discussion in two Strategic Foresight Workshops (SFWs), organized in Campinas and in Frankfurt. Together, these SFWs engaged about 70 specialists.

Activities leading to the background document included data and text mining of co-publications and co-patents; a structured open consultation to identify preferences from different groups of stakeholders; a broad survey of Brazilian organizations about critical issues on R&I cooperation; and an evaluation synthesis of existing foresight studies on the aforementioned six fields carried out in both the European Union and Brazil. The generated detailed information was used to inform and guide participants of the two SFWs.

Green Energy (non-fossil, carbon-friendly sources) – was definitely considered a central issue for R&I cooperation between the EU and Brazil.

Argument to support Green Energy as a priority topic

Previous foresight studies: Brazil and the EU have defined wide-ranging initiatives in the domain of energy, **particularly new sources of energy and renewables**. Enabling sustainable energy, lowering greenhouse gas emissions, pollution and fossil fuel dependence are common targets for both the EU and Brazil. Although different storylines exist between the two regions in developing their sources of energy (for instance: biodiesel v. bioethanol; electric v. flex-fuel engines; nuclear and coal v. hydroelectricity), there are several complementary initiatives in almost all range of possibilities related to sources of energy and energy efficiency.

Open consultation: participants stressed the overall importance of the energy topic for the development of the society and outlined the **favorable framework conditions of renewable sources** in Brazil. Respondents also recommended specific topics: renewable energy at the countryside of Brazil; bioenergy, second generation biofuels from waste biomass; solar energy, solar energy transportation, ethanol fuel, etc.

Analysis of scientific publications and patents: the main foci are biofuels and biofuel technologies; concentrated solar power; transport decarbonisation; wind power; environmental impacts of biofuels; smart grids; and new biofuels using sustainable feedstocks.

[59] Task 1.1. Understanding the R&I cooperation patterns among BR and EU R&I actions in priority áreas.
[60] Task 1.2. Applying strategic foresight to identify emerging topics for BE-EU R&I cooperation activities.

Broad survey of Brazilian R&D-intensive organizations on critical issues on R&I cooperation: the two main topics stressed by respondents were ICT and Energy.

Strategic Foresight Workshops: Green energy was clearly defined as a priority topic by SFW participants (see preferences and comments in Annex 1). It is considered not only a priority per se, but also a cross-cutting priority capable to positively impact many other themes such as food security, climate change, advanced manufacturing, smart systems and smart cities to mention a few.

Priorities for international cooperation in research and innovation (COM, 2016)[61]: "Since one decade ago, the EU and BR have had a Strategic Partnership, for instance, in the area of **Fusion Energy** Research. Brazil remains at the frontier of research in the fields of ICT, nanotechnologies and **energy**. Brazil has been invited to become a member of International Bioeconomy Forum. Etc. Furthermore, there is ongoing cooperation through the Sector dialogues facility in the field of Alternative Methods to animal use and **Agroecology Platforms**. More specifically in the field of energy, **advanced biofuels** is the topic of coordinated call in the WP2016-17 of Horizon 2020 which aims at exploiting synergies between Brazil and Europe in terms of scientific expertise and resources in this area. Joint work can build upon the Brazilian sugarcane ethanol model and should benefit from the Brazilian and European experience in biofuels. Brazil will be an important partner in the context of Mission Innovation". Other areas cross Green Energy, for example: the domain of nanosafety (manufactured nanomaterials), sustainable urbanization, with focus on 'sustainabel and re-naturing cities' and on the building of a platform of technologies inspired by nature.

Next item deploys what have been considered specific priorities within Green Energy.

Priority subtopics of Green Energy pointed by tasks 1.1 and 1.2

Table 1. Emerging priorities from previous foresight studies

TOPICS of research found in BRAZILIAN studies	TOPICS of research found in EUROPEAN studies
• Biofuels and Renewable energy, particularly bioethanol of first and second generations • Energy efficiency • Safety in production of oil, gas and coal to increase competitiveness of national industry • Electricity generation and Smart Grid • Co-generation (biomass for biofuels and electricity) • Oil and gas production in deep Waters • Solar and Wind Energy • Implementation of semi-industrial escalation of open platforms, multi-user and adapted to multiple purposes	• EU Energy strategy • Green House Gas Reducing Technologies and Methods • Renewable Energy Sources: Technology (SET Plan), Integration with Transmission • Create EU wide, single market for Energy • Storage Technologies • Smart Grid Technologies • Zero Energy Architecture • High Energy Efficient Consumer Products • Sustainable Land-use Practices for Biomass Production •

[61] Extracted from the document Priorities for International Cooperation in R&I. Report from the Commission to the European Parliament. Commission Staff Working Document, Brussels, 13 October 2016.

Table 2. List of research priorities reviewed by the Working Group on Energy (Task 1)[62]

List of priorities in Energy
1. Energy modeling/policy and regulation - benchmarking of best practices
2. Energy efficiency - metering, data collection and treatment; monitoring and evaluation
3. Energy efficiency - aplications: industry
4. Energy efficiency - aplications: buildings
5. Energy efficiency - aplications: mobility
6. Energy storage
7. Renewable energy - biorefineries and sustainable and advanced bioenergy (second and third generation biofuels)
8. Wind, solar and biomass - massive integration to the grid
9. Non conventional oil and gas (including fracking)
10. Challenges related to a better use of nuclear energy
11. Green house gas reducing technologies and methods
12. Smart Grids

Table 3. Outcome of average grade by individual specialists (Task 2)[63]

List of priorities in Energy	Average from individual grade
Renewable energy - biorefineries and sustainable and advanced bioenergy (second and third generation biofuels)	12,3
Wind, solar and biomass - massive integration to the grid	11,9
Energy modeling/policy and regulation - benchmarking of best practices	11,8
Energy efficiency - aplications: mobility	11,8
Energy storage	11,7
Energy efficiency - aplications: buildings	11,6

[62] The Task was to review the given topics (Table 1) and select up to twelve with high potential for cooperation research. From the previous themes the Group chose just one topic from the EU side because it was considered a theme of mutual benefit in R&D: Green House Gas Reducing Technologies and Methods.

[63] In this Task the Group gave individual assessment for the following criteria: 1. degree of established competences in Brazilian public and private-not-for-profit research organizations (compared to international standards); 2. degree established competences in Brazilian companies (compared to international standards); 3. degree of expected relevance for innovation (expectation to contribute to the generation of new goods, processes and services); and 4. degree of expected contribution for the establishment of strong R&D networks between Brazil and Europe (expectation to contribute to the creation/maintenance of lasting research collaboration).

Energy efficiency - metering, data collection and treatment; monitoring and evaluation	11,5
Non conventional oil and gas (including fracking)	11,5
Challenges related to a better use of nuclear energy	11,4
Energy efficiency - aplications: industry	11,4
Green House Gas Reducing Technologies and Methods	10,4
Smart Grids	10,0

Table 4. Suggested ranking of specific subtopics in Green Energy

Rank	Prioritazed topics	Comments
1	Energy modeling/policy and regulation - benchmarking of best practices	Studies of political, regulatory, impacts and planning issues need to be addressed considering specific goals of both sides, and also for support new goals and public policies. Modeling needs of specific processing in the EU and BR cooperation research. According to specialists special processing for planning issues as well, because of increase demand, and many other themes based on this topics, e.g. data and information need to be trustworthy. The research in these themes/issues can support discussion and research in all topics hereafter.
2	Energy efficiency - metering, data collection and treatment; monitoring and evaluation	The importance of smart metering is related, among others, to its potential as a backbone of IoT (Internet of Things or Everything) to collect data and its implication for big data and data mining issues. The use and processing of data and information should be researched to support political agendas (e.g.: Whom the information belongs to? What will be the utilities' rules?). New methodologies need to be defined to understand the behavior of the consumers. There is a gap in the use of methods and recommendations in this area. The other topics have specific issues to be addressed: (5) energy efficiency – applications: mobility; (8) energy efficiency – applications: buildings; and (9) energy efficiency – applications industry.
3	Smart grids	There are a lot of political issues to be addressed (e.g. the advanced of public policies and regulation decisions from USA government).
4	Energy storage	There are huge challenges in R&D, mostly related to generation issues (renewable and traditional). And all range of R&D, use and applications with different players in the global value chain. The individual production should be considered because of its influence on competitive issues.
5	Energy efficiency - aplications: mobility	The Group decided to divide the topic “energy efficiency” in three topics.
6	Renewable energy - biorefineries and sustainable and advanced bioenergy (second and third generation	There are huge challenges in this subject for both sides, Brazil and EU, in a way to promote different R&I opportunities considering the current value chain, and to increase competitiveness of this renewable

	biofuels)	market. Climate change, CO2 emission are big challenges in this context. There is a lack of studies in this field.
7	Wind, solar and biomass - massive integration to the grid	The market is dominated by China, Germany, USA, and Denmark. Considering this fact, the opportunity for R&D cooperation should focus on integration and intermittence issues. And also on different netWorking of gas, liquid, power, etc.
8	energy efficiency - aplications: buildings	The Group decided to divide the topic "energy efficiency" in three topics.
9	Energy efficiency - aplications: industry	The Group decided to divide the topic "energy efficiency" in three topics.
10	Green House Gas Reducing Technologies and Methods	Importance for cooperation between BR and EU because of the relevance of the topic for EU.
11	Non conventional oil and gas (including fracking)	New rules for environmental and human protection. Fracking must not harm the environment. Brazil has specialists in many areas relevant to gas and oil exploration.
12	Challenges related to a better use of nuclear energy	Follow up of international innovations and topics in nuclear discussions and methods. Poor logistics in Brazil.

Sustainable Use of Bio-Resources

This topic area is inextricably related to the Bioeconomy (a priority research area for the EU and Brazil (reference 2016 roadmap)). The bioeconomy broadly refers to the exploitation of biological processes and organisms across a great many fields and industries including: Bio-Fuels, Bio-Plastics, Health and Medical Applications, Pharmaceuticals, Industrial use of Enzymes and Organisms, Agro-Industry, GHG reduction systems, and Aquaculture. Due to its present and anticipated importance, the Bioeconomy was one of the five primary Research Areas highlighted in the initial INCOBRA project proposal, and has therefore been central to our Action Plan development of process through all of WP1.

The subsequent investigations confirmed the significance of the area and to specify the focus:

As our ***survey of past foresight studies demonstrated***, both Brazil and the EU have a long standing commitment to science, technology, and innovation with regards to Bioeconomy, and a shared concern for maintaining biodiversity as a valuable resource. The present and future value of Bioresources is further evidenced in both the ***publication and co-patent analysis*** (WP1.1), which showed an upward trend of value-adding EU/BR partnerships over the last decade.

The bottom up approach of the work package included an extensive ***open consultation*** to integrate multiple opinions on cooperation possibilities and explicit suggestions for cooperation from science and industry in Brazil and Europe. The participants stressed the complementary expertise and the synergetic competencies of Brazil and the EU and pointed at the strong links that exist between bioeconomy, energy, nanotechnology and sustainable agriculture. Bioeconomy was perceived as an area that could contribute to the societal changes and needs in the upcoming years. These results of the open consultation are in line with the fact that Brazil has been invited to become a member of the International Bioeconomy Forum. Furthermore, nearly 25% of participants in the INCOBRA open consultation identify as scientists and researchers with Bioeconomy, whose recent emergence as a collaboration area was underscored by data supporting that Horizon 2020 was their first experience with bi-lateral project proposals.

During the ***Strategic Foresight Workshop process***, it became clear through discussion, and critical vision development, that Brazil/EU cooperation in the area of bioeconomy should adopt an ambitious, visionary long-term oriented perspective with a clear orientation towards societal needs in both regions. Accordingly it was emphasised that the cooperation should not be narrowly focus on optimising one specific aspect of the bioeconomy but take a systemic and holistic perspective that spans across several sectors such as health, energy, agriculture and food, embraces different types and uses of bio-resources and also addresses the embedding into the context e.g. of an urban environment. Finally, recent developments in Brazilian policy (explicitly the Biodiversity Access Law of 2016), and Brazil's role in COP21 *Biofuture Program* shaped dialogue and creative visioning during both of the workshops – clearly elevating practices and policies that preserve biodiversity or environmental health even as industrial use of biology intensifies.

The proposed focus on "sustainable use and management of bio-resources" for the action plan development takes up all these considerations.

This newly introduced umbrella perspective does not substitute the topics that have been discussed under the heading of bioeconomy but instead aligns all key topics highlighted as relevant in both workshops ("Sustainable Bio-economy", "Sustainable use of Biodiversity for new therapies and Conservation of Biodiversity.", "Biorefineries", "Industrial Biotech with infrastructure for all types of bio product" "Rational and effective discovery and screening of bioactive compounds from the Brazilian biodiversity"). The new perspective however seeks to ensure the long term societal support for the transformation process towards a sustainable bioeconomy both from R&I communities and wider society in Brazil and Europe.

To sum up, as a results of the expert opinion gathered at both strategic foresight workshops, and in conjunction with the research into prior foresight, co-publications, and co-patents, the "Sustainable Use of Bioresources" is viewed as a critical over-arching topic area through which various INCBORA activities can align and provide exciting collaborative R&I progress to the benefit of both the EU and Brazil.

Next item deploys what have been considered specific priorities within Sustainable Use of Bioresources.

Priority subtopics of Bioresources pointed by tasks 1.1 and 1.2

Table 1. Emerging priorities from previous foresight studies

TOPICS of research found in BRAZILIAN studies	TOPICS of research found in EUROPEAN studies
• Bioethanol, first and second generation (E2G) • Thermal Biogas Plants • Bioplastics • Biotechnology • Industrial Biotechnology • Health and Medicine applications • Biopharmaceuticals • Agroindustry applications • Biofuels other than ethanol • Environmental applications	• Certification and standards to improve quality and trade conditions • Genetic engineering in production of: Animal feeds, food crops, and livestock • Bio-sensors for diagnostic, preventative, and cu-rative applications • Pharmaceutical productions, addressing genetic diseases • Energy efficient, biological pathways for industrial processes

• Sustainable use of biodiversity • Promotion of consumer awareness about the role they play within this domain • Investment in sustainable management tech-niques at local level aiming at better social-environment balance • Encouragement of responsible RD & I to promote the conservation, monitoring, mapping, modeling, management and valuation of goods and services supplied from biodiversity and ecosystems • Development of biorefineries • Green Chemistry and Sustainable Processes • Nanobiotechnology • Plant biotechnology • Biocatalysis	• Green House Gas Reducing Technologies and Methods • Ecological intensification (designing of multifunc-tional agro-ecosystems sustained by nature and sustainable in their nature) • Sustainable development of aquaculture

Table 2. List of research priorities reviewed by the Working Group on Energy (Task 1)[64]

List of priorities in Bioeconomy
1. Plant Biotech
2. Industrial Biotech (Enzymes)
3. Nanobiotechnology
4. Biopharmaceuticals
5. New active ingredient discovery for biodiversity
6. Intensification of sustainable agriculture within a highly dispersed biodiversity
7. Rational and more effective screening strategies for the Brazilian Biodiversity, early drug discovery
8. Genetic therapeutics (health application and engineering) includes synthetic biology
9. Advanced instrumentation for biosciences (medicine) through better access to EU facilities
10. rational utilisation of waste and residues to add value in the nano bio value chain

[64] The Task was to review the given topics (Table 1) and select up to twelve with high potential for cooperation research. From the previous themes the Group chose just one topic from the EU side because it was considered a theme of mutual benefit in R&I cooperation.

11.	Biorefineries (Biochemicals, Biofuels)
12.	Biosensors for point of care diagnostics

Table 3. Outcome of average grade by individual specialists (Task 2)[65]

List of priorities in Bioeconomy	Average from individual grade
Advanced instrumentation for biosciences (medicine) through better access to EU facilities	10
Biosensors for point of care diagnostics	9,7
Nanobiotechnology	9,6
Genetic therapeutics (health application and engineering) includes synthetic biology	8,9
Biorefineries (Biochemicals, Biofuels)	8,8
New active ingredient discovery for biodiversity	8,5
Plant Biotech	8,3
Intensification of sustainable agriculture within a highly dispersed biodiversity	8,2
Biopharmaceuticals	7,86
rational utilisation of waste and residues to add value in the nano bio value chain	7,7
Rational and more effective screening strategies for the Brazilian Biodiversity, early drug discovery	7,6
Industrial Biotech (Enzymes)	7,4

Table 4. Suggested ranking of specific subtopics in Bioresources

Rank	Prioritized topics	Comments
0 = Crosscutting	Sharing of advanced instrumentation facilities for bio-economy	This will bring together researchers and innovators in the domain and may initiate all sorts of co-operations including unexpected ones
1	Biorefineries	(see below)
2	Industrial Biotech	Strong industries in Brazil. Unique availability of huge diversity of feedstock e.g. Eucalyptus varieties. Brazil is competitive in sucrose as feedstock there is also a local industry for glucose sources. Industrial Bioetchnology to produce enzymes (new strains, process engineering, etc) which could bring cost effectiveness and positive impact on final Ethanol Cost are valuable to that industry. Brazil has recently announced a strategy in this domain,

[65] In this Task the Group gave individual assessment for the following criteria: 1. degree of established competences in Brazilian public and private-not-for-profit research organizations (compared to international standards); 2. degree established competences in Brazilian companies (compared to international standards); 3. degree of expected relevance for innovation (expectation to contribute to the generation of new goods, processes and services); and 4. degree of expected contribution for the establishment of strong R&D networks between Brazil and Europe (expectation to contribute to the creation/maintenance of lasting research collaboration).

		industry has launched a roadmap in 2013 (CNI). ->There is a strong potential for Brazil to move on and become a leader. Substantial contribution to decarbonisation of transport and thereby fulfilling the Paris agreement (see COP21 Biofuture Platform). Urgent need for better alignment of biofuel strategies with Europe. The strategies of European carmakers have strong impact on Brazil.
3	Rational and effective discovery and screening of bioactive compounds from the Brazilian biodiversity	Brazil has a competitive advantage here, it needs to move further. Cooperate where we are strong. Avoid role of raw material provider. The recent biodiversity law is facilitating cooperation in these areas. This is of tremendous importance for food security, energy, and regional development. Huge social and economic impact.
4	Plant biotechnology	Big potential for health, e.g. vaccines, disease control. Need to improve innovation with support from European companies.
5	Gene therapy and engineering	Brazil is strong in medical research which provides a good basis for cooperation. Brazil has good science but not enough research facilities. Cooperation with Europe will be of mutual benefit.
6	Biosensors/Lab on a chip	There were no comments
7	Intensification of sustainable agriculture including in highly dispersed biodiversity	There were no comments
8	Rational and effective use of industrial and agricultural waste/effluent	Current practices are highly unsustainable both ecologically and economically. Huge parts of biomass are just thrown away instead of used. Substantial savings can be excepted, e.g. in processing sugar cane. This is important for green cities.
9	Regenerative medicine	There were no comments
10	Nano-biotechnology	There were no comments

Food Security and Adptation of Agriculture to Climate Change

Introduction

Since its inception, INCOBRA Project established six primary areas of R&I to act as an initial base to be discussed by tasks 1.1[66] and 1.2[67]: Energy, Information and Communication Technology (ICT), Nanoscience and Nanotechnology, Food Security and Sustainable Agriculture, Marine Research and the Bioeconomy.

[66] Task 1.1. Understanding the R&I cooperation patterns among BR and EU R&I actions in priority áreas.
[67] Task 1.2. Applying strategic foresight to identify emerging topics for BE-EU R&I cooperation activities.

Task 1.1 and 1.2 have gathered and analyzed information about those primary topics from a variety of sources in order to prepare a background document as a basis of discussion in two Srategic Foresight Workshops (SFWs), organized in Campinas and in Frankfurt. Together, these SFWs engaged about 70 specialists.

Activities leading to the background document included data and text mining of co-publications and co-patents; a structured open consultation to identify preferences from different groups of stakeholders; a broad survey of Brazilian organizations about critical issues on R&I cooperation; and an evaluation synthesis of existing foresight studies on the aforementioned six fields carried out in the European Union and Brazil. The generated detailed information was used to inform and guide participants of the two SFWs.

Food Security and Adaptation of Agriculture to Climate Change is one of the five priority themes defined by task 1.2. This is a wide theme covering different subtopics that also relate to the present EU priorities for R&I cooperation recently defined by the Commission.

Argument to support Food Security and Adaptation to Climate Change as a priority topic

Previous foresight studies: Food Security and Sustainable Agriculture is a clear domain where both Brazil and the EU show mutual and deep interest. Brazil is the country possessing the biggest ready-to-cultivate land area in the world, with more than 150 million hectares available without cutting down forests. On the other hand, Brazil is also a major consumer of pesticides and other hazardous products, and agriculture is among the most polluting activities in this country, particularly for GHG emissions. On the European side food security and sustainable agriculture is a major and long-term topic of interest whether headed to health and environmental safety or to strategic food supply. The Common Agriculture Policy is probably one of the most enduring policies of the Region. Common challenges faced by both Brazil and the EU in developing their research and development capabilities for Food Security and Sustainable Agriculture include the **development of technologies that enable the adaptation of crops to climate change**, particularly to higher temperatures, and reducing environmental impacts of agri-food systems without compromising the long-term supply of food. One example of action recently carried out is RD & I to promote new products in agricultural, agro-industrial and agro-forestry through the sustainable use of Brazilian biodiversity and inputs suitable for sustainable farming, agroecological and organic production.

Open consultation: Some quotations found in the open consultation survey help to understand the importance of this issue to both sides. *"Sustainable crop production in Brazil and the EU are complementary not only due to the situation in different hemispheres and latitudes, but also because we share many crops and common research interests. Brazil can provide valuable genetic resources for some crops and the EU for others."; "Scientific capabilities in agriculture in Brazil are fairly good (plant breeders, pathologists, molecular biologists, excellent plant genetic resources and germplasm banks) and they can speak at very similar level with EU partners". "Brazil has put in place important institutions (for instance EMBRAPA) to foster innovation in agriculture and agro-industries. Brazil has developed technologies for growing crops typical of temperate climate in tropical soils. This strategy has been a success in terms of productivity. However, there are still concerns about environmental aspects of these techniques which could eventually been studied through cooperative arrangements. There could be a complementarity of capabilities between the two teams - the Brazilian team and the EU team".*

Some specific topics from open consultation are: food safety – control of contaminants will improve public health and trade-; smart irrigation and water management through ICT Complementary strengths in Europe and Brazil; sustainable agriculture taking into account human and animal lives; smart sustainable plastic packaging; etc.

Analysis of scientific publications and patents: sicentific and technological production from R&I cooperation between the EU and Brazil show high level of publications on topics about nutritional aspects of food products; agro-economic areas; agroecological intensification; low carbon agriculture; production of safe seafood products; certification and standards to improve quality and trade conditions; food security; sustainable agriculture; Improvement of agricultural production systems; etc.

Broad survey of Brazilian R&D-intensive organizations on critical issues on R&I cooperation: Sustainable agriculture and Food Security together accounted for more than 35% of preferences pointed by participants.

Strategic Foresight Workshops: Food security and adaptation of agriculture to climate change is also a high priority topic that came up during the two SFWs (see the list and comments in Annex 1). Climate change is supposed to have far-reaching impacts on crop, livestock and fisheries production, and will change the prevalence of crop pests. Many of these impacts are already measurable, but others are still to be studied (climate impact studies are focused on the effects on crop yields), as for systemic approaches for food production and quality. Given the serious threats to food security, attention should be shift to an action-oriented research agenda.

Priorities for international cooperation in research and innovation (COM, 2016)[68]: Cooperation through the Sector Dialogues facility in the field of Alternative Methods to animal use and Agroecology Platforms. Identified topics in that document include ocean observation and forecasting systems, food security (including aquaculture).

Next item deploys what have been considered specific priorities within Food Security and Adaptation to Climate Change.

Priority themes

Table 1. Emerging priorities from previous foresight studies for food security and sustainable agriculture

TOPICS of research found in BRAZILIAN studies	TOPICS of research found in EUROPEAN studies
• South-South Cooperation in Food Security • Global Food Supply • New agricultural, agro-industrial and agro-forestry products • Increased agricultural productivity • Precision agriculture • Integrated agri-forest systems • Lowering GHG emissions • Enabling small-holders to access systems of research and innovation • Agriculture and agroindustry as a way to promote regional development	• Improvement of agricultural production systems • Adaptation to climate change • Nutritional aspects of food products • Seabed critical raw materials • Agro-economic areas • Low carbon agriculture • Production of safe seafood products

[68] Extracted from the document Priorities for International Cooperation in R&I. Report from the Commission to the European Parliament. Commission Staff Working Document, Brussels, 13 October 2016.

Table 2. List of research priorities reviewed by the Working Group on Food Security and Sustainable Agriculture (Task 1)[69]

List of priorities in Food Security and Sustainable Agriculture
1. Climate changes and sustainability (above mentioned)
2. Food security (above mentioned)
3. Global Food Supply
4. Increased agricultural sustainable productivity. It Includes precision agriculture, genetic improvement, digital farming, specimen diversification, land use and cover, improvement of agricultural production systems, and hydric resources;
5. Integrated agri-forest-livestock systems, including Includes Low carbon agriculture.

Table 3. Outcome of average grade by individual specialists (Task 2)[70]

List of priorities in food security and sustainable agriculture and marine research	Average from individual grade
Food security	13,00
Climate changes and sustainability	12,67
Integrated agri-forest-livestock systems	11,00
Global Food Supply	9,67
Increased agricultural sustainable productivity	9,67

69 The Task was to review the given priorities (Tables 1) and select up to twelve with high potential for cooperation research (Tables 2).

70 In this Task the Group gave individual assessment for the following criteria:
Degree of established competences in Brazilian public and private-not-for-profit research organizations (compared to international standards);
Degree established competences in Brazilian companies (compared to international standards);
Degree of expected relevance for innovation (expectation to contribute to the generation of new goods, processes and services);
Degree of expected contribution for the establishment of strong R&D networks between Brazil and Europe (expectation to contribute to the creation/maintenance of lasting research collaboration).
Table 3 shows the result based on average grades given by experts for each priority topic.

Table 4. Final ranking by the Working Group and comments in Food Security and Sustainable Agriculture[71]

Rank	Prioritized topics	Comments
1	Increased agricultural sustainable productivity	Including Precision agriculture, genetic improvement, digital farming, specimen diversification, land use and cover, Improvement of agricultural production systems, and hydric resources
2	Food security	Including Production of safe seafood products, aquaculture, food chain management, Nutritional aspects of food products
3	Integrated agri-forest-livestock systems	Including Low carbon agriculture
4	Global Food Supply	There were no comments
5	Climate changes and sustainability	Including Lowering GHG emissions, Sustainable Atlantic ecosystem Adaptation and mitigation to climate change

Advanced Manufacturing and Nanomaterials

The topic area of “Advanced Manufacturing and Nanomaterials” emerged from the strategic foresight workshop (WP1) component of the INCOBRA project as an area of critical convergence for future collaboration. While the original INCOBRA project proposal included Nanotechnology as a key area for ongoing and future bi-lateral cooperation, developments within the field as it moves to integrate with industrial applications led us to further refine the topic area as it aligns with, and invokes new, technological and procedural advancements in the manufacturing sector. The newly defined area better reflects and the current and forward thinking expert opinion concerning Nanotechnological research and innovation, and focuses the INCOBRA Action Plan to be of more utility to policy makers, investors, and social stakeholders.

Through the strategic foresight workshop series, and the research that accompanied and supported both events, the importance of Nanomaterials emerged as a critical both a critical R & I area for both the EU and Brazil, and as the primary conjunction of nanoscience and industrial applications. Evidenced in the prior foresight studies analysis, expert feedback, and co-publication analysis, as nanomaterials proliferate across numerous industrial products, a primary area for collaborative R & I remains the development of safety regulations for handling these materials. Furthermore, the development of advanced nanomaterials has applications across numerous economic sectors, including: Health and Medicine, Biotechnologies, Food security, Energy Systems, and ICT. Diverse application areas demand increased R & I into best practices in the integration of nanomaterials into

71 In this task the Group was asked to discuss the priority topics above (Table 3) in order to reach a consensus.
Interestingly, the specialists disagreed with the calculated priority in Task 2. When asked about the reason for that decision, they said that they really disagree with the effectiveness of the previous criteria. For them, the priority should be based on real needs in the Brazilian context. Additionally, possible areas for further development should be prioritized.
At the same time, the aspects that the Europeans partners could be interested in developing should be also considered. Likewise, the possibility of expand the theoretical state of the art of any theme should be considered as a criterion. In sum, the criteria from the specialists were not essentially based on the partner’s competence, but on the real application of the results obtained from the research collaboration.

production process for production safety, production efficiency, and consumer safety as well as the development of novel use cases for products.

While the co-publication analysis revealed that EU/BR collaboration in scientific research has been steadily rising over the past decade, the co-patent analysis for the area of the Nanotechnologies found little evidence of research that could be tied to valuable applications. This strongly suggests that there is a supportive foundation for quality research in the nanosciences, but that policies and programs should be enacted to move research into practical and industrial settings. As a result, we focused the topic area to Nanomaterials and their utility within, and implications for, advanced manufacturing. By doing so we also address the finding of the co-publication analysis that suggest engineering as potential priority area for cooperation.

Due to their wide-ranging applicability, Nanotechnologies were implicit within a number of the Hot Topic Areas that emerged from the long-term visioning process. Cutting across six of the those areas, particularly in relation to end-user utilization of products wherein nanomaterials play a vital role, the proposed research area of “Advanced Manufacturing and Nanomaterials” was finalized as a critical juncture to explore in developing the INCOBRA Action Plans.

Smart Liveable Cities & Smart Systems

The priority R&I areas for cooperation between BR and EU outlined in the call for the INCOBRA project did not include smart liveable cities and smart systems but instead ICT with the sub-areas “Technology and applications for smarter societies” and “E-infrastructures” where mentioned. The report of the European Commission on priorities for international cooperation in research and innovation acknowledges Brazil as a world-class player in the field of ICT. ICT is an established cooperation area between Brazil and the EU among other things demonstrated by three coordinated calls funded jointly by Brazil and the EU. The report of the Commission mentions in addition the exploitation of cooperation potential in the area of sustainable urbanization. The newly framed topic “smart liveable cities & smart systems” builds on these arguments and suggests that an additional specific emphasis of the contribution of smart systems to smart liveable cities could be of mutual benefit for both regions in the future.

The link between ICT, smart systems and smart liveable cities was strongly proposed during the open consultation process of the INCOBRA project. Participants suggested among others ICT for E-Governance, ICT for Functional Assistive for people with disabilities, IOT (internet of things) in the health and transportation sectors and ICT for Water Management. This argumentation line was supported during the strategic foresight workshops when participants suggested a more comprehensive consideration and demonstration of the societal benefits in both regions linked to the cooperation in research and innovation in general. In addition, urbanization was selected as one of the priority topics for cooperation within a group of experts that discussed the Grand Challenges and when discussing the priority topics for cooperation within the ICT area the participants included several topics linked to smart liveable cities and smart systems. The complete list of the priority areas from the foresight workshop included:

- Smart systems and technologies applied to food, energy and the environment;
- Blockchain;
- Smart system and technologies applied to human health and wellbeing;
- Human centric computing;
- Connectivity and convergence;
- Internet of things;
- Data Intensive Computation, Visualisation and Analysis;
- Cyber Security;
- Smart cities and homes;

- Autonomous systems.

Smart liveable cities & smart systems could be an umbrella for diverse cooperation activities in R&I that can build on existing excellence in research and cooperation links between the two regions, while simultaneously addressing societal needs of growing importance for the long term development of both Brazil and the EU.

9.2 | **Methodological steps for concise scenarios planning**

Step 1 – select two main major variables that allow an overarching vision of the critical issues on the [priority topic]

Step 2 – cross the variables in a quadrant-like matrix.

Step 3 – identify the main characteristics of each quadrant and give them a sound title.

Step 4 – describe the main characteristics of each quadrant – for this point on called scenarios.

Step 5 – identify the influences and implications of each scenario for the priority topic.

Step 6 – make an overall conclusion trying to define the robust trajectories for the [priority topic].

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