A New Framework for Shaping and Implementing Innovation Policies for a Sociotechnical Transition of Cities and Regions towards more Sustainable Pathways

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Abstract

This paper proposes a new framework for shaping and implementing innovation policies in Brazil. The Sustainable Cities Technology Programme (SCTP) of the Ministry of Science, Technology, Innovation and Communication (MSTIC) commissioned this research to define a concept of sustainable city related to STI and priority areas to structure the SCTP.

Bringing to the fore the voices of society stakeholders into a narrative and language shared by quadruple-helix actors, enabled the development of a participatory disruptive vision for sustainable cities. In particular the engagement of children provided elements for a due diligence process. This was key for actors to jointly explore new ideas, strategic questions and new visions used to clarify and expand their mutual understanding of present situations and associated future city challenges. Also, to negotiate solutions in terms of co-designing and implementing adaptive innovation policies.

A futures literacy workshop was organised with research, industry, government, students, religious groups, NGOs and different societal groups. This process was adapted with design thinking, story telling and visualisation techniques to be applied to youngsters. The resulting framework structured a discussion with children from 6 to 16 years old during the Science and Technology Week organised every year by MSTIC for schools in cities across the country. Outcomes were combined, exposing the similarities and differences that these two main groups (i.e. pupils and adults of different backgrounds) expect for liveable and sustainable cities in Brazil, and enabled mutual understanding of different perceptions and assumptions.

Results were organised for comments and for eliciting options for adaptive innovation policies considering the different contexts of the Brazilian territory. Methodologies used by the Brazilian Ministry of Planning and Brazilian Institute of Geography and Statistics (IBGE) were adapted to help participants understand specificities of Brazil and to organise 5.570 municipalities into around 30 region typologies.

A target set of experts was drawn from the Lattes database of researchers in Brazil using both data mining and data visualisation tools. The resulting database consisted of 3,900 potential participants, of which 15% contributed with inputs. A dedicated workshop identified relevant criteria for MSTIC to prioritise projects to be financed.

Final results were discussed at an international seminar organised together with the EU Commission DG RTD and with relevant national and international stakeholders. Outcomes were organised into a concept of sustainable cities for use by MSTIC and six lines of action to be fostered by SCTP considering the different typologies of Brazilian cities and regions: built-in environment, energy, mobility, sanitation, ecosystem services and biodiversity restoration, and integrated long-term planning. These currently shape the SCTP of MSTIC. Moreover, the process employed in this research and its results were used to structure the Sustainable City Innovation Observatory, which shall become a new framework for shaping and implementing innovation policies in Brazil to foster a sociotechnical transition of cities and regions towards more sustainable pathways.

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1. Introduction

Cities have become the nexus of the global agenda. Cities and city districts should be understood as transitory and experimental spaces in which structures and behaviours that are needed today can be created and modified along time in order to shape a transition towards sustainability. After decades of urbanisation, currently more than half of the world population live in cities [UN, 2014]. The rate of urbanisation is increasing especially in African and Asian countries [UN, 2014], which shall account to almost 90% of urban population growth up to 2050 [WBGU, 2016], as well as in small and medium cities of Latin America and other developing countries which are growing fastest since 2000 [ONU HABITAT, 2012]. In fact, Latin America and the Caribbean is more urbanised than any other region in the developing world [ONU HABITAT, 2012], with 80% of its population living in cities today, a share expected to rise to 85% by 2025 and 90% by 2050 [ONU HABITAT, 2012]. Overall, by 2050 two thirds of the world population is expected to live an urban life [WBGU, 2016]. Specifically in Brazil, in 1950 its urbanisation rate was 36%, in 2010 already 84% and by 2020 it shall achieve 90% [ONU HABITAT, 2012].

Such an influx of people into cities due to demographic growth or relocation caused by migration from the countryside to cities or from smaller cities to bigger ones or from poorer countries or those in conflict to richer ones, shall cause unprecedented human agglomeration in the urban space, which will bring to the fore several social, environmental and economic challenges, also for wealthy countries [WBGU, 2016]. Cities already account for 80% of global GDP as well as 75% global consumption [UNEP, 2013] of resources (such as water, energy and food) and are responsible for about 70% of global energy use and related CO_2 emissions [SETO et al., 2014] as well as overall 70% greenhouse gas emissions [UN-HABITAT, 2011; GGP, 2014] and 75% of solid waste [UN, 2016b]. For Brenner et al. [2013 *apud* WBGU, 2016] the urban demand for resources has such a reach that we are living in the age of planetary urbanization or, in other words, a world cities society [WBGU, 2016]. Solutions to these challenges should, therefore, foster alternative and transformative pathways able to guarantee a transition of these loci towards more sustainable, fair, prosper and inclusive urban environments, ultimately assuring a sense of belonging and solidarity-based quality of life for all [WBGU, 2016] as well as safeguarding the natural life-support systems; all of which embedded into a collective long-term integrated or systemic vision able to provide orientation for societal change.

In developing countries and emerging economies it is important to highlight that one third of the urban population do not have access to adequate housing and vital infrastructures, and this figure is even higher in sub-Saharan Africa: currently it adds up to almost two thirds of its population living in slums or informal settlements in degrading city districts [UN DESA, 2015]. According to IPEA [2006], 40,5% people in Brazil live without access to adequate housing in slums, informal settlements or areas subject to landslides or floods, often in the periphery of cities and without access to basic services such as water, energy, sanitation, schools and hospitals. This percentage increased to 43% in 2008 according to IBGE [2010]. In fact, in Brazil around 48,6% of its citizens have access to sewage collection and 40% of overall sewage is treated [SNIS, 2014]. Also, around 38% of the Brazilian population do not have access to services related to appropriate treatment or destination of waste, and about 42% of the solid

waste in Brazil still goes to dumps or controlled landfills, which do not present the necessary conditions for environmental protection [ABRELPE, 2015].

In this context, massive social exclusion of people carries with it the potential of social destabilisation, which requires a fundamental change in perspective from fighting symptoms to focusing on what causes the emergence of informal settlements, thus avoiding path dependencies. Moreover, urban transformation towards sustainability requires fundamental changes in land-use, energy and transport systems, in the management of materials and materials flows, in urban settlement policies, and in the structural-spatial design of cities [WBGU 2016], to name but a few.

The above highlights that developing countries and emerging economies have a dual agenda in terms of actively enabling a transition of cities towards more sustainable pathways. This is certainly the case of Brazil as identified via the research being depicted in this paper, which has to address concomitantly challenges inherited from a historical unequal development as well as contemporary ones. These include challenges that have been dealt with in many advanced economies such as sanitation, adequate housing, degraded areas subject to environmental risks, poverty, and unequal access to urban land and services. But it also include current and future challenges such as ecological footprint, conservation of biodiversity, of ecosystem services and of natural resources; climate change mitigation, adaptation and resilience; urban expansion, resource flows, land occupation and use; citizenship and participation; and quality of life and universal access to services.

Activities, forums and networks aiming to strengthen cities as key arenas of transformation and to create spaces for experimentation are growing exponentially. One major step towards fostering a transition of cities towards more sustainable pathways are the recent global economic and political agreements and consensual agendas related to urban quality of life coupled with simultaneously maintaining and restoring Earth's natural life-support systems. Most notably, the adoption of the Sustainable Development Goals (SGDs) and the Paris Agreement (COP 21) of 2015, as well as the Habitat III world conference held in 2016. These have been key to help operationalize global consensus at city level, and have progressed towards detailing a social contract for the urban transformation, thus offering general guidance and orientation for cities to develop their own specific transformation pathways based upon a common vision of urban societies up to 2050 and collective challenges to be addressed [UN, 2016; WBGU, 2016]. The role of national policies would then be to identify overlapping priorities of these agreements and establish a cohesive development strategy, based on a unifying vision, that supports progress against all of them together, including through the provision of a framework able to empower cities to implement and incentives towards solutions that align with priorities articulated in the policy [FISCHER, 2017].

In this context, possible solutions to complex and interrelated challenges need to be contextualised to local and regional reality and conditions. This includes, for instance, taking into account social-cultural diversity in and of cities, their urban form and the autonomy of city residents as key aspects of people-oriented urban transformation in the creation of urban quality of life and identity. Ultimately, transformation in cities will not be able to follow a universal pathway because of their diversity and complex interplay of historical, cultural, socio-economic and ecological contexts [WBGU, 2016]. Many have been the attempts to build city or city-region typologies [NEUMAN e HULL, 2009] in order to enable one to contextualize challenges and associated solutions, to develop place-based policies and financing instruments adapted to city specificities [EU, 2016], to design smart specialisation strategies [FORAY, 2014], to foster

innovation and growth [NESTA, 2001], to name but a few attempts and aims to contextualise local and regional situations in order to foster sustainability.

In Brazil, the main effort to develop a city typology was done by the Brazilian Institute of Geography and Statistics [IBGE, 2008], which depicts the structure and organisation of the Brazilian territory and its dynamics thus creating an urban network of relationships and flows, as well as building an in-depth understanding of the regions of influence of Brazilian cities. This was the departing point of the research outlined in this paper, which is structured as follows: section 2 outlines the main challenges or situations faced by cities in order to transition towards sustainability, integrating various analogous global endeavours. Section 3 contextualises identified challenges in Brazil through a threefold process: development of a vision related to the future of sustainable cities identifying key strategic questions for collective action, a citizen-wide consultation using an adaptation of the city typology developed by IBGE, and refinement and validation workshops. In section 4 the main findings as well as policy recommendations to the Brazilian Ministry of Science, Technology, Innovation and Communication (MSTIC), who commissioned the research, are outlined. Section 5 summarizes the policy impacts and spin-offs achieved, whereas section 6 concludes the paper.

2. Challenges for a transition towards sustainability

According to WBGU (2016), targets set by the UN SDGs [UN, 2015] as well as COP 21 (Paris), Habitat III (Quito) and COP 22 (Marrakesh) may be missed by a large extent if an accelerated reinvention of the cities does not take place through transformative strategies able to deliver a leapfrogging effect. Such measures must affect the form of cities as well as their materials, operations and functions. If such transformation does not happen, we may achieve at Earth system's tipping points [LENTON et al., 2008] thus breaching the climate-protection guardrail, which could lead humanity into a crisis of civilisation. Hence, the spread of conventional urbanisation processes on a global scale must stop and be reverted through new guiding concepts and strategies to avoid path dependencies that can lead to a point of no return [UN HABITAT, 2016c].

Diverse actors see different areas for action which hold greatest potential for urban development and to leverage city transformation towards sustainability. Somehow, these can be located within the UN SDGs, which were adopted by 193 countries on 25 September 2015. These relate to a set of goals to end poverty, protect the planet and ensure prosperity for all as part of a new sustainable development agenda, which has been recently debated and detailed both in Quito at the Habitat III Conference [UN HABITAT, 2016a] and in Marrakesh at COP 22. Each goal has specific targets to be achieved over the next 15 years.

In this context, the urban environment is a complex tissue that behaves like a living organism [ACUTO et al., 2018] and sustains diverse relationships and dimensions. Different research has used a variety of approaches to organise the main challenges facing cities and potential pathways towards urban sustainability [ACUTO et al., 2018]. In fact, this is an on-going debate and the attempt here is not to devise an ultimate model for organising challenges and likely solutions able to address these. Instead, the effort here was to perform an in-depth mapping looking at main trends and both present and future challenges related to urban development. Also, to organise the results in a way that enables one to better understand these in order to devise contextualised policies and associated local actions aiming to ameliorate the dynamic

situations that constitute such challenges. Table 1 below summaries and depicts the main results.

Table 1 – Challenges for city transition towards sustainability		
Themes	**Challenges**	**SDGs**
Natural resources and biodiversity	To restore and conserve natural life-support systems and ecosystem services, including clean air and both surface and underground land and water	SDG 2 (goal 2.4) /// SGD 6 (goal 6.6) /// SDG 14 (goal 14.2) /// SDG 15
Water	To ensure clean drinking water and adequate sanitation, stimulate an urban design sensitive to the water natural cycle and promote responsible water consumption	SDG 6 /// SDG 11 (goal 11.1) /// SDG 13
Energy	To ensure energy security, reduce greenhouse gas emissions (decarbonise energy systems) and increase energy efficiency in cities	SDG 7 /// SDG 11 /// SDG 13
Education	To enable the acquisition of required knowledge and skills for future jobs, and access to knowledge able to catalyse transformative processes	SDG 4 /// SDG 11 /// SDG 13 (goal 13.3)
Innovation and competitiveness	To promote a dynamic job market, connectivity, and sustainable consumption patterns, strengthening the roles of science, education and innovation in the urban transformation	SDG 9 /// SGD 11 (goal 11.a) /// SDG 12 /// SDG 13
Governance and citizenship	To embed sustainability in the planning of the city, and ensure citizens actively shape urban development and the improvement of their living conditions	SDG 11 (goals 11.3 and 11.7) /// SDG 13 (goals 13.2 and 13.b)
Security	To enable citizens' to use and move within public and private spaces freely and without risk, reducing the sense of insecurity in cities	SDG 11 /// SDG 16
Resilience	To prepare cities to anticipate, prevent, mitigate, respond and adapt to climate change and socio-environmental disasters, including new design features for urban development in transition	SDG 11 (goals 11.5 and 11.b) /// SDG 13 (goal 13.1)
Built-in environment	To provide access to adequate housing, develop long lasting and less resource and carbon intensive infrastructure, all in alignment to an appropriate long-tem land use planning	SDG 11 (goals 11.1 and 11.c) /// SDG 13
Solid waste	To minimise waste generation in cities and manage effectively its collection, treatment and recovery or disposal, fostering its reduction, reuse and recycling	SDG 11 (goal 11.6) /// SDG 13
Health	To offer an inclusive, accessible and quality healthcare system to all as well as promote an increasing quality of life to overall citizens' and communities in the city region	SDG 3 /// SDG 11
Mobility	To guarantee accessible cities, zero emission and non-motorised mobility, road safety, and affordable, low-carbon and quality public transport options to all, with a reduced urban metabolism	SDG 11 (goal 11.2) /// SDG 13 (goal 13.2)
Food	To provide safe, healthy, sufficient and nutritious food for all, ensuring food security and a balanced diet to citizens', and increasing the amount of locally grown and distributed food	SDG 2 /// SDG 11 /// SDG 13
Inclusion	To ensure the end of poverty and socio-economic disparities, and provide universal access to basic infrastructure and services in the city region	SGDs 1-11 and 15-16

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3. Challenges in Brazil

3.1. Sustainable city future vision

Sustainability transitions are characterised by long-term processes of changes in technology, organisation, politics, economics and socio-cultural systems. To achieve intended goals, such transitions need a strong guidance and governance involving a broad range of actors and stakeholders working in a coordinated way [MARKARD, 2012; FRANTZESKAKI, 2016]. This approach recognizes that the dialogue between different knowledge holders may lead to visions and opinions that are relevant to policy-science shaping sustainability transitions. Urban policy, especially, could benefit from this type of perspective ensuring that public policies can adequately respond to current challenges reflecting citizen's needs [FRANTZESKAKI, 2016].

The visioning process developed in this research aimed at building alternative and transformative pathways able to foster a transition of Brazilian cities towards more sustainable, fair, prosper and inclusive urban environments. In order to do so it was clear from the outset that the developed vision had to be participatory to assure a sense of belonging and solidarity-based quality of life for all, as well as to build an increased awareness about the need to safeguard the natural life-support systems. Moreover, by bringing different stakeholder groups together to debate diverging points of view and also to find converging ones, the aim was to shape a truly collective vision with shared responsibilities and ownership. In this context, the objectives of the visioning process were six-fold:

- ▪ To generate scenarios about the future of sustainable cities;

- ▪ To make explicit the anticipatory assumptions we use to shape the future;

- ▪ To use the future as a mechanism to expand our individual and collective understanding of the present (Futures Literacy);

- ▪ To create knowledge through collective intelligence, thus making sense of specificity and context to generate learning;

- ▪ To investigate (due diligence) deeper and systemically what constitutes a sustainable city in diverse Brazilian contexts by articulating a system of challenges and problems (situations) in order to propose and criticise possible solutions; and

- ▪ To obtain different and complimentary inputs to further enable the development of a strategy that encompasses and integrates complexity, emergency and novelty.

For the participants who were engaged in a creative and dynamic process through a systemic, systematic and applied approach to using the future [MILLER, 2007; MILLER, 2011; CAGNIN et al., 2013], the main expectations were:

- ▪ To expand participants' capacity to tell anticipatory stories (narratives) using a rigorous imagination process;

- ▪ To share expectations and hopes, and both specific and contextualised knowledge, in order to expand both the understanding and the potential of the present;

- ▪ To amplify both the individual and the collective capacity to question and invent the anticipatory assumptions that inform our decision-making processes; and

- ▪ To identify new challenges and associated solutions as well as potential roles and prioritisation criteria for the Brazilian Ministry of Science, Technology, Innovation and Communication (MSTIC).

It is important to highlight that two creative workshops were applied. The first was designed to last a whole week debating with different children groups of diverse ages. The second took place in two full days and engaged a variety of stakeholders, including university students, experts, policy makers, businesses, civil society organisations, artists, and different religion representatives, among others. Overall, it is critical to bring to surface the main similarities and differences from these two main exercises. This is important because, ultimately, these are the assumptions that reflect in great measure the culture and values of the Brazilian society in a particular and historical moment in time, both contextual and specific. These are the assumptions one has to either foster or transform in order to shape sustainable cities in Brazil in the near future.

In a nutshell, in both exercises – one with children and one with diverse stakeholders – the same methodology was applied. However, in the conversations with children, which took place during the National Science and Technology Week organised by the MSTIC, the methodology was adapted to facilitate the dialogue with children varying between 6 and 16 years old. Basically, the Futures Literacy Learning Laboratory [CAGNIN et al., 2013, MILLER, 2007] was adapted with design thinking, story telling and visualisation techniques to be applied to youngsters. In this regard, around three conversations of about 30 minutes each took place daily during the week with different groups of children of similar age (from the same school class). The results of each group were built upon the previous discussions and were translated into a real time illustration on a 2m by 6m wall, which children could also use to build their own illustrations or express their ideas; all of which were later transposed to the main illustration developed by a professional hired for the purpose.

In the end, the final collective vision comprised the consensual anticipatory assumptions which reflect the joint expanded understanding of what constitutes a sustainable city in Brazil. Table 2 below summarises such vision.

Table 2 – Collective vision of a sustainable city in Brazil based on common assumptions
Greater resilience through a sustainable and adaptive built-in environment, based on recycled materials and reuse of residues
Individualised and vocational education system focused on holistic abilities and a practical and contextualised learning
Inclusive economic system strengthening collective values, although difference in income is still a reality
Responsible consumption and respect for the water cycle associated to access to water as a public good
Green areas for leisure, encounters and the practice of sports across the city, thus promoting greater longevity and quality of life
Local food systems focused on individualised nutrition and diets, combining technologies with local production
Preventive health system prepared for the elderly and combining technology with healthy food and active individual mobility
Clean, decentralised and distributed energy systems, with wind and sun as the primary sources with the end of fossil fuels
Quality mobility systems with accessibility for all with a focus on collective and public transport systems as well as the use of clean / renewable energy

Regarding the main differences in terms of assumptions between the children and the other stakeholders it is important to highlight two main aspects:

▪ Security

- ✓ Stakeholders outlined as main aspects: technological advances, information systems, integrated planning and monitoring indicators.

- ✓ Children outlined as main aspects: prison system will cease to exist and people who infringe the law will be sent to universities.

- ▪ Governance

  - ✓ Stakeholders outlined as main aspects: main transformation actors are policy makers and children.

  - ✓ Children outlined as main aspects: main transformation actors will be artificial intelligence sensitive beings, which will also lead to greater societal control through generalised monitoring of individuals.

Finally, the conversation with stakeholders during the workshop enabled a more in-depth debate which brought as result aspects the children did not address, as well as criteria for the MSTIC to use when deciding investments for both national and city projects:

- ▪ Assumptions: (i) tipping points transforming behaviours and culture; (ii) greater awareness leads to sharing of resources and responsibilities; (iii) integration of policies with social participation; (iv) articulation actors creating spaces for dialogue, thus connecting demands and leveraging a participatory governance; (v) use of indicators as well as evolving and contextualised city guidelines at the heart of more sustainable cities; and (vi) new partnerships between businesses, governments and society lead to contextualised solutions across neighbourhoods with a sustainable flow of resources among functional regions.

- ▪ Criteria for MSTIC: (i) project is viable economically, both in its implementation and maintenance; (ii) promotes social inclusion, participation and citizenship; (iii) promotes increased public transparency; (iv) promotes distributed access to services and resources; (v) generate jobs; (vi) promotes reconciliation between nature and humanity; (vii) promotes the development and implementation of sustainable technologies; (viii) stimulates local creativity and culture; (ix) promotes increased resilience and security; (x) reduces the ecological footprint; (xi) promotes greater accessibility and improved mobility; among others.

3.2. Visioning methodology

The vision building methodology used was based on a process being currently developed by a global consortia lead by UNESCO, of which CGEE is a partner. It is called Discipline of Anticipation (DoA) and it comprehends the acquisition and use of design principles to think about the later-than-now [MILLER, 2007; CAGNIN et al., 2013]. When one becomes better at the art of anticipation, it also becomes capable at using the future to understand the present [MILLER, 2007; CAGNIN et al., 2013]. This happens when we are able to execute three main tasks (refs): (i) clarity of purpose or clear rationale for thinking about the future; (ii) conscious relationship established between the objectives one has to think about the future and the methods to do so; and (iii) greater level of sophistication achieved, as expected, once discipline brings with it more deepness, clarity and legitimacy. These are the attributes of mastery acquired through learning [MILLER, 2007]. The DoA assumes that the future is defined by four fundamental attributes of the universe [MILLER, 2007]: (i) practical irreversibility of time; (ii) birth and death or differentiation and repetition; (iii) unpredictability; and (iv) connectivity.

In practice it consists of activities that always involve narratives, collective intelligence and construction of meaning [MILLER, 2007; MILLER 2011]. It is a meta-scientific structure to detect and make sense of the present [MILLER, 2007; MILLER 2011] . The process aims to develop an in-depth understanding about the way we operate in systems that are known, at least partially, as well as those that are unknown. This is how we become able to detect novelty, by using two distinct ways of using the future [MILLER, 2007; MILLER 2011]: (i) use of a model to imagine the future aiming to predict what can happen (predictions and expectations); and (ii) use of a disruptive model whose objective is to reduce or eliminate predictive or normative barriers. By participating in such a process, a form of self-consciousness (meta-cognition), in which anticipation is brought out in a way that the future exists in the present, an amplified understanding of anticipation (models, systems and processes) that can be defined as Futures Literacy [MILLER, 2007; MILLER 2011] is obtained through learning-by-doing [MILLER, 2007; MILLER 2011].

The departing assumption is that being able to make decisions that embrace complexity and treat uncertainty as a resource rather than a threat demands capacity to use the future as a means to expand the understanding of the present. Building such capacity requires that anticipation is brought out into the open in a way that the future exists in the present. It then becomes clear that human consciousness, in its process of search and choice, uses a number of anticipatory systems to imagine and use the future in decision-making. An applied anticipatory systems approach to use the future, therefore, enables policy and decision-makers and individuals alike an expanded capability to question and create anticipatory hypothesis that base their choices [CAGNIN, 2014; MILLER, 2007; MILLER 2011]. Futures Literacy offers such capacity [CAGNIN, 2018; MILLER, 2007; MILLER 2011].

The process reveals and questions the anticipatory assumptions, explicit or implicit, which we use to think about the future. Participants of such process are involved in a simulation that develops their capacity to make strategic decisions in contexts of ambiguity by exploring the potential of the present [CAGNIN et al., 2013; MILLER, 2007; MILLER 2011]. In this way, diversity and complexity become sources of inspiration, and we become better at embracing the precious heterogeneity of the world as well as at respecting the spontaneous creativity of freedom and serendipity [MILLER, 2007; MILLER 2011].

The methodology follows a learning curve in three phases, according to Figure 1. The aim is to engage the collective intelligence of participants to make explicit the anticipatory assumptions that shape our decision processes. Ultimately, Futures Literacy is a systematic approach to improve our anticipatory systems [MILLER, 2007; MILLER 2011; CAGNIN et al, 2013]. Decision-makers able to use the future will become more conscious of the expectations and values that shape not only theirs, but also their community's vision of the future. Also, they will be better able to design processes of collective intelligence that use the future to identify opportunities in the contemporary world, shaped by complexity, fluidity and spontaneity. Finally, by expanding what we imagine to be the future helps us to amplify our appreciation about the potential of the present [MILLER, 2007; MILLER 2011].

In the first phase participants made explicit their expectations or predictions, what they believe shall happen in the defined time horizon, as well as their desires or values, what they would like to see happening in this timeframe. In the second phase we left behind expected or desired futures to experiment a discontinued or alternative model that should be proposed aiming to alter the conditions of change, those which are consensual in determined time and space. The idea was to enable a practical experimentation of our anticipatory assumptions in shaping imagined futures and the potential to address the creative challenge to invent futures based on

new or different paradigms. Finally, in the third phase, the aim was to examine how certain anticipatory assumptions influence our understanding of the present and how certain images of the future can bring meaning to different aspects of the present. In this last phase the challenge was to think about new questions, such as those that could have been considered unimportant or incomprehensible if the participants had not engaged in imagining the future using different anticipatory assumptions. In practice, one tries to identify new questions and investigate different solutions based on the expanded understanding of the object under analysis.

To enable and facilitate making tacit knowledge explicit and, therefore, to reveal the collective anticipatory assumptions in the first phase, the research used the Causal Layered Analysis (CLA) method [MILLER, 2007; MILLER, 2011]. Here participants had to introduce their ideas to others in a group and collectively shape a narrative using the four categories of the CLA method: (i) headlines or common sense (litany); (ii) nature or attribute of systems (systems/social); (iii) points of view of specific actors (worldviews); and (iv) myth or metaphor that captures the spirit or central idea of each scenario and that connects to the other layers of the analysis. The objective of CLA is not to predict the future, but rather to open the present and the past to create alternative futures. It departs from the premise that individuals, organisations and civilisations see the world from different points of view (horizontal and vertically). Hence, there are different levels of reality and forms of 'knowing'. Critical when applying the method is the vertical movement between the four layers, which enables the integration of analysis and synthesis. The horizontal movement enables the integration of discourses, of different ways of 'knowing' and different worldviews, thus increasing the richness of analysis. It is important to highlight that no layer should be privileged. The results are differences that can be captured in diverse scenarios, each representing different ways of 'knowing'.

In the second phase, creative methods like role-play [CAGNIN et al, 2013] and the construction of prototypes [CAGNIN et al, 2013] were used to facilitate the imaginative process of participants. Participants were divided in groups of six people each, totalizing 6 groups (total of 36 participants), and were given a reframing model developed for the purpose [CAGNIN et al, 2013]. This model is called of "learning intensive society" [CAGNIN et al, 2013] and it changes the conditions of change with the aim of questioning and stimulating the development of new anticipatory assumptions, thus reframing the challenge of a sustainable city. In each group participants had a facilitator and the support of the research team. Participants were given a specific actor and had to play along how such actor would behave in such an imaginary future. Finally, participants had to think about the audience and formats of an exhibit that would communicate the ways in which their imaginary city would function. Hence, each group developed a prototype of their imaginary future using a variety of gadgets such as Lego pieces, bulk, pieces of magazines or pictures from the Internet as well as videos and other media, among others.

Finally, in the third phase the world café method [CAGNIN et al, 2013] was used to enable participants both to identify new questions and, in a second moment, to address these trying both to find and criticise solutions in a process of due diligence. Five questions were highlighted for an in-depth discussion, which enabled participants to both invent new ways of improving the existing system and to transform it by inventing new configurations or disruptive systems that would be better placed to foster alternative pathways for contextualised sustainable cities in Brazil. The questions were: (i) what is your vision for a sustainable city in 2050?, (ii) what are the main challenges for such a city in 2050?, (iii) what are likely solutions to these challenges?, (iv) what are the possible roles for MSTIC and innovation policies?, (v) what criteria should MSTIC use to select challenges to be addressed and solutions to be fostered via investments?

An example of a new configuration developed is the "neural city", where local governments operate in coordination and alignment, and together with social technologies emulate a collective intelligence and self-organising system, therefore without the need for an institutionalised central decision-making body. The cells or neurons function as compact and polycentric neighbourhoods that foster coexistence and deliver all necessary services and basic infrastructure for the communities residing there, including jobs. However, there are flows of materials, resources and people between the cells that are responsible for the total balance of the system, which reaches a final urban metabolism with zero carbon emissions and ecological footprints in the city-region. The city expands through the development of new "neurons" that are both autonomous and inter-dependent.

3.3. Main challenges in Brazil

A citizen-wide online structured consultation was implemented in order to consolidate, validate and refine the main results of the research in terms of challenges for sustainable cities, related solutions, and possible roles for innovation policy and MSTIC, including associated prioritisation criteria. Also, the aim was to contextualise the findings of the study in the Brazilian territory in order to identify those challenges which are most critical to different city typologies as well as likely solutions able to address these for each city typology.

The methodology chosen to portray city typologies in the Brazilian territory was the one devised by the Brazilian Institute of Geography and Statistics [IBGE, 2008], which depicts the structure and organisation of the Brazilian territory and its dynamics thus creating an urban network of relationships and flows, as well as building an in-depth understanding of the regions of influence of Brazilian cities. In fact, this methodology was used throughout the research in order to contextualise findings, and once again was used in the citizens' consultation process. The IBGE methodology typifies the Brazilian territory in six main categories: metropolis, regional capital, sub-regional centre, zone centre and local centre.

Moreover, the IBGE methodology was combined with a study developed by CGEE for the Ministry of Planning [CGEE, 2008], which divided the Brazilian territory in six main regions with specific socio-economic and environmental contexts which must be considered when designing national policies: Amazon forest, North-Northwest coast, North-Centre, Backwoods and Northeast semi-arid, West-Centre, and Southeast-South. However, when piloting the online questionnaire the methodology was adapted to enable participants to have an easier grasp of regional differences that would relate to their personal realities and also to diminish the time required to complete the survey. The final adopted typology was composed of six categories: (i) metropolis (over 1 million inhabitants) – North; (ii) Metropolis – South; (iii) medium cities (between 100.000 and 1.000.000 inhabitants) – North; (iv) medium cities – South; small cities (less than 100.000 inhabitants) – North; and (iv) small cities – South. Finally, North-South was considered to be a line that connects the cities of Rio Branco, Porto Velho, Sinop, Brasília and Vitória.

The consultation was open for a period of a month and targeted experts were initially selected based on the Lattes database in Brazil, which encompasses over 4 million CVs of all researchers in Brazil. Other targeted participants were selected based on the initial mapping, including social media, business representatives, students, NGOs and other civil society organisations with an interest in the subject. The initial sample of likely respondents contained around 3.800 persons. These contacts received the link to the online questionnaire and were asked to disseminate over the consultation to their own networks of interest through a co-

nomination process or snowball effect, thus forming an overall database of about 3.900 possible respondents. Around 15% responded the questionnaire, or a total of 572 persons, with over 56% holding a PhD and more than 23% with masters. The remaining participants were either students or had a specialisation in a related subject.

Overall, it is important to highlight two main results from the wide-consultation process. The first one is that the Brazilian agenda for sustainable cities is twofold. The dual agenda is composed of challenges inherited from an unequal development process since Brazil was a colony from Portugal as well as contemporary challenges that most advances economies face today. These challenges have to be dealt with concomitantly, rather than focusing in one set of challenges and then the other. The first set of challenges can be summarised in: sanitation; adequate housing; degraded areas subject to environmental risks; and poverty and inequality of access to urban land. The latter set includes: ecological footprint, conservation of environment and of natural resources, and restoration of ecosystem services; climate change and resilience; urban expansion and land occupation and use; citizenship and participation; and quality of life and access to services and infrastructure.

The second result worth highlighting is the definition of prioritised criteria for MSTIC to decide on both national and city investments. These are: (i) promotes social inclusion, participation and citizenship; (ii) promotes distributed access to services and resources; (iii) promotes reconciliation between nature and humanity; (iv) project is viable economically, both in its implementation and maintenance; (v) stimulates local creativity and culture; (vi) promotes increased resilience and security; (vii) reduces the ecological footprint; and (viii) reduces socio-spatial inequalities.

A refinement and validation workshop took place with selected experts and representatives of different stakeholder groups that had participated in previous workshops in order to debate the results from the consultation process. The discussion highlighted the difficulty to contextualise identified main challenges in the Brazilian territory according to the defined typology, which was also criticised although participants agreed that the adopted categories were easier to thing about regional differences than the original methodologies used as departing points. A first analysis brought to light that many challenges are similar and associated solutions are thus applicable throughout the country. This happens because the country still has fundamental issues to tackle, all with deep connections to poverty and inequality. However, the in-depth debate enabled the achievement of a general consensus in terms of an association of challenges to the adopted typology of Brazilian cities. The priorities are as follows:

- For all city typologies
  - ✓ Resilience and adaptation to climate change.
  - ✓ Continued quality education.
  - ✓ Integrated and participative long-term city design, planning, management and governance.
- Metropolis in the North
  - ✓ Access to water and sanitation.
  - ✓ Safe and accessible mobility.
- Metropolis in the South
  - ✓ Safe and accessible mobility.

- ✓ Adequate, sustainable and resilient housing.

- ▪ Medium cities in the North

  - ✓ Safe and accessible mobility.

  - ✓ Access to water and sanitation.

- ▪ Medium cities in the South

  - ✓ Safe and accessible mobility.

  - ✓ Minimise solid waste generation and ensure their appropriate management and treatment.

- ▪ Small cities in the North

  - ✓ Generate jobs, local and vocational income, and socio-economic equality.

  - ✓ Food and nutritional security.

- ▪ Small cities in the South

  - ✓ Generate jobs, local and vocational income, and socio-economic equality.

  - ✓ Food and nutritional security.

Finally, an international seminar was organised with the EU DG Research & Innovation policy agenda on renaturing cities in order to bring together diverse initiatives and various partners from EU and Brazil working on urban sustainability and nature-based solutions. Also, several of the participants of previous workshops and the online consultation were invited to the discussions. The aim was to share experiences and both refine and validate the findings of the research developed in this paper. The debate not only endorsed the results achieved but also brought to light important aspects for shaping a novel focus of intervention on sustainable cities for MSTIC, or a concept for adoption from the STI standpoint. This includes STI solutions that are inspired or supported by nature and which require continual experimentation in order to ameliorate dynamic situations and, therefore, address a specific and contextualised challenge at hand. In doing so, it is cost-effective, resource-efficient and systemic, thus building resilience by restoring ecosystem services and reducing the overall ecological footprint of a given city-region. Finally, it provides simultaneously social, environmental and economic benefits, ultimately leading to sustainable patterns of production and consumption.

4. Policy recommendations

The value of national policies lies not only in the resulting legislative framework and associated incentives for cities to develop and implement contextualised solutions in alignment with priorities articulated in such policies. Rather, the process of analytical, inclusive, thoughtful decision making is a central goal. Hence, the aim is to foster a more comprehensive view of challenges and priorities faced by a country's cities' as they evolve by involving stakeholders from both the national realm and the urban communities in conversations. Ultimately, in addition to setting a vision for individual cities that serve their residents equally and enable all to improve their quality of life, countries must shape a collective foundational vision and establish a financing and implementation framework to realise such systemic vision at the same time it empower cities to create the change they need and make the decisions that best suit their

specific situations. This is key to enable cities to seat at the decision making table and reinforce their key role in addressing national and global challenges, thus leveraging their power over the necessary resources to achieve these goals. Therefore, rather than prescribe a set of solutions, national policies should provide cities with the capacity and resources to achieve both the country's and local set of social, environmental and development goals in line with the global agreements to which all have committed to [FISCHER, 2017].

Based on the above understanding, the research being here depicted was careful in involving stakeholders from different national government ministries as well as state and municipal administrators and a variety of citizens' profiles (i.e. artists, religious and indigenous groups, children, NGOs, research, industry and higher education students) both through dedicated workshops and discussions, as well as citizen-wide online structured consultations, as previously mentioned.

The result of the desk research required to properly engage stakeholders in the evolving conversations brought to the fore key elements to support the MCTIC in refining their national STI policy for sustainable cities in Brazil and developing an associated strategy for its implementation.

MSTIC and its Programme of Technologies for Sustainable Cities (PTSC) currently work on four strategic themes: i) sustainable construction of social interest (including a circular built-in environment); ii) mobility and mass-transit systems; iii) environmental sanitation (sewerage and solid residues); and iv) sustainable energy systems. The results of the research validated the criticality of these in Brazil and identified five extra themes (see Table 3 below), three of which are also key and should be addressed in the country via STI policies and associated contextualised solutions, these being: i) long-term integrated planning; ii) ecosystems and biodiversity conservation and recovery, with a special focus on clean water and its adequate management; and iii) knowledge platform to enable access to and appropriation of contextualised solutions and required resources for their implementation.

In terms of business model, the PTSC of MSTIC currently has an inductive model with a focus on social inclusion to maximize the impact of scarce financial and human resources. Essentially, the program works only with induced orders. This means that it scans existing projects nationwide with potential to leverage social impacts within its focus of work as well as key institutions to involve and support. Those that seem promising are then contacted and relevant actors are engaged either to develop or leverage an existing STI solution to deal with a specific problem in a city or city-region in the country. Hence, based on a previous articulation a demand is jointly prepared before this is actually sent to the MSTIC, thus maximising the likelihood it is fit for purpose and that it will attain both the expected results and associated impacts.

In spite of having developed a strong portfolio of successful projects during the past seven years, the PTSC has been unable to build scale so far. Therefore, it has been proposed that it gradually shifts its business model from working with induced projects alone to also include partially induced and spontaneous projects. This would entail that expected results and impacts from project proposals would have to be detailed beforehand by partners of each consortium, which would come together to respond a specific call launched by MSTIC. Hence, partially induced and spontaneous projects would be fostered through public competitive calls targeted at addressing clear and specific challenges. Selection of projects would be based on merit and through an independent external evaluation of proposals received by MSTIC. This process would enable innovative proposals to be put forward in terms of STI solutions able to address contextualised challenges without the need for MSTIC to be involved throughout the process (i.e. designing or supporting institutions to design a fit for purpose proposal). Rather, MSTIC

would then have a more strategic role in terms of designing calls which are fit for purpose and in assessing proposals together with specific evaluators. Table 3 below details the various business models here outlined.

Table 3 – Financing a New STI Agenda					
Project Type	**Challenges**	**Themes**	**Participating Institutions**	**Project**	**Results & Impacts**
Induced Demand	Previously defined by MSTIC based on its mapping of existing and aligned projects across the country	Sustainable and circular built-in environment

Mobility and mass-transit systems

Environmental sanitation

Sustainable energy systems

Preventive diagnosis and monitoring for improved health

Food and nutrition security | National research and firms, as well as beneficiary and interested parties defined previously | Defined previously by MSCTIC based on potential social impact | Results (research, technology, knowledge) and impacts (economic, environmental, social) are previously defined in great measure |
| **Partly Induced Demand** | Previously defined by MSTIC based on strategic anticipatory intelligence connected to city reality, otherwise undetected | | International firms (tech transfer) and research defined previously, as national beneficiaries and interested parties

National research and firms defined in the proposal | Defined on the basis of competitive call for tender | Expected technological results and overall impacts defined in the tender, but refined/improved in the proposal to adapt to context |
| **Spontaneous Demand** | Previously defined by MSTIC based on strategic anticipatory intelligence connected to city future problems if an intervention is not realised in the present | Ecosystems and biodiversity conservation and recovery

Collaborative knowledge platform

Long-term integrated planning | International research and firms (assuring tech transfer) as well as national research, firms, beneficiary and interested parties defined in the proposal | Defined on the basis of competitive call for tender | Expected technological (disruptive) results and overall impacts defined in the tender, but refined/improved in the proposal to adapt to context |

5. Policy impacts: sustainable cities innovation observatory

In order to provide anticipatory strategic intelligence for shaping innovation policies that are robust and adaptive to different contexts in Brazil a sustainable city innovation observatory (SCIO) is being currently developed. It has been proposed as a spin-off of the research being here depicted.

The SCIO will tackle seven major challenges in alignment with requirements of MSTIC and its Programme of Technologies for Sustainable Cities (PTSC):

- Sustainable built-in environment with a circular and de-carbonised construction industry

- Low carbon mobility systems and improvement of citizen's accessibility to and in the city

- Clean, renewable, efficient and decentralised energy systems

- Universal access to and rational and sustainable use of potable water, as well as efficient and decentralised systems for treatment of effluents and solid waste

- Nature-based solutions that use and deploy the properties of natural ecosystems and the services that they provide in a smart and 'engineered' way, designed according to processes and shapes encountered in nature and applied in green and blue infrastructure, industrial components (bio-mimicry), among others, thus providing more efficiency in the use of resources and resiliency towards climate change

- Options for innovation strategies and policies based on the customisation of the smart specialisation EU approach (RIS3) to Brazilian cities and regions, aiming at the creation of new or the strengthening of existing value chains

- Integrated and long term planning, including the use of geo-referenced data (GIS), city-region typologies and co-creation mechanisms, in order to integrate inclusive and shared visions of the future of cities

The framework for tackling the above challenges through an investigative process is fourfold:

- Desk research for mapping and scanning the state of the art solutions and experiments being applied globally to both tackle and build a better understanding of the challenges at hand in their specific contexts

- Creating spaces for dialogue for different society stakeholders both to craft a collective vision able to empower cities and their residents to create the change they need and make the decisions that best suit their specific situations, and to experiment with different living labs approaches to prototype specific solutions and innovation policies able to ameliorate current city conditions or situations and related specific problems or challenges

- Big data analysis both to inform and to be informed by desk research and by the outcomes of stakeholders' dialogue in order to collect and organise, in a systematised manner, big amounts and variety of data and distil information that shall be used for further analysis

- Due diligence analysis to build breadth and depth in terms of both understanding the contextualised conditions or situations at hand, and the promising solutions or experiments that should be further promoted to test their likelihood to unlocking new strategic questions and tackling specific challenges in order to shape innovation policies that are adaptive

The above steps are concurrent and shall take place in parallel or in a circular fashion rather than linearly since they should feed into one another, continually. Ultimately, this circular process embedded in the SCIO should function as a new framework for shaping and implementing innovation policies in Brazil.

6. Conclusions

The paper outlines a collective long-term integrated systemic vision able to provide orientation for societal change. Such vision is key to enable transformative pathways able to guarantee a transition of Brazilian cities towards more sustainable, fair, prosper and inclusive urban environments. In the end, once this broad vision is adapted to different city-region contexts or

typologies in a participatory manner with city dwellers, it may be able to assure a sense of belonging and solidarity-based quality of life for all as well as safeguarding the natural life-support systems.

The defined unifying vision serves as a framework for national innovation policies both to set investment priorities and to measure progress against national and international agreements for urban sustainability. It also provides a framework able to empower cities to experiment contextualised solutions and city specific mechanisms for implementation aligned with priorities articulated in the policy developed by MSTIC and its Programme of Technologies for Sustainable Cities (PTSC).

Furthermore, a shift from a business model that only fosters induced projects to one that also includes partially induced and spontaneous projects is outlined as key to enable the scaling up of solutions as well as to provide further spaces for experimentation of potential solutions to contextualised city challenges.

The development of a strategic intelligence capacity able to offer a long-term perspective to the PTSC becomes, therefore, fundamental. This shall enable MSTIC to continuously anticipate potential sustainable city challenges across the country and associated STI lines of action to be fostered or induced. Ultimately, this would enable the PTSC to achieve a more robust performance with the potential to generate replicable solutions or solutions that are adaptable to different contexts of the national territory with associated resources needed for implementation in alignment with stakeholders' requirements both at national and local levels. By doing so and prioritising transformative actions that both benefit cities and are required from cities, STI national policies can truly become inclusive, efficient and build on complementarities between stakeholders rather than giving room for the duplication of efforts.

The Sustainable City Innovation Observatory (SCIO) is currently under development to provide anticipatory strategic intelligence for shaping innovation policies that are robust and adaptive to different contexts in Brazil. In this sense, different city-region typologies in Brazil shall be crafted for each of the seven challenges being tackled by the SCIO. These shall be based on existing data and statistics in the country and aligned with the Sustainable Development Goals (SDGs). Ultimately, these typologies shall enable a wider understanding of specificities in the country related to each of the seven challenges. In turn, this will enable decision making to consider different realities in Brazil when designing and implementing national policies. Finally, it is envisaged by MSTIC that when the SCIO is fully operational if may offer the national government with a new framework for shaping and implementing adaptive innovation policies in Brazil based on an evolving roadmap for the experimentation and the scaling up of solutions according to different city-region typologies.

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