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Preface / A word of welcome and thanks

It is a matter of great pride that the 20th-anniversary Globelics International Conference is being held in Thiruvananthapuram. This conference deliberates on an issue of much contemporary relevance – Innovation-driven Knowledge Economies and Transformation in the Global South, which is at the centre stage of development strategy both at the national and that of the government of Kerala. In 2006, when inclusive development was a major issue of global concern, Globelics conference was held in Trivandrum and deliberated on Innovation Systems for International Competitiveness and Shared Prosperity.

This Conference intends to bring together scholars across disciplines from over 50 countries to pool together experiences and expertise to reflect on varied issues involved in the process of transforming developing economies into sustainable, resilient, and inclusive innovation-driven knowledge economies.

In the conference, to be inaugurated by Shri Pinaryi Vijayan, the Hon'ble Chief Minister of Kerala, scholars of eminence will join as keynote speakers and panelists in plenary sessions and special sessions. The conference, organized in nine parallel tracks, will also have book presentations, excursions, and cultural events. As part of the conference, about 20 leading scholars from Globelics will visit different universities and colleges in Kerala to deliver lectures and interact with faculty and students, which is facilitated by Kerala Higher Education Council and Kerala Economic Association.

We welcome with great appreciation the Honourable Chief Minister Shri Pinarayi Vijayan and all the dignitaries who joined us for the inaugural address and eminent scholars delivering keynotes and addressing in different plenary sessions, special sessions, and parallel sessions. While the invisible hand of our honourable Chief Minister is there in all the important initiatives of GIFT, this program has been ably guided and steered by our Chairperson Shri K N Balagopal, Hon'ble Finance Minister of Kerala.

This important event is the outcome of the collective effort of all those involved, especially the Co-organising institutions: RIS, New Delhi, who inter alia managed the political clearance from the Ministry of External Affairs, IIM Bangalore, K DISC and the Digital University of Kerala. Our partnering institutions, ICSSR, Kerala State Higher Education Council, Centre for

Development Studies, Kerala Economic Association, and the Centre for Latin American Studies also have been helpful in organising this conference.

With much appreciation for all of you for being with us, we welcome you

K J Joseph
For the local organising Committee

About the 20th Anniversary Conference

The central theme of the 20th Anniversary Globelics International conference is Innovation-driven Knowledge Economies and Transformation in the Global South.

This conference intends to bring together scholars across disciplines from over 50 countries to pool together experiences and expertise to reflect on varied issues involved in the process of transforming developing economies into sustainable, resilient, and inclusive innovation-driven knowledge economies. Episodes of development in economic history highlight the successful experience of countries that have managed to harness Learning, Innovation and Competence-building Systems at the global, national, subnational and sectoral levels in order to transform their social and economic structures for achieving prosperity. In the current times, the constellation of innovations driven by rapid advances in digital technologies has given rise to a new technological revolution, commonly referred to as the fourth industrial revolution, or Industry 4.0, with profound impacts on all sectors of the economies and sections of societies. New and persisting developmental challenges have driven a renewed interest in different types of innovations that highlight their impact on society and the natural environment, such as inclusive innovation, responsible innovation, transformative innovation, grassroots innovation and Jugaad. At the core of all these approaches is how knowledge, both science-based and experience-based, is harnessed for addressing development challenges, the basic premise being "the knowledge divide is at the root of the development divide"

At the current juncture, wherein globalization is at the crossroads, the economies across the world, ravaged by the once-in-a-century pandemic and external shocks, consider strengthening the innovation system as a strategic approach towards building resilience. Evidently, there is an acrossthe- board drive among developing countries to transform their economies into innovation-driven knowledge economies. Such a transformation is often viewed as capable of building resilience by addressing many of the downsides of globalization-induced high growth, like excessive exploitation of exhaustible resources and accentuated divides within and between countries. Such

initiatives in India are manifested, among others, in Atal Innovation Mission (AIM), Digital India, Skill India, and Make in India and other concerted efforts to transform India into an innovation-driven knowledge economy. It is also in sync with the national agenda of harnessing Science, Technology, and Innovation (STI) to achieve sustainable development. The choice of the location of the conference is inspired by Kerala's strategy towards transforming the state into a knowledge economy, as explicitly stated in the budgets starting with 2020-2021 and the subsequent concerted efforts that followed. It is in this background that Globelics revisits India for the 20th Globelics International conference with the chosen central theme: 'Innovation-Driven Knowledge-Economies and Transformation in the Global South'.

The 20th Anniversary Globelics is also an occasion to celebrate the journey of Globelics from Brazil 2003 to India 2023 and its varied achievements. At the same time, it is also a forum for critically reflecting on our perspective and the approaches inter alia in terms of its achievements and limits. This is especially important at the current juncture wherein there is growing disenchantment with the development experience under globalisation on the one hand and the need on the other hand, for reimagining innovation systems in the COVID and Post COVID world towards building the much needed resilience in the South.

Globelics-India 2023 coincides with India's Presidency of G-20 that inter alia aims at influencing the development dynamics of Global South and it is an appropriate time for translating the insights of the conference with respect to strengthening Learning, Innovation and Competence-building Systems (LICS) into policy action. For the past two decades, we have observed an increasing influence of Global South in shaping the paradigms and trajectories of the global development agenda—sustainability, climate change, pandemic, and energy security issues—with India playing a key role; all being closely linked to the research domains of the Globelics.

World-leading scholars are set to give this year's keynote address on innovation and development. It is planned that the conference will be inaugurated by the Chief Minister of Kerala and there will be a special keynote on the conference theme along with a Globelics Lecture and Freeman Lecture. The conference will combine plenary sessions, presentations of research papers in parallel tracks, thematic panel sessions or special sessions, poster presentations, book presentation sessions, excursions, and cultural events.

Conference Tracks

While submissions on the central theme of the conference have been especially encouraged, submissions on all the issues conventionally deliberated in the Globelics international conferences are also included. Submissions have been organized around the following themes:

1. Science, technology, innovation: Theory and policy for a knowledge economy
2. Transformative innovation, responsible innovation and mission-oriented innovation
3. Knowledge-driven development of national, regional, local and sectoral innovation systems, including Agricultural innovation systems and rural development
4. Measurement of the knowledge economy: Indicators, data requirements, different approaches and methodologies
5. Skilling for the knowledge economy: Industry-academy interaction, Intellectual property rights, open innovation and development
6. Industry 4.0 and development: Digitalization and automatization, productivity and employment implications, gig economy and quality of employment
7. Economic and social upgrading for sustainable Catch-up: trade policies, FDI, value chains and innovation networks in a knowledge-driven economy
8. Innovation for inclusive development: Indigenous knowledge, Grassroot innovations, Jugaad, informal economy, micro and small enterprises
9. Entrepreneurship, employability and gender dimension in innovation and development
10. The green economy and financing innovation: Low carbon innovations, environmental technologies and renewable energy

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Is the directionality of transformative innovation policy ethical enough? A capability approach analysis of TIP experimentation.

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Abstract

Transformative Innovation Policy (TIP) is a novel approach to shaping and implementing science, technology and innovation policy that recognises the importance of addressing societal needs and pursuing sustainable, inclusive and equitable development. However, we argue that TIP principles, despite having a directionality orientation, do not sufficiently include an ethical dimension. The capability approach, a broad normative framework for the evaluation and assessment of individual wellbeing and social arrangements, brings substantial ethical considerations to TIP, broadening the understanding of what sustainable, inclusive and equitable development implies. This paper presents an ex-post capability assessment of a TIP experimental policy engagement conducted at the South African Living Catchment Project, which aimed to strengthen water governance in the country. Considering the insights of this analysis, we discuss normative and ethical implications for the multi-dimensional directionality orientation of TIP. Together, the directionality considerations and capability approach can be useful in designing and developing an innovation policy with transformative potential.

Keywords: transformative innovation policy; directionality; capability approach; ethical analysis; experimentation; TIPC

1. Introduction

Transformative Innovation Policy (TIP) is a novel approach to shaping and implementing science, technology and innovation (STI) policy (Weber and Rohracher, 2012; Schot and Steinmueller, 2018). It recognises the importance of addressing societal needs and pursuing sustainable, inclusive and equitable development. The TIP framework goes beyond relying solely on technological solutions and emphasises the significance of systemic change and the involvement of diverse actors, not just policymakers and researchers, in fostering social development and environmental sustainability. TIP acknowledges that conventional STI policies often focus on promoting technological advancements without sufficiently considering broader social, economic and environmental dimensions. While technological innovation is undoubtedly crucial, TIP recognises that sustainable development requires a more systemic, holistic and inclusive approach.

However, despite its directionality on social and environmental sustainability, we argue that TIP has not sufficiently discussed and developed an ethical dimension. Issues such as equity in accessing innovation benefits, or a deeper concern about barriers to participating in innovation processes or power imbalances, have not been considered enough in TIP (Boni et al., 2021). This paper proposes the use of the capability approach (CA) (Sen, 1999; Robeyns, 2005; 2017; Alkire and Deneulin, 2009) to ethically assess TIP. Although the CA cannot be considered a theory of social justice,[1] it can be considered a theoretical framework about wellbeing, freedom to achieve wellbeing and all the public values in which either of these can play a role, such as development and social justice (Robeyns, 2017: 23). It is especially useful for evaluative (and normative) exercises, including most prominently the following: (1) the assessment of individual levels of achieved wellbeing and wellbeing freedom; (2) the evaluation and assessment of social arrangements or institutions; and (3) the design of policies and other forms of social change in society (Robeyns, 2017: 23). Therefore, we argue that the CA can bring substantial ethical considerations to the directionality of TIP, broadening the understanding of what sustainable, inclusive and equitable development implies.

To accomplish this goal, we first present a particular approach to TIP developed in the Transformative Innovation Policy Consortium[2] (TIPC), which includes six principles for designing innovation policy with transformative potential (Section 2). Then, we describe the main characteristics of the CA (Section 3) and how it has been applied to assess innovation policies (Section 4). After that, we present the Experimental Policy Engagement conducted at the Living Catchment Project; this was a TIP experiment conducted by TIPC in South Africa that aimed to strengthen water governance in the country (Section 5). It should be noted that this engagement was designed without taking into consideration the CA. Then, using the main elements of the CA, we develop an ex- post ethical assessment of that engagement, highlighting what a CA analysis

can bring to the implementation of a TIP experiment (Section 6). Next, we return to the TIP framework and discuss the normative implications of our analysis and how these can be useful to design and conduct an innovation policy with transformative potential, considering especially the consequences of the directionality principle (Section 7).

2. Transformative innovation policy

Schot et al. (2019) argue that complex challenges like those posed by the Sustainable Development Goals (SDGs) require a new type of innovation policy that embraces uncertainty and complexity by promoting experimentation to inform and facilitate learning processes and changes in people, organisations and institutions. This approach is based on the Multi-Level Perspective on socio-technical transitions (Rip and Kemp, 1998; Geels, 2002; Geels and Schot, 2007), which identifies three levels of interaction: landscape, regime and niche. Niches are protective spaces where transformative ideas and practices can develop and evolve, but their potential is constrained or enabled by the more powerful structures of the regime. System transitions may occur when the regime is destabilised by external trends in the landscape, creating windows of opportunity for niches to influence or replace the regime. To foster sustainability transitions, the TIPC proposes six principles for designing policy with transformative potential, including focusing on directionality, societal goals, systems-level impact, learning and reflexivity, conflict and consensus, and inclusiveness (Schot et al., 2019: 23–24; Schepers and Steinmueller, 2019).

1. Focus on directionality: technological solutions that are offered to address social and environmental problems are not neutral. A variety of technological choices and alternative innovation pathways need to be considered for transformative innovation.
2. Societal goal: TIP should be directed to address grand social challenges such as the provision of food, energy, health, biodiversity and impacts of climate change, in line with the SDGs.
3. Systems-level impact: TIP should be directed to change underlying routines, values and norms that guide the use and application of technologies in society, keeping with the view that transformational impact is in alignment with new routines across several dimensions of a socio-technical system (culture, governance, industry, market, science and technology.)
4. Learning and reflexivity: a transformative policy initiative should facilitate the exchange of accumulated knowledge and continuous reflections on existing routines, understanding each other's assumptions and worldviews (second-order learning), with a view of changing mindsets and assumptions embedded in dominant practices.
5. Conflict and consensus: TIP must recognise the conflicts arising from the recognition of diverse interests and different views. Conflicts and a

search for common ground that allows consent should be integral to the process.

6. Inclusiveness: TIP should ensure both breadth of participation and empowerment of actors excluded from policy processes, such as civil society, users and marginalised communities as well as depth of participation — the extent to which included actors can influence the processes of the policy cycle.

These TIP principles are further discussed through the lens of the multi-dimensional nature of directionality in Section 2.1, below.

Going beyond the principles, TIP scholars have proposed concrete frameworks on enabling transformative change through innovation policy. Ghosh et al. (2021) propose a set of transformative outcomes (TOs) to guide policy initiatives towards transformative directions. A total of twelve TOs, provide practical guidance to design and assess the transformative potential of TIP interventions. These interventions are categorised into three macro-processes directed to produce system change: (1) Nurturing niches (TOs: Shielding, Learning, Networking, Navigating expectations); (2) Mainstreaming niches (TOs: upscaling, replicating, circulating and institutionalising); and (3) Opening up and unlocking regimes (TOs: destabilising and dealigning regimes, unlearning, empowering niche regime interactions and changing perceptions of landscape pressures).

The set of twelve TOs can be used to formulate and implement "experimental" innovation policy initiatives to unlock the potential for delivering transformational impact. Experimentation is a central element of the TIPC proposal, since the inherent nature of complex challenges and solutions requires an organised learning process focused on specific contexts (Molas-Gallart et al., 2021). TIPC's formative evaluation approach to experimental policy interventions focuses on monitoring progress by tracking learning and offering real-time guidance to enhance policy implementation. Within this approach, key principles involve integrating evaluation in the design and implementation phases, fostering inclusivity and participation, employing a diverse range of methods and techniques and utilising flexible and Transformative Theories of change (ToC) (Boni et al., 2019; Molas-Gallart et al., 2021; Ghosh et al., 2022).

Within the domain of transformative innovation policy, a Transformative ToC serves as a practical means to operationalise systemic change, explicitly representing the expected changes resulting from an intervention. Outcomes are central to building ToCs. These are defined as changes in individuals and organisations, guided by the TOs to maximise their contribution to systems change over time. This approach enables the measurement of outcomes at specific points in time and continuous improvement in the implementation process to facilitate transformational objectives (Ghosh et al., 2021; Ghosh et al.,

2022). The adoption of the TIPC formative evaluation approach and the thoughtful utilisation of TOs, we argue, contribute significantly to the pursuit of impactful and transformative innovation policy interventions.

2.1 TIP and directionality

In the literature on innovation, the idea of assigning directions to innovation stems from the fact that innovation systems traditionally operated with the dominant logic of efficiency, growth and optimisation (Schot and Steinmueller, 2019). It is said that for transformative change, innovation should be "oriented towards a certain direction of change" (Foray, 2019: 1390; Dierecks et al., 2019; Pel et al., 2020; Weber and Rohracher, 2012). While assigning directions to undirected innovations is justified by its own merit, it is, however, problematic if powerful actors control which direction and which technologies to support, benefiting a few and excluding many. Who drives, in which direction and why — all have implications on whether the innovations will be truly sustainable and just. Directionality is defined as "embracing and realising an otherwise suppressed diversity of possibilities" in innovation (Stirling, 2023). The concept departs from earlier understandings of "directing" or "giving direction" or unidirectional, to "bidirectional" or multidirectional process (Yang et al., 2022; Mylan et al., 2019). As sustainability and justice are both extremely complex and political destinations, the direction is also not singular. There can be many directions in which many types and forms of innovations can be driven, which begs the questions: whose direction is preferred? Who decides (and how) which direction is better? This is why it is argued that there is a need to shift from "directing" or "giving direction" to "embracing directionality" as a logic of innovation governance.

Directionality can be understood as an exploration of alternatives, acknowledging multiple pathways to change, as opposed to given, driven, offered or chosen by any single set of actors at a single space or time. Directionality is the deeper philosophy that actor(s), innovator(s) and societies recognise and embrace, to acknowledge that there are many possibilities for innovation, multiple alternatives to the "best solution", many knowledges that guide (or are suppressed from guiding) innovations, and many ways of resolving conflicts between "institutionally diverse actors" (Pel et al., 2020) and making meaningful advances without minimising the diversity of solutions.

Shaping and assessing the directionality of change, therefore involves illuminating possibilities of alternative innovations, "an explicit evaluation of alternatives" recognising that innovations are not neutral, and that each alternative has its consequent opportunities and threats associated with it (Schippl and Truffer, 2020). Such openness to multiplicity also means removing privileges in actor networks and knowledge networks: a phenomenon where deliberate attention to plurality of perspectives and diverse understandings of needs and demands is present (Edler and Boon, 2018). Plurality itself can be

varied in quality and the degree to which each recognised perspective is distinctly different from one another. Directionality, practically speaking, starts with collectively mapping out different directions (and subsequent uncertainties associated with each direction), instead of decisively moving one way forward (a way that may seem self-evident to some, but could have intended or unintended consequences). An example of such lack of directionality is the push for electric vehicles as the face of sustainable mobility, when improving public transportation systems and infrastructure for walking and cycling are, arguably, equally important innovation trajectories.

Appraisals of directionality involve a manner of inclusion, one where the plural agency in exploring the multiplicities of directionality is enabled in a more open and substantive sense. Such agencies can only manifest in an open democratic space, one where shared visions (instead of technologically inspired cockpit vision) thrive. Ultimately, directionality of innovation for transformative change is all about nurturing a general reflexivity and acceptance of democratic struggle. In a dynamic change process, it is desirable that systems are "caught between different directionalities" of change — exploring multiple pathways, navigating contradictions and managing uncertainties. It is through these explorations, contradictions and uncertainty navigations that a democratic and pluralistic approach to transformative innovation can be maintained.

The question that remains is how can we better understand and mobilise the complex notion of directionality in TIP theory. As we explored in the previous section, TIP is built around six principles, of which directionality is one. However, we argue in this article that each of the other five principles of TIP embraces other aspects, meanings and operationalisation of the concept of directionality. This is what we call "directionality orientation". In Table 1, below, we demonstrate how each TIP principle has a different directionality orientation and these orientations further strengthen the original directionality principle of TIP.

Table 1: Directionality orientation and strengthening of TIP Principles

TIP principles	**Aspects of Directionality**	**Directionality orientation**	**Strengthening TIP Directionality Principle**
Societal goal	Carefully, openly and accessibly compare diverse alternative directions for change for achieving multidimensional societal goals, rather than just "direct" what power-play wishes to portray as one apparently self-evident *"way forward"* or the	Goal oriented directionality.	Different Societal goals (e.g., 17 SDGs) make choosing a non-neutral technology a difficult task.

	best solution.		
Conflict vs Consensus	Deliberate attention to the plurality of perspectives, acknowledging conflicting views and reasons for agreements and disagreements; Supporting a bottom-up range of visions, however contradictory, and attempts to make them shared visions.	Perspective- oriented directionality.	Different perspectives allow questioning the non- neutrality of technologies.
System level focus	Nurturing diversity of solutions, for changing deeper routines and practises.	Rule-oriented directionality.	Rules across different system dimensions (market, policy, culture, etc.) show technologies are not the only solutions.
Learning and reflexivity	A general sense of reflexivity throughout the process of inclusion; appraising varieties and qualities of plurality in the process.	Process-oriented directionality.	A reflexive innovation process questions and alters the assumptions about previously perceived neutral technologies.
Inclusion	Opening up the democratic space for plural agency is critical for justice; Avoiding misrepresentation, misframing and other forms of hidden injustices.	Justice-oriented directionality.	Recognitional a
Source: Prepared by the authors			

3. The capability approach

The Capability Approach (CA), originating from seminal contributions by Amartya Sen (1999) and Martha Nussbaum (2000), is a theoretical framework for evaluating individual wellbeing and social justice that focuses on people's capabilities or real opportunities to achieve a life they have reason to value (Robeyns, 2005). The basic principle of the capability approach is that, when asking normative questions, we should ask what people are able to do and what lives they are able to lead (Robeyns, 2017: 7).

The CA distinguishes between capabilities and functionings. Capabilities refer to the real opportunities or freedoms that people have, whilst functionings refer to their actual operation into valuable states or conditions, such as being healthy, educated or having social relationships (Robeyns, 2005). The CA argues that individual wellbeing and freedom depend on both capabilities and functionings, and that material and non-material goods are only instrumental in achieving these states or conditions. As Robeyns (2017: 51) highlights, both

capability and functioning are the main elements of the evaluative space of the CA. However, functionings can be positive (the ones that expand wellbeing and freedom), but they can also be negative (i.e., having stress or suffering from physical violence). So, the CA can also be extended to promote wellbeing and to promote the weakening of functionings that have a negative value (Robeyns, 2017: 52).

By focusing on capabilities and functionings, the CA offers a more comprehensive and nuanced view of individual wellbeing and social justice than traditional economic measures that rely solely on income or consumption. In this sense, it can provide a valuable framework for designing (innovation) policies and interventions that expand people's capabilities and remove the obstacles that block the expansion of other capabilities (Sen, 1999; Robeyns, 2005; Alkire and Deneulin, 2009).

Besides capabilities and functionings, two other key components of the CA that can be useful for our analysis are agency and conversion factors. An agent is "someone who acts and brings about change, and whose achievements can be judged in terms of her own values and objectives, whether or not we assess them in terms of some external criteria as well" (Sen, 1999: 19). An agent is not a passive recipient but takes an active role in their own or their community's wellbeing (Olsaretti, 2005). According to Robeyns (2017), in capability studies, some authors have given agency a key role in a capability theory (Crocker, 2008), while others have studied the necessary preconditions of agency, which may include capabilities (de Herdt, 2008). This is, precisely, how agency will be examined in our ethical assessment of TIP experimentation, as we will present in Section 4.

Finally, the CA introduces the concept of conversion factors, which are the personal traits, social arrangements and environmental conditions that determine an individual's ability to convert resources into capabilities (Robeyns, 2005). Drèze and Sen (1995) argue that social conversion factors are essential for human capabilities:

> *The [capability] approach used in this study is much concerned with the opportunities that people have to improve the quality of their lives. It is essentially a 'people-centered' approach, which puts human agency (rather than organizations such as markets or governments) at the centre of the stage. The crucial role of social opportunities is to expand the realm of human agency and freedom, both as an end in itself and as a means of further expansion of freedom. The word 'social' in the expression 'social opportunity' […] is a useful reminder not to view individuals and their opportunities in isolated terms. The options that a person has depend greatly on relations with others and on what the state and other institutions do. We shall be particularly concerned with those opportunities that are strongly influenced by social circumstances and public policy […]. (Drèze and Sen, 1995: 6)*

Capability, functionings, agency and personal, social and environmental conversion factors are the core elements of the CA that will be used in our ethical assessments of TIP experimentation. However, as Robeyns (2017) points out, in each application of the CA, these core elements can be supplemented with other values, under the pluralism of the CA approach. To analyse the directionality of TIP experiments, we consider that three further critical elements should be added:

- The relevance of democratic decision-making and public deliberation in shaping social norms and values (Crocker, 2008). It recognises that what constitutes a good life and wellbeing is socially defined and declared and that socially embedded agents should be able to participate in political and social affairs that shape their lives.
- The importance of power relations in processes of decision-making. Sen (1990) can be particularly useful for addressing this issue. Sen argues that people do not have singular affiliations, but rather multiple and intersecting social identities that are articulated strategically according to specific contexts and situations. Therefore, individuals' bargaining power is the result of the relations between levels of cooperation and conflict articulated in the process of decision-making (Frediani et al., 2019).
- The importance of epistemic justice, which claims that making epistemic contributions (i.e., generating interpretive materials to speak of people's realities) is fundamental to human wellbeing, dignified human life and broadening freedoms (Fricker, 2007; 2015).

Table 2 presents the core components of the CA we will use in the ethical analysis of TIP experimentation:

Table 2: Elements of the CA used to ethically assess TIP experimentation

Elements	Definition
Capabilities	Real opportunities to achieve a life people have reason to value.
Functionings	Actual valuable states or conditions.
Agency	Someone who acts and brings about change for their own or their community's wellbeing; includes examining the capabilities that are preconditions of agency.
Personal, social and environmental conversion factors	Personal traits, social arrangements and environmental characteristics that influence the conversion of resources into capabilities and functionings.

Democratic decision - making	Socially embedded agents should be able to participate in political and social affairs that shape their lives.
Power relations	Analysis of levels of cooperation and conflict articulated in the process of decision-making.
Epistemic justice	Epistemic capability to make epistemic contributions.
Source: Prepared by the authors	

4. CA and policy innovation

As Chiappero-Martinetti et al. (2017) point out, the CA has not been widely used in innovation research. One reason for this may be that innovation research has traditionally focused on economic growth and productivity, closer to the notion of economic development, while the capability approach emphasises the importance of human development and wellbeing (Bajmóci and Gébert, 2014). However, there has been a growing recognition of the limitations of traditional economic measures of innovation and the need to incorporate a broader range of social and environmental questions into innovation policy (Schot and Steinmueller, 2018; Ziegler, 2015). As a result, there is potential for the CA to play a greater role in innovation policy research.

One group of contributions that have used the CA to examine the links between human capabilities, human development and social innovation are described in the special issue edited by Chiappero-Martinetti et al. (2017). For our ethical analysis of TIP experimentation, two contributions are particularly relevant. Firstly, Mazigo (2017) stresses the importance of using action-research methodologies to involve marginalised communities in processes leading to social innovation. In his research on the fishing sector in Tanzania, he noticed that action research methodologies helped to reflect on individual and collective challenges and to propose novel ideas, strategies, services and products. Moreover, using these methodologies, marginalised communities experienced a change in their perception of social status, which is an important aspect contributing to their aspirations and capabilities. We strongly support this view through our observation of different experimental policy engagements. As we will see in the next section in a particular case study, the design and implementation of participatory methodologies are crucial in TIPC experimentation (see the directionality and inclusiveness principle of TIP in Section 2). Moreover, similarly to what the Tanzanian case shows, reflective and creative capabilities, and increasing the self-awareness of participants as agents of change, have been crucial in the TIPC experimentation.

Secondly, Ibrahim's (2017) contribution is also relevant to our analysis. She notes that by engaging in collective actions, the poor can enhance their agency and create new collective capabilities that each individual alone would not be

able to achieve. While the primary focus of this paper lies beyond the scope of delving into the debate on whether capabilities can be confined solely to individuals or extended to collectives,[3] it remains intriguing to observe the emphasis the author places on participatory methodologies (the 3C). These methodologies foster a collective vision, enabling effective collaboration with the state, civil society and donors in the pursuit of challenging prevailing power relations. This is also relevant for TIPC experimentation: the collective vision (in our case expressed through a theory of change guided by the transformative outcomes as we explain in the next section) is the basis for enacting TIP. However, a deeper analysis of power relations (such as that conducted by Ibrahim, 2017) is still lacking in TIP theory.

Furthermore, Capriati (2013) stresses the relevance of the CA to normatively analyse the social and institutional context in which innovation systems evolve. He points out the fact that the enhancement of some capabilities can be achieved in a context where other capabilities are disregarded (i.e., innovation processes can be linked to the creation of inequalities). And, referring to the democratic deliberation principle which states that democracy is a precondition, not a result of growth (Sen, 1999), Capriati alerts that innovation cannot preclude citizens' participation.

Capriati also highlights the importance of the learning capability, which not only has an instrumental value in enhancing wellbeing, but it can also be considered a substantial capability in innovation processes. In Lundvall's words (2007: 36) quoted in Capriati (2013: 8),

> *The learning capability is thus one of the most important of the human capabilities and it is conditioned by national institutions and forms of work organization. It does not only have an instrumental role in development but also, under certain conditions, substantive value. When learning takes place in such a way that it enhances the capability of individuals and collectives to utilize and co-exist with their environment, it contributes directly to human well-being. Furthermore, to be able to participate in learning and innovation at the work place may be seen as 'a good thing' contributing to a feeling of belonging and significance.*

As we have presented in Section 2, learning is one of the key principles of TIP. It is also a central component of two TOs. Hence, we concur with Lundvall and Capriati on the substantial value of the learning capability; however, to be more in tune with the TIP approach, we suggest considering deep learning as a substantive element of the learning capability, which is a kind of "tacit" learning that encourages reflection, changes in beliefs, values, behaviours and assumptions in the understanding of social and environmental problems and solutions (Schot et al., 2019).

Another key contribution has been made by Bajmóci and Gébert (2014), examining the national systems of innovation approach using the CA. Although their CA analysis is on a different framework of innovation, some of their considerations on the usefulness of the CA are pertinent to our analysis.

First of all, the authors note that the CA shifts the attention from the means to the ends. In the CA, the first question we must address during the process of social choice is what capabilities are deemed to be valuable for the community and how valuable they are (Sen, 1999). We concur with the authors that without this evaluative judgement, the endeavour to provide a broader set of means for people through the operation of the innovation system (and in our case the TIP approach) cannot really be assessed.

Secondly, the CA draws attention to the fact that policymakers require knowledge and information that is scattered amongst a large number of actors. Consequently, Bajmóci and Gébert (2014) highlight that innovation policy needs novel ways of policy learning and to reshape the border between expert and layperson/citizen. This point has been definitively incorporated into the TIP proposal (see Principle 6 in Section 2); however, its practical implementation is not as straightforward, as we present further.

> Thirdly, the authors discuss that, within a society, there may exist several (sometimes competing or even contrasting) viewpoints about the contribution of technology and innovation to the expansion of capabilities: *The direct corollary of this formulation is that the particular objectives of innovation policy are not fixed once and for all. They will obviously differ in space and time since they are formulated as results of social choices, where the competing or contrasting viewpoints are negotiated* (Bajmóci and Gébert, 2014: 99).

This corollary is extremely relevant for the TIPC proposal which integrates, as one of its main principles, conflict vs consensus. Experimentation, as developed by the TIPC, acknowledges that conflict is an intrinsic part of transformation and a source of learning. Furthermore, TIPC recognises the openness of TIP experimentation by constantly evolving according to the context conditions. As we present in the next section, the theory of change depicting the directionality of the experiment is flexible and should be revisited and renegotiated through the experimentation process.

Finally, Bajmóci and Gébert (2014: 99) stress the relevance of individual, social and environmental conversion factors that influence how people may achieve different valuable functionings through new technologies (Oosterlaken, 2012). This is exactly what could make innovation policies differentiated, since the set of information required for policymaking — besides being specific to a given community or society — incorporates knowledge elements that are possessed by local actors.

Overall, the different applications of the CA to analyse innovation policy have highlighted: (1) the importance of participatory methodologies not only to answer to the inclusiveness principle but also to expand reflective and creative capabilities and to reinforce the awareness of being an agent of change; (2) the importance of the learning capability as a substantial capability in innovation processes; (3) the relevance of building a collective vision, based on the valued capabilities of participants and with a fair process of decision-making; (4) the acknowledgement of contested visions due to the inherent diversity of visions and the openness of innovation processes; (5) the influence of conversion factors in innovation policymaking that rend each policy deeply contextual;

(6) the importance of enlarging the knowledge and information basis that is scattered amongst a large number of actors, especially the non-expert ones.

All these elements are going to be considered in our ex-post analysis of the TIPC experimentation of the Living Catchment Project in South Africa, which is briefly described in Section 5.

5. The experimental policy engagement with the living catchment project

Within the TIPC methodology, Experimental Policy Engagements (EPEs) serve as action research initiatives, fostering collaboration between policymakers, researchers and various stakeholders. Their primary objective is to harness the potential for systemic change towards a more desirable future. As "experimental" endeavours, EPEs recognise the absence of a one-size-fits-all solution for complex challenges, marked by numerous uncertainties and the involvement of diverse interests and expert and non-expert knowledge. This constant interplay demands ongoing collaboration, coordination and negotiation. The essence of EPEs lies in their ability to establish complementarity, effectively addressing these challenges while placing a strong emphasis on the continuous learning process of all participants. This focus on learning is integral to sustaining changes over the long term, fostering an environment conducive to transformative shifts.

In 2020, The Department of Science and Innovation of South Africa (DSI), a core member of the TIPC, provided a unique opportunity to develop a 16-week EPE aimed at enhancing the transformative potential of a funded project known as "Living Catchments" (LC). This project was in development between July 2019 and November 2023 and forms a crucial part of South Africa's 2015–2025 Water Research, Development and Innovation Roadmap. The roadmap is a national planning intervention designed to address the pressing issue of water scarcity in the country.

The societal goal was transforming water governance, as South Africa grapples with multiple pressing water issues, including supply security, ecological infrastructure degradation, inadequate landscape governance and resource pollution. These challenges are further exacerbated by ageing built

infrastructure, a rapidly growing population and the impacts of climate change. Presently, over 98% of the dependable surface water is already allocated, leaving demand exceeding supply. If these existing water challenges are not effectively addressed, the country could be confronted with a distressing 17% deficit in water supply by the year 2030 (Department of Water and Sanitation, 2018).

Hence, the main objective of the LC was to fortify water governance structures by fostering communities of practice (CoP) that brought together local communities, researchers, water practitioners and national and local policymakers. This collaborative approach sought to strengthen water security by integrating both built and ecological infrastructure. The project encompassed four river catchments, namely Umzimvubu (Eastern Cape Drakensberg), Thukela (Northern Drakensberg), Berg-Breede (Boland) and Olifants (Mpumalanga Drakensberg). Through this initiative, a catchment-based learning platform was established to bolster research, innovation and the overall impact of the engaged CoP within these key catchments associated with Strategic Water Sources (SWSAs).

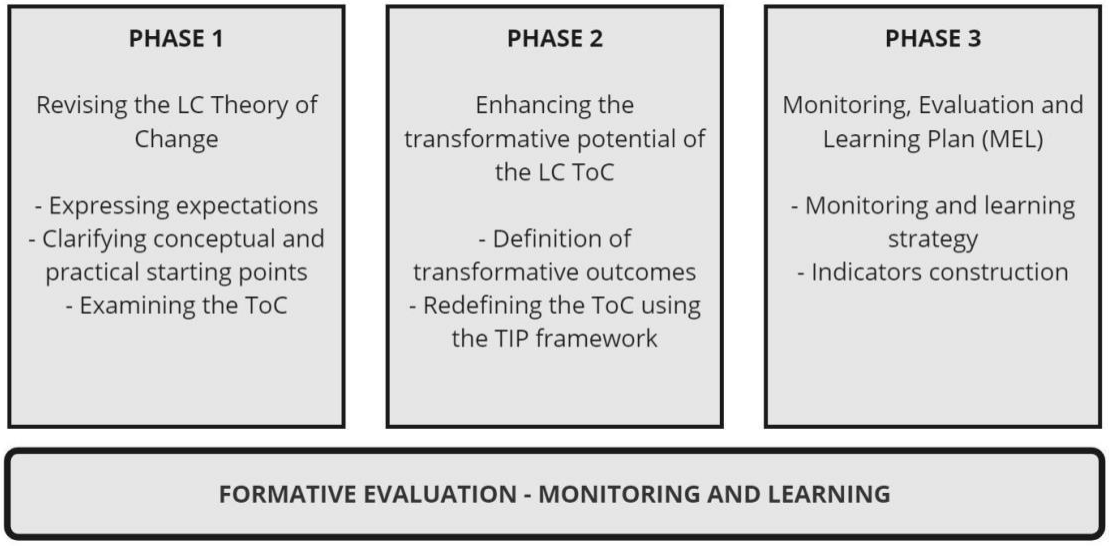
The 16-week EPE featured the participation of 37 people. Nine practitioners in charge of the funding, design and implementation of the LC from the Water Research Commission (WRC), the South African National Biodiversity Institute (SANBI) and the DSI. Four research assistants and one professor coordinating them from the University of Johannesburg. Fourteen observers from a diversity of organisations such as the Human Sciences Research Council, the National Department of Environmental Affairs and the University of Pretoria. Participants from the LC project were selected in coordination with the DSI and the WRC, prioritising work package leaders and those with direct influence on the project implementation. The observers were selected by the DSI to enhance capacity-building within key organisations and facilitate learning and reflection on the process. The University of Johannesburg participants contributed from their nascent trilateral national chair in Transformative Innovation, the Fourth Industrial Revolution and Sustainable Development.

The engagement benefited greatly from the participation of student research assistants, contributing to both the development of the initiative and their training process. As the EPE concluded, both observers and research assistants compiled documents reflecting on their perspectives and experiences during the process.

Instead of traditional "training sessions" the team responsible for developing the project, comprising TIPC researchers and practitioners implementing the project, opted for a collaborative approach through co-creation sessions. In these sessions, a blend of theoretical concepts and their contextual application within the project was explored. The team engaged in mutual learning by strengthening an existing ToC for the LC developed before the engagement.

The teams had to adapt the methodology to a virtual setting due to the COVID-19 pandemic restrictions, which added extra complexity and joint thinking on how to ensure the sessions remained fully participatory. Sessions typically included preparatory reflections, sense-making discussions on relevant concepts, methods and project specificities, collaborative work on the ToC using digital boards and a closing reflection session for sharing impressions. The design of the sessions was initially proposed by researchers and later discussed with the full team. Each session occurred bi- weekly with preparatory work in between. Additional interactions between team members took place to further discuss the methodology and to improve the coming sessions. Topics addressed included examining power and agency in the process, contextualising the theory and ensuring equal contributions to knowledge production from both practitioners and researchers.

Figure 1: Living Catchments project EPE methodology



Source: Prepared by the authors

TIPC researchers proposed a three-phase methodology which was discussed with the teams and tested throughout the EPE (see Figure 1). The purpose of the first phase included building trust within the team by getting to know each other, setting expectations up front, building a shared understanding of the LC project, discussing the main theoretical concepts related to TIP and formative evaluation to be used throughout the engagement and reviewing an existing ToC built by the LC team prior to the EPE.

The second phase utilised transformative outcomes to refine the LC ToC and align water system transformation efforts within the scope of the project. The evolved ToC emphasised empowering participants in the catchment CoPs and fostering durable outcomes beyond outputs, such as general community events or the inclusion of postgraduate students in the project. The team also reflected on what voices were excluded and how the agency of those involved in the

CoPs could be enhanced by creating participatory spaces where different knowledge and experiences could contribute towards the better integration of ecological and built infrastructure for water provision. During three online workshops and two in-between reflections between different members of the team, the ToC was further developed to define three clusters: co-learning in primary catchments associated with SWSAs across South Africa; enhancing SANBI's social learning facilitation; and strengthening policy advice for improved water security response.

Five outcomes were defined among the LC team after the second phase interactions. The first three outcomes are part of Cluster 1, the fourth of Cluster 2, and the fifth of Cluster 3:

1. Catchment-based social spaces foster agency, trust, connection, convening, collaboration, co-creation, co-learning and agenda-setting between scientists, policymakers, implementers and local stakeholders working in SWSAs at the nexus of built and ecological infrastructure.
2. Co-learning occurs within and between different SWSAs at the nexus of built and ecological infrastructure.
3. Social spaces fostering collaboration and co-learning are sustainable and locally institutionalised.
4. The science of transformative social learning facilitation is visible and valued by key institutions and individuals working at the nexus of water and ecosystems.
5. Policy and associated advice (operating at the nexus of water and ecosystems) are articulated and worked with in a way that is responsive to current needs, co-owned by key stakeholders and implementable.

In the third and final phase, a Monitoring, Evaluation and Learning Plan was developed based on the LC's ToC. TIPC's formative evaluation approach (outlined in Section 2) emphasises learning and reflexivity, starting from the intervention design. The ToC served as a catalyst for ongoing reflection in the action-learning cycle, fostering an agile implementation approach for the LC. During this phase, the focus was on selecting critical areas within the ToC that contribute to the change process and significantly impact the project's aim. Indicative evaluation questions were employed to build indicators, such as examining the co-creation of the research and innovation agenda in the catchment, the role of co-creation and learning in conflict resolution, the relationship between facilitation capacity and stakeholder trust, and whether policy advice reflects diverse stakeholder voices.

It is noteworthy that these indicators were used as proxies to monitor the intended changes, rather than being the central focus of the evaluation process. The monitoring process aimed to surpass mere accountability, emphasising action-based deep learning and reflexivity to continually improve the interventions.

The completion of the three phases yielded valuable insights for both researchers and practitioners, shedding light on the practical implications of designing, implementing and evaluating TIP. A crucial outcome of this exploration was the recognition of the necessity to incorporate discussions on power dynamics, gender considerations, post-colonial perspectives and trust-building as integral components of the co-creation processes. By addressing these vital aspects, EPEs can foster more inclusive and effective TIP initiatives.

6. An ex-post analysis of the LC project based on the capabilities approach and directionality

As previously elucidated in Section 2, our conceptualisation of directionality encompasses a democratic innovation governance logic that not only fosters possibilities for innovation with direction but also facilitates comparison between multiple directions of innovations. In this way, it addresses power imbalances and eliminates privileges, while simultaneously mapping out diverse directions for system change by alternative solutions. To fortify the normative principles of TIP and imbue the notion of justice with tangible substance, we propose leveraging the human capabilities approach and its diverse elements (Table 2). Drawing from these analytical lenses, we will utilise the LC experience as an ex-post illustrative example, showcasing the insights that such an approach can offer to forthcoming TIP experimental policy initiatives.

The LC project's primary focus lies in addressing the governance of the water supply challenges faced by South Africa, aligning with the objectives outlined in the 2015–2025 Water Research, Development and Innovation Roadmap. It responded to a broader goal- oriented directionality, acknowledging that the inclusion of diverse stakeholders in key catchments associated with SWSAs extends beyond technical considerations. Moreover, the project's emphasis is on establishing social spaces to nurture local agency, where democratic decision-making processes shape agendas and optimise the use of ecological and built infrastructure. However, a capability perspective on agency and democratic deliberation could have enhanced the political approach to collaborative spaces introducing reflections and, potentially, contestations on power issues *(Perspective- oriented directionality*). According to the CA, collaborative spaces promote participation, not just as a tool but also as a principle and a political position (Boni et al., 2021). Also, a more political approach would have triggered questions related to sustainability, justice or solidarity (which are central in the CA) that would have fostered conversations and reflections on social justice issues that were absent throughout the sessions (*Rule-oriented and Goal-oriented directionality*).

The EPE significantly engaged with socio-technical directionality, demonstrating an upfront acknowledgement of the diverse dimensions crucial for water system transformation. The establishment of CoPs with strong local

actor presence and the involvement of social scientists and decision-makers in the agenda-setting process went beyond the conventional technical solutions focus, though it was not without contestation and challenges. The LC's effort to address these issues represented a partial approach to *perspective-oriented directionality*. However, limitations arose due to digital restrictions and the design of the EPE, resulting in the absence of participants from the actual catchments and overlooking local perspectives in constructing the LC's ToC. In that sense, a capabalitarian analysis suggests paying attention to epistemic justice concerns and making efforts to include the less privileged voices while ensuring, at the same time, the conditions for meaningful participation (*Justice-oriented directionality*).

Nevertheless, the LC project achieved success in convening key stakeholders, fostering collaboration, transcending silo and simplistic water management approaches and providing timely data to inform policy practices. Furthermore, it played a pivotal role in shaping the research and innovation agenda linked to the Water Research, Development and Innovation Roadmap (SANBI, 2023).

Furthermore, upon post-execution analysis of the LC using the CA as a lens, we observe that the collaborative co-creation sessions could have benefited from deliberately designed methods to expand the creative and reflective capabilities of the participants. By placing a stronger emphasis on deepening the team's agency and providing tools to foster and train catchment CoPs in addressing power imbalances and facilitating processes of democratic deliberation within LC activities, we believe that the project could have enhanced process-oriented capabilities for social relations, social networks and participants' epistemic capabilities. This approach aligns coherently with the *Process and Justice-oriented directionality* that the TIP approach entails.

Moreover, the LC lacked consideration of the personal conversion factors among EPE participants and within the project's ToC design. Conducting a personal conversion factors analysis would have yielded valuable information on the participants' characteristics essential for inclusion and meaningful participation in the formative evaluation process. Insights into values, motivations, expectations, political affiliations, ideals and emotional factors are crucial for effective project planning and implementation *(Perspective-oriented and justice-oriented directionality)*.

While the first phase of the engagement partially explored participants' backgrounds and expectations, it lacked specific criteria for designing more effective collaborative spaces (important for justice-oriented directionality). Additionally, the LC's ToC design failed to account for how the creation of CoPs should align with participants' characteristics to leverage available resources and enhance their learning and epistemic capabilities.

Lastly, a more comprehensive examination of social conversion factors would have provided a more contextual understanding of the experiment and its socio-technical system, particularly in the realm of water provision. The CA would have called for a deeper exploration of the political context, gender relations and other social norms, enriching discussions and reflections within the formative evaluation process and broadening perspectives on the directionality and potential systemic change. By incorporating the CA lens and addressing these conversion factors, the LC could have strengthened its capacity for inclusivity, effectiveness and overall impact (*Goal-oriented directionality*).

7. Towards a more ethical understanding of TIP

An ex-post ethical assessment of the TIP experimentation with the LC project reveals that a normative orientation of innovation activities can potentially make the activities and outcomes more transformative. We show this by conceptually working on two perspectives: (1) On the CA, showing that selective elements of the CA enhance the six TIP principles ethically; (2) On the TIP approach, showing that the directionality orientation of all the six TIP principles help in unpacking the multi-dimensional aspect of normative considerations, through an emphasis on diverse perspectives, processes, goals, rules and justice.

Table 3, below, summarises the main points of this contribution.

Table 3: Contribution of the CA to the Normative Considerations of TIP

TIP Principle	**Directionality orientation of TIP**	**Relevant elements of CA**	**Contribution of the Capability Approach**
Principle 1: Directionality	Non-neutrality of technological solutions	Capabilities; functioning's; social conversion factors	CA can contribute to guiding innovation pathways with purpose by emphasising the importance of expanding people's capabilities and removing unfreedoms as well as conditions under which technologies have to be appraised with specific directionality, which are, hence, non-neutral.
Principle 2: Addressing Societal Goals	Goal-oriented directionality	Capabilities; agency	CA can add a normative dimension to the identification of Societal Goals by emphasising the importance of expanding people's capabilities and agency and removing un freedoms as a societal goal in itself. This can help ensure that Societal Goals are not just about addressing climate change, but about creating further favourable conditions towards transformative change.

Principle 3: System-level impact	Rule-oriented directionality	Agency, conversion factors	CA can be applied to evaluate the agency of actors and organisations involved in TIP initiatives in changing deeper rules (beliefs, norms, habits, etc.) in each dimension of a socio-technical system (culture, regulations, industry market, science, technology). By applying the CA, policymakers and practitioners can assess whether personal traits such as habits and routines, social arrangements such as social norms and regulations, and environmental characteristics are changed through the agency of participants in TIP.
Principle 4: Learning and reflexivity	Process-oriented directionality	Democratic decision-making; epistemic justice	CA recognises the importance of learning as part of democratic decision-making in enhancing people's capabilities and empowering them to make meaningful participation in the innovation process. CA emphasises the importance of reflexivity in fostering human development through epistemic justice, as it enables individuals to make more informed choices and engage more effectively with others. These are ethical arguments to put in practice participatory methodologies that can enhance learning and reflexivity in TIP experimentation.
Principle 5: Conflict and consensus	Perspective-oriented directionality	Power relations; agency	CA can contribute to navigating conflicts and enhancing co- operations, identifying possible tensions and trade-offs, and gaining awareness of stakes and stakeholders through managing power relations in innovation processes that are inclusive of diverse perspectives. CA emphasises the importance of participation and agency or the ability to bring about change, particularly among the most marginalised groups.
Principle 6: Inclusiveness	Justice-oriented directionality	Democratic decision-making; conversation factors	CA can add a normative dimension to TIP by emphasising the democratisation of innovation and ensuring access, participation and recognition of diverse voices in the innovation process. This ensures that innovation outcomes are inclusive and responsive to the needs and aspirations of all individuals and communities. To ensure inclusivity and justice, CA also helps policymakers assess what personal, social and environmental conversion factors are at play in enhancing people's capabilities and removing unfreedoms that limit the opportunities of diverse individuals and communities.
Source: Prepared by the authors			

8. Concluding remarks: towards a more ethical account of the directionality of TIP

This paper shows what the CA approach could add to the TIP or transformative innovation in general, by not only identifying relevant normative aspects but also refining the understanding of them. The CA can add a normative dimension to all six principles of TIP, by emphasising the importance of expanding people's capabilities and agency and removing unfreedoms in pursuit of more inclusive, equitable and sustainable innovation outcomes. Furthermore, the CA can bring useful insights to take into account the relevance of personal, social and environmental characteristics of TIP experimentation, providing a more nuanced understanding of both the participants and the context in which the experiment takes place.

However, the CA is not just a normative plug-in on the TIP. By combining the directionality analysis of TIP principles with the seven elements of the CA, we go a step further into reflecting about TIP normative considerations and how a TIP approach can learn from, combine and complement the CA approach to fulfil ethical considerations. We argue that TIP as an approach that seeks fundamental transformations in society, economy and environment through innovation, has a lot to benefit from capabilities, democratic choices, empowerment and justice. The CA approach provides insights into these aspects and hence enriches the TIP approach.

Using a concrete TIP EPE, we show that normative and ethical considerations are more than just including the first TIP principle, which is directionality in terms of non- neutrality of technological solutions. It is also more than ensuring that all six principles are considered in the TIP experimentation, as there often remains a large gap between considering the normativity and ensuring that these are realised. A CA and TIP analysis ensures that normative and ethical considerations are not only included, but also accounted for in the process of experimentation. At the same time, taking only the CA approach, without the TIP approach in the LC project would have not been sufficient for transformative change. A TIP approach, and particularly the formative evaluation approach which revolves around the Transformative Theory of Change, was necessary in order to strengthen the transformative water governance potential of the LC project and enhance deep learning among participants.

Experimentation is a novel yet difficult way of approaching innovation policy design and implementation. The CA sheds light on the complexity of TIP by splitting wellbeing into capabilities, functionings, conversion factors and agency. Also, due to its pluralism, the analysis can be enlarged to include other normative considerations. The plasticity of the CA could be relevant for the analysis of TIP empirical work and a fertile dialogue between the two

approaches could benefit the directionality of innovation, addressing its failures and reorienting it towards sustainable and equitable pathways.

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Notes

[1] With some exceptions: see Nussbaum (2006) and the theory of disadvantage by Wolff and De-Shalit (2007) for a comprehensive theory of justice based on the CA. For an understanding of the CA as a non-ideal theory of justice relevant to innovation policy, see Papaioannou (2021).

[2] TIPC is a five-year programme focused on policy experimentation, evaluation, capacity building and research agenda development. As part of TIPC, South Africa has set a portfolio of experiments to trigger innovation for transformative change. The LC project was selected as the first project to work directly with TIPC researchers to enhance the project's design and implementation based on a formative evaluation guided by the TIP principles (Molas-Gallart et al., 2021).

[3] For scholars that have advocated for collective capabilities, see Stewart (2005) and Ibrahim (2006).

2

Public engagement with S&T for national development in India- Towards a Historical Perspective on the STI Transformations

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1. Introduction

This article examines India's science, technology and innovation (STI) policies and their integration with the wider policy regimes for national development followed after gaining political independence. The impacts of the conduct and performance of the political and bureaucratic apparatus and the transnational and national capital on the system building at the national level during the pre-reform and post reform periods on knowledge creation, learning, competence building and transformative innovation making are assessed.

A critical perspective is provided on the sources of emergence of conceptual diversity of the discursive space in respect of the making of policies for STI integration with transformative innovation for national development. The article gives an understanding of the politics of inclusion, exclusion and accommodation of socio-technical imaginaries. The analysis explores the historical dynamics of the processes of closure and opening of spaces for progressive transformations and pro-people outcomes of integration of STI engagement with socio-technical transition management and governance.

A historical analysis of the emergent internal contradictions of the pre-reform and post reform periods is offered. The historical analysis suggests that while the Indian political and bureaucratic apparatus openly embraced the practice of "STI for market" to be undertaken in collaboration with transnational actors after the 2000s, but the influence of primacy to market calculations becomes evident through the emergence of the contradictions of the implicit policies for capitalist development with the explicit policies on STI directions for the making of self-reliant development.

The shift away gradually from the immediate post-independence period Indian state directed STI practice to market calculations directed STI practice in all the different phases of capitalist development across sectors and

organizations is taken note of and critically evaluated for the implications for self-reliance and peoples' well being. The outcome is that the Indian capitalist state has ended up considerably neglecting the practice of "STI for common good" that took roots in the national system of innovation on account of the national liberation movement legacy.

Today the development of STI structures is explicitly geared to supporting the transnational capital for the knowledge production. Transformative innovation making space building is not anymore on the radar of the political bureaucratic apparatus and the communities contributing to scientific, technological and innovation making practice. The article suggests that the post-reform period outcomes of alignment in respect of technological accumulation and innovation activities have proved to be myopic. India needs one more freedom movement to bring the STI landscape back on track.

Freedom movement, STI policy dynamic, opening and closing of spaces for the politics of transformative change

In the immediate period after the freedom movement until the mid eighties, planning for science and technology was a global practice. The practice was actively followed in China and India and in many African countries. India chose to integrate the STI practices with the national development agenda of decolonization (Jahnavi Phalkey and Zyoue Wang, 2016). The vision and strategy of system building for science, technology and innovation (STI) were directed towards the formation of pathways to state directed capitalism and capitalist modernity in India. But the pathways for capitalist modernization were formed under the direct influence of politics of freedom movement. Mostly the pathways under formation sought decolonization of knowledge production. Efforts for the creation of a politically independent national system of learning, competence building and innovation making chose to advance the project of social progress with a lot of political space for diversity and plurality in STI structures.

In the state formation project diversity and plurality of alternative political philosophies were actively accommodated to a significant extent until the mid seventies. In India, the freedom movement represented a united struggle of the Indian people against the institutions of colonialism sustained through the mechanism of drain of resources, consolidation of semi-feudal relations and the underdevelopment of science and industry to serve the interests of British imperialism. Although the freedom movement generated a lot of contestations, but the impact of the united struggle of the Indian people was visibly evident in the STI structures. The Nehruvian thinking took care of the accommodation of STI practices informed by Gandhian and Left politics in the spheres of knowledge production. The ideas of planning for science and technology had itself come out of the intense ideological struggle of the perusal of Nehruvian Gandhian and Left ideas within the political leadership

and in the scientific community. The diversity of paths and challenge of engagement with plurality of knowledge systems was in-built into the need of the freedom movement[1].

Contestations between these tendencies in terms of the ideas focused on the strategies to be used to cultivate modern science and technology, engage with the issue of choice of technique, foresight and assessment of technology and socio-technical system design(s) and coevolving social relations of scientific and technical change[2]. A vast majority of leaders of emergent scientific community had embraced the Nehruvian idea of seminal contribution of science and technology to social and economic transformations[3]. As far as the challenge of building of STI structures is concerned the Bernalist imagination of planning for science and technology adopted by the Association of Scientific Workers (ASWI) was an idea promoted by the Left formations. The Left faced the challenge of how to keep alive the contestations and experiments in respect of STI systems building going in the direction of people oriented development. Politically speaking, they were outsiders to the system. The Association of Scientific Workers (ASWI) sustained the efforts with the help of the mobilized publics for the perusal of alternatives in S&T and development during the first four decades of Indian independence[4].

Even as India's Prime Minister Jawaharlal Nehru accepted to become the president of Association of Scientific Workers (ASWI) and many of the scientists who were till the fifties "outsiders" to the policymaking or even the S&T system became insiders within the emergent national S&T system. They played a significant role in shaping the transformative spaces for the implementation of national S&T priorities and had to face their own respective challenges and dissonance. Although the Nehruvian, Gandhian and Left ideas had divergent views on the directions to be emphasized while pursuing the path to self-reliant development, but they were together in pursuing the idea of self- reliant development. They were united and one in embracing the value of perusal of indigenous transformative research activity in a systematic way[5]. The need to develop the human resource for science and technology as well as the need to practice the culture of science in all the creative endeavours united them in struggles.

The tradition of constructive action was actively pursued by the organizations of scientific leaders of all the three imaginations in practice. Nehruvian, Gandhian, Left and Ambedkarite imaginations have been analyzed critically in the writings of several STS scholars. Meera Nanda points out that B R Ambedkar accepted the universal legitimacy of science and understood that modern science had made a break with the sacred sciences of the past[6]. As a victim of Hinduism's sacred cosmology, he welcomed this break and sought to institutionalize scientific reason for the pro-Buddhists by interpreting it as the essence of Buddha's teachings. Achievements of integration of policies for research and technology for development (RTD) with the challenges of socio-

technical system transitions owe their success to the contestations, ideologically active scientific workers but also by the organizations of working class and peasantry led by the Left.

The emerging political leadership got their early lesson from the National Planning Committee set up through the efforts of M N Saha and others in the Science and Culture Group in 1938 on how the post-independent India would need the contributions of modern S&T. At the core, the ideas of scientific and technological nationalism evolved during the freedom movement were imbued with anti-imperialist, secular, socialistic and transformative values of social and political change[7]. An early contestation of this group with the Gandhian idea of Hind Swaraj made the members of scientific community to shift to the socialist ideas of economic and political independence.

The National Planning Committee (NPC) functioned under the leadership of Jawaharlal Nehru whose own socialistic vision of national S&T system was supportive of a politically independent path of "autonomous development", which allowed the nation to reduce import dependence, pursue self-reliant development which included walking on many legs including trade but without subjecting agriculture to export oriented development. Policies proposed shaping the trajectories of industrial development for the achievement of import substitution. Policies for power, agriculture, medicine, education and science had a focus on the pathways of not only import substitution but also indigenous traditional industries and knowledge development[8]. The Higher Education Commission (Radhakrishnan Commission) set up in 1948 by the post-independent government engaged officially with the diverse conceptions of higher education system.

The Commission consciously approached the paths of selective delinking in the domains of general education, technical education and education for rural development. In the Radhakrishnan Commission report the policymakers incorporated its longest chapter on rural university and had proposed their own unique conception of rural university after reviewing the models available for the development of agriculture and rural industries in United Kingdom, United States of America and Denmark. The proposed model of rural university was accommodative of Gandhian and Left discourse. The Radhakrishnan Commission got the inputs because of the full participation of adherents of Nehruvian, Gandhian and left oriented scientists like Radhakrishnan, K.T. Shah, Megh Nath Saha and so on in the proceedings in spite of their ideological differences (J N Sinha, 2008, Dinesh Abrol, 1985, 2007). The influence of this commission on the policymaking for higher education could be seen in the formulation of National Policy on Education in 1986 by a government led by Rajiv Gandhi, who championed the introduction of computers in the economy.

Much credit for such a participative development in respect of the building of transformative spaces should go to the contribution of politics of transformative change undertaken within and outside the public sector by the scientific community over the vision and strategy of integration of plans for science and technology with plans for development. The freedom movement had taught to the scientific community to be open to pursuing wherever possible the collaboration not only with the industry but also with the social movements practicing the tools of non-cooperation and constructive action with the objective of bringing about a transformation in the social relations of scientific and technical change. It was the legacy of freedom movement that had allowed the diversity of ideological visions to be accommodated. The scientific community, political and bureaucratic apparatus, entrepreneurs emerging from within the professionals working for the absorption and assimilation of new and emerging technologies and the business groups such as Tata and Birla came to work with scientific community in domains of their choice could come together to take forward the endeavour of "Science for Nation". There was the realization of much success with regard to integration of policies for STI with policies for socio-technical system transitions[9].

The perusal of non-mainstream pathways to S&T for development was a normal that the Nehruvian politics of S&T accepted, and which got substantive importance in the R&D portfolios of Department of Atomic Energy, Space, ICMR, CSIR and ICAR. The central government S&T departments created a number of programmes to support the non-main stream STI activity without asking these political trends to eschew their active ideological struggle. Evidence exists of how the establishment of a national S&T system involved contestations, accommodation and collaboration as the normal of S&T planning discourse in India and realized within the publicly funded national S&T system. The dynamic of accommodation of the prevailing Gandhian and Left ideas by the Nehruvian leadership played a significant contribution to the creation of diversity in the S&T system under development. Spaces continued to emerge on a regular basis for the perusal of ideas with regard to technology choices and the conduct of experiments undertaken in the domains of food, water, energy, mobility, transport and communication, public health and many other domains[10].

There was not only accommodation of diversity in the experiments being undertaken on the S&T trajectories outside the formal system of science and technology but also within the mainstream publicly funded research and development organizations. The emergent scientific community, which had its own heterogeneous interests and diverse imaginaries to offer in the form of large multipurpose dams, national laboratories, rural university, public sector and cooperatives, started its collaboration with the domestic industry before India became independent. However, it is also true that the STI policy paradigm that the Indian government chose was mostly formed with the

Nehruvian perceptions of 'self- reliance' and 'development with capitalistic growth' in command. The Nehruvian notions of national development were aimed at the strengthening of domestic capital. The STI system helped the domestic capital to expand the home market through the perusal of the planning of S&T for import substitution in the modern sectors and the uncertainty prevailing with regard to technological upgrading based on appropriate technology in the case of traditional and modern sectors[11].

Achievements and limitations of domestic capital were reflected in the realization of potential of contribution of public sector R&D and innovation making in the relevant domains of agriculture, industry, education, health, environment and energy, transport and services[12]. In practice, the STI system shaped the systemic dimension of development of productive forces under implementation as a part of the perusal of path of semi-autonomous capitalist development during the period of 1950-1980[13]. The STI system helped the political leadership to accelerate the agenda of green revolution in agriculture. Experiments undertaken outside the mainstream system through the groups associated with Nehruvian, Gandhian and Left ideas received support from inside the system for the values of democratic deepening and technological self-reliance. Outsiders who were participants in the movement of scientific workers for self-reliance became insiders in many instances in the STI structures created by the CSIR system of laboratories, Department of Space, Department of Atomic Energy, ICMR and Rural Development[14].

Research into this kind of effort of undone S&T always needed some push from the progressive members of the scientific community involved with political and social movements in India[15]. Although the list of scientific community promoting research consciously on several "unknown knowns" aiming to discover and create solutions based on alternate paths to technology development or "undone S&T" is long in the early years of post-independent India, but it is also true that even when the national laboratories and public sector devoted a lot of their energy and time very few of them were picked up for technology implementation by the big business[16].

All the leaders who had led the freedom movement and come to be engaged in the efforts of the Indian STI system were also around to exercise influence over the formulation of approaches and strategies for national development. Diversity of knowledge generating systems remained alive in the system of higher education institutions and government R&D institutes being set up by the government during the pre-reform period. Enterprises of all sizes representing the non-big business sections had better access to the emergent science, technology and innovation making efforts of the public sector institutions than they could actually get after the implementation of reforms. During the pre-reform period, there existed across the board quite a lot of space for the national level programmes of solar energy utilization for cooking and water heating, biological reclamation of saline lands, development of

vegetable dyes, coal gasification, condensed milk out of buffalo milk, vegetable tanning of leather and many other such technological innovations, many of which were prematurely allowed attrition and ultimately abandoned[17].

During the pre-reform period, selective delinking was actively sought by the political leadership with the help of the scientific community pursuing alternate routes to development of critical resources and materials namely coal and steel through Tatas and SAIL, power through BHEL and NTPC and pharmaceuticals through IDPL, HAL and non-big business promoting CIPLA, Ranbaxy and many other such companies led by chemical engineers and chemists, AMUL in milk processing-an innovation prompted by the research work of CSIR-CFTRI, high external input responsive agriculture through the efforts of public sector research and extension. Efforts taken to fruition by the chemists and chemical engineers establishing small and medium scale enterprises in collaboration with the CSIR laboratories deserve the credit for putting the pharmaceutical industry on the global map. Abrol (2006) brings out how these efforts got successfully pushed in the form of "undone science and technology" pursued by the CSIR laboratories as research in medicinal chemistry and synthesis for the benefit of the development of local pharmaceutical production (Abrol, 2014, 2015).

Quite a few of these efforts were pushed by the left. Favourable outcomes followed from the pathways that promoted selective delinking and incorporation of non-market calculations into the design of socio-technical systems. However, there is also some evidence that at a technical level, the success of technological alternatives and products comes at the cost of a process in which the more politically charged design elements and social organizations are made to drop out. Often social movements as well as the scientists found their goals being incorporated at a technical level by the mainstream but at a cost of severing the technical goals from the broader political and justice goals. Closure and narrowing of space for diversity took place only when the Nehruvian path came into crisis. Lessons obtained also suggest that historically grown knowledge structures can be expected to support and strengthen certain economic and political interests to the detriment of others, and this holds true for both, the mainstream as well as radical social movements. Political and social movements pursuing the agenda of appropriate technology and environmental concerns failed to take some of the emerging technological developments into account (See Abrol, 2018).

Fluidity in the influence of notions of development, national planning and self-reliance was visible and seen as making an impact on policymaking for socio-technical transitions until the early 2000s. There was active participation of all of these political trends in the STI landscape. Experiments were possible. Their results were incorporated in the plans in some ways. Up to the decade of nineties ideas of diverse nature with regard to institution building for

knowledge production were considered in socially inclusive ways in the committees and commissions set up with appropriate political composition by the Nehruvian regime. The National Committee on Science and Technology reflected this kind of practice. The Technology Policy Implementation Committee was also carried out as somewhat of an inclusive exercise. It needs to be recognised that under the influence of the policy agenda that emerged from the womb of the freedom struggle India became one of the first few newly liberated countries to formulate an explicit scientific policy resolution, 1958, develop a national S&T plan in 1973-1975 and announce technology policy statement (TPS) in 1983.

Even in the recommendations of TPIC implementation committee, only a little before the onset of liberalisation of capital and technology as a regime of governance of STI and society, the Indian scientific community attempted to develop a set of radically different policy instruments that could have helped the STI policies and practice to incorporate non-market calculations in the way of development contracts, societal and technology missions and built within the government deliberative forums for the industry and scientific community to plan the development of science and technology[18]. The selected pathway to industrialization emphasized industrial upgrading wherein the production of capital goods, energy, metals and basic chemicals was to receive priority to reduce import dependence. This initial phase of accommodation of diversity in respect of institution building for knowledge production, knowledge mobilization and innovation-making proved to be helpful in not only uniting the country but also putting the country on its feet.

Dynamics of the accommodation of the heuristics of residual pathways for STI development in the face of development of capitalism

At the time of independence, a pre-capitalist traditional manufacturing for subsistence living was the dominant mode of production. Cottage industries existed in large numbers as family labour-oriented labour units. As India entered a period of transition to modern form of large-scale industry, the need to promote cottage industries for employment considerations was also actively considered by the mainstream. The mainstream believed that the economy was in no position to absorb the surplus labour being released. The mainstream Nehruvian leadership accommodated the Gandhian tradition through the policy of promotion and protection of the cottage industries. The Nehruvian state policy provided space for the governmental protection, economic support and incremental technological upgrading of traditional manufacturing. The cottage industries sector acted as a bargain sector. Its existence allowed the Nehruvian leadership to bargain with both the big business as well as the landed gentry.

Place of gandhian imagination

In terms of its "socio-technical" frame, the Gandhian imagination followed the heuristics of upsizing by modernizing the indigenous technology. The individual producer was sought to be made competitive by upgrading the local / traditional technology. When Schumacher inspired appropriate / intermediate technology (AT) movement its practitioners were using the frame of Gandhian tradition. During the decade of seventies this AT frame became the heuristics of State sponsored movement for a wide range of departments and agencies. The governmental agencies encouraged the practitioners to upgrade the technologies embedded in indigenous / local knowledge, local raw materials, skills and capabilities to make the individual producers competitive. In the Gandhian tradition, the holistic meant an individual producer completing the production process without any or minimum division of labour. In this movement the "small was beautiful" but the small could not be made powerful.

The State formed of mainstream Nehruvian leadership gave support to the activists of Gandhian orientation for the protection, modernization and development of cottage industries in parallel to the mainstream programmes envisaged for industrialization. In the strategy of industrialization formulated by Mahalanobis during the Second Five Year Plan (FYP), Gandhian experiments had encouragement directly from the State via the Khadi and Village Industries Commission (KVIC). The KVIC had the benefit of policy space and financial support for the practice of 'constructive action' for pro-poor development. Activists of the Gandhian orientation could use the support of KVIC to implement programmes for the development of cottage industries and strive to meet the challenge of technological upgrading of traditional manufacturing.

Place for 'modern' small scale

Scaling up from cottage industries, the micro, small and medium scale industry (MSMEs) was sought to be developed through "downsizing of modern technology". Under the State-sponsored programmes of technology diffusion the down-sized modern technology was provided from the publicly funded agencies to the small-scale industry for implementation. The mainstream Nehruvian thinking promoted this frame of "appropriate" / "economical"/ "commercial" sizing & designing all across the country and protected the small-scale units in several sectors using sectoral reservation. This socio-technical frame of modern small-scale unit was implemented not only in the Council of Scientific and Industrial Research (CSIR) but also in the Indian Council of Agricultural Research (ICAR). It was implemented through the Department of Textiles, Small-scale Industry Development Corporations and National Small-scale Industry Corporation. This socio-technical frame allowed the State to accommodate the role of micro, small and medium scale

enterprises (MSMEs) in the emerging mainstream economy for the first four decades of post-independent India.

Place for left imagination

The Left tradition gave support to the ideas of promotion of public sector and protection of small-scale industry as a transitional strategy. The State formed under the Nehruvian leadership accommodated some of the views of the Left in part when it supported the public sector and small-scale industry. By the end of sixties, the measures like protection of small producers, promotion of public sector and restrictions on foreign direct investment, bank nationalization and many other such policy developments were an integral component of the policies. State ownership of basic industries was enunciated as a principle of policy, and it received a high level of priority in the process of planning up to the mid-1980s. But this orientation was not adhered to after the eighties. The public sector gets no more the support it deserves. The Left imagination encouraged the heuristics of workers' participation in the management of the state sector to build the accountability of large technical systems was accommodated in the banking sector. This is no more supported by the Nehruvians. In terms of the socio-technical frame, the Left wanted the government to strengthen the cooperatives of workers as a mechanism of ownership, management & control - wherever the organized sector was making an exit. The PSMs have been engaged in developing the approach of multi-level systems of networked production.

Table 1 gives a brief description of the diversities existing within the prevailing political philosophies that the pre-liberalization phase of STI policies that India sought to explicitly accommodate and incorporate under the influence of freedom struggle in the innovation policy process, actors, activities and modes of innovation.

Table 1: Social shaping of STI for development under Panorama of Diverse Political Philosophies

Aspects of social shaping of STI for development process	Gandhian orientation	Nehruvian orientation	Left orientation
Socio-technical imaginations, development path vision and agency for coordination of path upgrading	A self-sufficient village economy, small is beautiful, Redistribution of land through 'Bhoodan', non- party system of democracy, Gandhians adopting anti- statist stance after facing the crisis of Nehruvian path, Neo-	Priority to establishment of large technical systems as a blueprint of development, Planning for capitalist development with land redistribution attempted mainly as	Centrally coordinated workers managed large technical systems (LTS), in transition planning Building State capitalism as anti-imperialist step, with radical redistribution of

	Gandhians resorting to post-modernist / neo-traditionalist politics	rhetoric and its vision of the public sector in commanding heights, small-scale industry, after the emergence of big business as a major player in the economy & with the deepening of the crisis of Nehruvian imagination shift to market governance	assets, especially land- as transitional demands; later opting for decentralized planning for participatory local area development; State's accountability to the people.
Strategy and priorities of industrialisation	Decentralised industrial development; 'textile-first-type' strategy, limits to trade as engine of growth	Industrialization and establishment of basic industries and capital goods sector; import substitution, Protection of cottage industries; after the experience of crisis export promotion, limits to trade as engine of growth	Extended support to heavy industry strategy development of home market via cottage industry employment & irrigated agriculture for food grains supply, limits to trade as engine of growth
Axis of transformation and choice of mode of technological & organizational transformation	Traditional & local knowledge, priority to individual small- scale industry, cooperatives in consumer/financial/other service areas	Import substitution via replication	Agrarian transformation, S&T for new and emerging needs of the people, state intervention in essential spheres; self- reliance in large systems (LTS), irrigation, rail, road, telecom, steel, heavy industries, rail, roads, energy, health in public sector; small scale in consumer goods, in agriculture cooperatives.
Socio-technical Framing of the heuristics of the challenge of pro-poor innovation-making	Upsizing of traditional small- scale industry and peasant-based agriculture	Downsizing of modern technology to make it 'appropriate' for small scale / tiny / micro enterprises	Use public sector based large technical systems (LTS) to meet the needs of irrigation & energy, rail, road, telecom; support workers'

			cooperatives in industries / services amenable to small scale, trying in Kerala decentralized planning of area development and partial support for People's Science Movement - PSM experiments in the development
Concept of social carriers of production & innovation for development	Landowners & big business as trustees of wealth, individual small producer,	State sector in basic industries & strategic areas, foreign and Indian big business in consumer goods, Individual small producer in retail	Minimize dependence on big business, more reliance on public sector, small scale business in retail & workers cooperatives
Priorities for pro-poor development	Protection of village industries,	Access to irrigation & power, roads, etc.	Land reforms, access to irrigation & power, education & health to poor on priority, target poor peasants by adapting technology of green revolution
Priorities for the social sector	Local self-government, Sanitation	Area development, small scale business, targeting of credit & information for poverty alleviation, provide school education for all	Public distribution of food, availability of transport & health through public sector agencies, provide universal education
Source: Compiled and created by the author			

Phase wise contradictory influences of the development of capitalism on STI structures and practice of integration

It is also necessary to turn to contradictory influences of the Nehruvian strategy for capitalist development, which also need an exposition of the consequences of the weaknesses of the divergent visions and strategies under implementation for learning, competence building and innovation making in India. Often the strategy was reduced to mere import of products and capital

goods in semi-knocked down conditions in many sectors. Since this left the S&T system in complete limbo and even directed it in unproductive directions it is important to realise the impact of the transition path chosen by the Indian polity. Limitations of the strategy of duplication or imitative replication of systems obtained from elsewhere contributed to the failures of the S&T system to promote the use of local resources at home and the building of capabilities for the benefit of employment generation and self-reliant industrial development.

While the Nehruvian strategy of economic growth included the protection of domestic market and its accelerated development through the development of domestic capital as a whole, but the home market development was not pursued systematically by the Indian political and bureaucratic apparatus, scientific community, civil society and social movements and business groups. Initially when the leadership chose to support and nurture the domestic capital through active state intervention as an organiser, fiscal source, norm setter and regulator, it tried to be inclusive and created the economic space in favour of not just for the big business but also for all the fractions of domestic capital. Although major gains were made by big business, the ethos of keeping the doors of STI support as being open to all changed for the worse after the eighties. The big business has succeeded in driving the system towards there is no alternative (TINA). Now there is more of homogenization and less of diversity in STI.

Phase I

In the first and second phase of pre-reform STI, wherein the first phase happened to be relatively less turbulent, and a stable phase (1950-67), the nation could achieve some balance in terms of the pattern of state allocations to all the different S&T fields and programmes meant for the use of a large number of economic sectors. Most of the engineering and design related elements of the capabilities that the modern industries required for the development of production systems were put in place with the help of public sector units. In the industries, like steel, coal and food processing, the private sector was allowed to use the publicly funded R&D infrastructure as virtually in-house units which they impoverished openly without showing interest in their maintenance and renewal. As the elements of the publicly funded S&T infrastructure got the opportunity to develop the R&D and engineering capacity for the development of emerging industries where the private sector was still not strong, the country succeeded to support far more the non-big business elements of the private sector. For example, the non-big business sections were able to build the pharmaceutical sector only after this phase.

Phase II (1968-1984)

During the second phase, it was not easy for the Nehruvian Leadership on its own to pursue the coupling of productive system with domestic S&T capabilities in all the sectors. During the pre-reform period, the politics of selective delinking and system building required the intervention of the Left leadership. Examples are nationalization of banks and nationalization of coal and oil and gas industries. The patent act of 1970 was an outcome of the Left's effective intervention. Struggle for technological and economic self-reliance was one of the key planks of the Left politics. The country was enabled to achieve the goals of self-reliance through the defense put up by the Left of the framework of planned combination of the building of S&T capacity and the development of manufacturing in the interest of national autonomy. Even in the domain of movement for cooperatives, the organisational model of India Coffee House, a chain of eateries set up all over India, which has been managed till this date as a workers' cooperative, was set up in the mid-fifties with the help of the Left trade unions. Although Gandhians were not the only social carriers of cooperatives and even Nehruvians supported the idea of cooperatives, but it was the Left of all hues present in India which provided the leadership to the workers to organize themselves in the form of social cooperatives.

Many enterprises including banks are being run as workers' cooperatives in Kerala. Cooperatives were not enough for the revival of several traditional industries where the need for technological upgrading is today a big challenge to be tackled by the Left movement in Kerala. There also emerged some success stories where unorganized petty producers' cooperatives were able to produce by organizing themselves for competition and could achieve the economies of scale and scope in practice to some extent. Technology models emerged with the potential to develop the competitiveness of peasant-artisan economies can ultimately bring jobs to the people (See Dinesh Abrol, 2012, 2016).

Phase III (1980-1989)

During phase III, contradictory influences of the unplanned signing of foreign and technical collaborations for the acquisition of brand names and rent seeking through import of components in SKD /CKD form were normal. The acquisition of technological capabilities for production operations, investment and innovation for the development of a mature STI system suffered ultimately. Slavishly created imitative systems proved to be not only import intensive but also energy intensive and environmentally unacceptable anymore in several spheres. The governments had to subsidize in many cases. But their unregulated diffusion was allowed to accelerate by the regime to the detriment of the local systems of production and technology that the petty

producers were using to make a living in the areas of agriculture and rural industries.

Even the limited success of non-big business got facilitated through the fight put up by the Left and democratic movements to delay external liberalization till the late nineties for a sector like pharma. In electronics and renewable energy technology, the private sector failed because the information technology agreement (ITA-1) could not be prevented from being signed. The correlation of forces in this sector was less favourable because of the emergence of the domestic companies whose interests were already far more intertwined with global economy. Analysis of not so stable (1967-80) phase clearly brings out distinctly the contradictory influences that the Nehruvian perceptions of self- reliance and social justice faced and how the forces antithetical to the Nehruvian aspirations came to the fore.

Lesson from the implementation of technology policy statement of 1983 that the government brought out are quite instructive. The programme of Science and Society was launched by the Ministry of S&T in 1983. For example, the scheme of S&T for weaker sections was promoted. The peoples' science movements have been actively using this scheme to undertake their own experiments. These experiments have given the required space to several voluntary organisations to experiment. This space was used largely by the people of Gandhian, Left and Nehruvian socialist orientation. During the decade of eighties with the involvement of peoples' science movements' (PSM), experiments succeeded in establishing models that even acquired the status of technology missions. As an illustrative example, we can make a mention of the leather technology mission, which was inspired by the models developed by the peoples' science movements (PSM) members. While the gainful employment provided by the small-scale industry was large, but the fraction of production based on indigenous technologies which the agencies developed remained comparatively small in number[19].

Phase IV (1990s-2000s)

Internal and external liberalization, post-2000s global integration and dynamics of politics of path setting for new and emerging technologies

Relatively speaking, during the post-reform period, the space began to be closed for the introduction of alternative technologies and organizational forms in the sectors of agriculture, industry, energy, transport, health and education in the country when the Nehruvian politics adherents started compromising with the neo-liberal thinking of the big business and of the scholars of STS and innovation studies choosing to go along with the ahistorical abstractions of outcomes of evolution of S&T in post-independent India. When the contestations undertaken on the basis of knowledge production for technological alternatives become weak in the absence of

investment from the protagonists of democratic visions in the conduct of real-world experiments, the right- wing politicians have used the vacuum and the drift to come to power using the agenda of "development"[20].

In the post reform R&D and innovation system, such policies and programmes were not an integral element in the STI policy package. Thus benefits drawn by the professionals working for the U.S.-owned companies are also absent. Foreign R&D centers responsible for R&D service exports to the U.S.-owned businesses are today not only an important component of the post-reform system of R&D and innovation but also a key driver of the education in STEM and of the Indian higher education institutions (HEIs). Foreign R&D employment reported by U.S.-located companies increased 6% between 2018 and 2019 when there was only 4% growth in foreign employment and 4% growth for foreign R&D expenditures. In India, foreign R&D employment by these companies was the largest in India (196,000), China (85,000), and the UK (67000). Already the overall distribution of manufacturing and non manufacturing R&D reported by U.S.–located companies is evenly split[21].

In the absence of parallel programs for indigenous innovation, India's higher education institutions (HEIs) are the incubator for those who wish to go abroad as well as for those who wish to join the R&D centers exporting engineering R&D services to the U.S.- owned industries. Bangalore alone accounts for about 64 per cent of the patents granted to Indian inventors at the USPTO. Most of the patents have been secured by MNCs operating from India[22]. Most of the patents technology-wise are in computer implemented inventions. Many MNCs and particularly those from the USA use now India as a base for doing R&D and creating IPRs[23]. The export of R&D services from India grew by around 40 per cent in nominal terms per annum during the period 2004-18: export of R&D services, which were just USD 118 million in 2004, touched almost USD 4 billion in 2018[24].

Although there have been claims that there is little or no evidence of the foreign R&D centers interacting with Indian firms and institutions, there is also available evidence which shows that there exist significant interactions of the foreign R&D centers with the Indian STI institutions[25]. Foreign R&D centers act as listening extractive devices. The U.S. innovation system benefits much from the access to talent and publicly funded R&D activity outcomes. Absence of programs run in parallel run with the help of public procurement of indigenous innovations is virtually making a difference. There is absence of investment in "independent innovation" for civilian (non-defense) objectives[26]. The amount spent on importing technology from abroad in the form of the amount spent on royalty and technology licensing fees has been growing. There is a significant decline in the ratio of the expenditure made on domestic technology development vis-à-vis technology import. The ratio was 13.63 in 2000. It is 2.18 in 2018. The RBI appointed a committee to inquire into

the burgeoning of royalty payments. After the takeover by Suzuki there has been a major rise in the royalty payments in the case of Maruti Suzuki[27].

Bayer and Monsanto combine, Dupont and Dow combine, Syngenta ChemChina combine, all these examples also confirm the tendency of increased drain of foreign exchange. After the mergers they have gained far more market power and are in position to extract even more from the Indian peasantry. A good amount of foreign exchange from the pesticide sector on account of royalty and dividend payments and tied imports is taking place. Technological services dependence and greater reliance on the active ingredients (AI) imports are now an integral characteristic of India's NSI[28]. Global integration of the foreign sources of AIs is reflected in the list of sources approved for the purpose of import of technical for the purpose of formulation of pesticides chosen for sale in the Indian market. Unlike China where competition policy included harm to indigenous innovation is incorporated India is unable to stop the outflow of foreign exchange outflow taking place even when Suzuki manufacturing Maruti has a large domestic market at its disposal.

Internal brain drain

Currently the total number of S&T professionals working in India is about 5 lakhs. Estimates suggest that close to 2 lakhs of India's S&T personnel are working for transnational capital directed RDE activity. The industrial, trade, investment and intellectual property rights (IPRs) policies of the government are not seeking the contribution of STI activity to S&T self-reliance through the planned promotion of "development block" approach. Self-reliant S&T based development occurred only from 1950 onwards until the late eighties, after which technological fragmentation and dependence proliferated. Among India's S&T personnel, even those nurtured by the institutes of national importance and higher education institutions (HEIs), most have the aspiration to join jobs available in Bangalore, Hyderabad, Gurgaon and NOIDA. Trivandrum, Kolkata, Bhubaneswar and Jaipur now want to catch-up.

Support for this path was a key recommendation of the STIP 2020, yet to be formally adopted. Implicitly the policy is on. Close to one lakh have been given jobs through FDI policy was claimed by the S&T minister. Although there is still a brain drain from India, but even when they do not choose to go abroad India is not a beneficiary. For lack of alternate employment India's HEIs are currently used by the foreign companies. Directional change is necessary to save the institutes of national importance (INIs). Central Public Sector Enterprises (CPSEs) need to be conceptualized as strategic partners of INIs; India's power and energy transition after gaining independence happened through the collaboration between INIs and CPSEs. To conclude, post-reform STI policies moved the country away from promoting forward

and backward linkages for the localization of sectoral systems of production and innovation.

PLI delusion

Production linked incentive (PLI) schemes in use in thirteen sectors have been ostensibly encouraged by the Indian government to reduce import dependence. Even the production linked incentive (PLI) schemes have also their focus on inviting the foreign firms to invest in the manufacturing activity by wooing the companies wishing to leave China and relocate some of their production activity in India. The sectors include mobile phones, pharmaceutical products, automobiles, specialty steels, textiles, photovoltaic panels and advanced chemistry cell batteries. The PLI is valid for five years, ending in 2026-27. The minimum capital outlay is US$14 million with an exception for Indian micro, small and medium enterprises, for which US$1.4 million is the entry level investment. The PLI schemes aim to place India more firmly within the global supply chain. Although there are claims from the side of the Union Government, but policies and programmes for indigenous or independent innovation are missing from the package of STI policies. Going by the experience of China it can be claimed that the PLI framework would not be able to achieve much.

Aborted NMCC's attempts

Experience of the National Manufacturing Competitiveness Council (NMCC) too offers a major lesson on account of the failed attempts of the innovation bureaucracy. Attempts were made by NMCC to float a special purpose vehicle (SPV) wherein the proposal aimed to develop the aircraft with the involvement of a foreign player, a PSU and a national laboratory. There was also an attempt to approach a foreign company capable of joining hands in the production of chips with the assured demand with the government willing to purchase and use the chips for the assembly of laptops to be supplied to the students with budgetary support. NMCC wanted to try the idea of development contracts mooted by the TPIC with the aim to attempt indigenous or independent innovations for the perusal of new and emerging technology options. Now with the Modi government in saddle India does not have the required political will for the perusal of indigenous innovation path. For the lack of continuity in the existence of innovation bureaucracies the PSRIs and public sector can be often left high and dry. Lack of patient bureaucratic capital has been a source of failures encountered in the course of technology development.

Weakening of state and STI capacities

The MoEF has closed and decided to merge not only industry catering but also society serving STI institutions. Engineering colleges are winding up courses and leasing land for commercial objectives. STI institutions need to be

mobilized to contribute to self-reliant development through the establishment of structures devoted to societal missions directed towards solving the problems arising out of lack of basic services, chaotic urban development, environmental and climate risks knocking at the door. Relevant issues and concerns with regard to the revitalization of the Nation's State capacity and the STI capacities need to be explored afresh in the Indian context. The challenges of socio- technical transitions involving directional changes in respect of the paths to technology development for the products required to be not only globally competitive but also locally directed towards solving the problems of agriculture, energy and environment as well as public health would require the use of dispersed STI capacities and decentralization of the state capacity for the implementation of societal missions.

Import dependence has become pervasive. Dependent development of Latin American vintages has become an integral feature of the development trajectories in the case of new and emerging technologies. In the way India has implemented import substitution and export promotion strategies it is clear that import dependence has got accentuated rather than being reduced. Today India faces a huge challenge from the situation of growing reliance of the capitalist economic system for the manufacturing sector on imports. When the big business wins, we know that the R&D portfolios of institutions also change. Today the situation is that the state apparatus is hardly willing to discipline the rent seeking activities of the powerful over S&T activities. The control of big business over the STI apparatus is growing. The government is planning to strengthen the institution of private intellectual property rights. The corporate sector faces very little challenge in the domain of digitalization from the publicly funded and controlled enterprises.

Current challenges of dependent agricultural development

Currently the problems arising out of the agricultural development were far more visible. Not much could be done by the scientific community and the environmental movements to unsettle the corporate sector in agriculture on account of the limitations of and the blind spots in their own respective STI imaginations. However, the challenge of Kisan movement is actually growing. The challenge remains with regard to the radical socio- technical imagination redefinition in India. Agrarian crisis is deepening. Corporate control over agriculture is growing. Food security and sovereignty are getting undermined. Acceptance of WTO Agreement on Agriculture (AoA) as well export orientation in agriculture for profiteering are already being flagged as the emerging barriers to the systemic (interconnectedness) character of the development of productive forces in agriculture. Very little effective contestation was seen in the sphere of knowledge production in the agriculture sector in the seventies. Environment and health continued to be treated as externalities till almost the 2000s by the protagonists of autonomous development and democratic visions.

Compared with the earlier technological system that had crop-livestock interactions at the core and was artisanal production and labour intensive in respect of the production operations the new technological system is dependent on monocultures. This has accelerated the use of external large industry system-based inputs of chemical fertilizers and pesticides. Crop rotations that the peasantry in well-endowed regions began to practice ignored legumes and obtained nutrients through external chemical inputs. They began to use chemical pesticides for plant protection. Not only did they deprive the soils of organic matter that used to come from livestock, they also drew a lot of ground water, which has lowered and polluted the water table. They also ended up reducing the use of rural labour and local artisanal industries.

Although the power and attraction of high external input system of agriculture is even today holding away the protagonists of the visions of national and peoples' democracies from dealing with the challenge of changes in the socio-technical system of agricultural development and rural industrialization. Negative consequences for the state of health of soil and water, incidence of pest and diseases and bio-diversity conservation are directly an outcome of this. There is a degradation of agro ecosystems and landscapes and the melt down of natural ecosystem service provisions leading to ecological sustainability becoming the bigger barrier to the enhancement of agriculture productivity. The solution for the agrarian crisis lies in changing not only the production relations but also the relations between the resources used in the production.

It is clear that through the liberalisation, privatization and globalization process India cannot achieve the agenda of regenerative agriculture. Transformative frame without the space for selective delinking and contestations over technology choices in which transnational actors are not interested is clearly an unproductive route. The transnational systems of innovation would not be able to promote social change and undertake simultaneous exploration of technological alternatives at different levels (international, national, regional, and local, entrepreneurial, regulatory). Let us not allow the market to destroy us. Don't forget that cars occupy 60% of public space in cities, and that system thinking is needed to achieve human-scale cities. Systemic change is more likely to occur when associated with collective values, such as equity[29].

Concluding remarks

Lessons from the dynamics of contribution of freedom movement have been analysed. We have been able to examine how the STI system could manage to create the conditions of combining successfully all the different layers of STI policies and the role played by the politics of transformative change in industrial and STI system restructuring. We bring out that this required not

only the perusal of politics of import substitution but also how the politics of pluralism and diversity and of inclusive deliberations within the STI was a legacy of the freedom movement born out of struggle against colonialism. The necessary and sufficient conditions for capitalist transition were created through contestations, accommodation and collaboration of political tendencies formed in the course of freedom movement. The pathways to "selective delinking" that drove the STI policy changes were an outcome of the freedom movement got weakened during the reform period wherein the path of liberalization, privatization and globalization was actively pursued by the post-reform Indian governments.

The closure of the pathways to "selective delinking" occurred due to the weakening of legacy of Nehruvian, Gandhian and Left politics. The elements of deeper transition towards decolonization of knowledge creation were more an outcome of the pre-reform period of selective delinking rather than of the periods where the Indian governments chose to pursue global integration. Successful outcomes could be realized at the level of formation of novel technological trajectories only by decolonising the systems of knowledge production. Multiple sources of initiatives were made possible through the struggle of the Left Movements, Social and Environmental Movements created by contesting the transnational actors during the post-independence period. We also explain how the conditions for the realization of selective delinking from the international division of labour mattered.

In fact, the failures of efforts at technological upgrading of traditional industrial sectors, innovation making in new sectors and alternate path construction remain closely connected to the failure of politics to prioritize the efforts to build viable social carriers of innovation with the aim of selective delinking from the innovation systems of advanced capitalist countries. We also bring out how and when the national and local actors shifted into the pathways of neo-liberal global integration of the national STI systems, and how the STI policy makers will have to strategically disengage from the pathways continuing to strengthen the power of transnational corporations to proceed with the process of transformative innovations and recovery of technology autonomy. Social carriers of innovation and transformation came from among the non-big business sections and the civil society groups associated with the social movements aligned with the interests of peasantry, artisans and workers to some extent only when selective delinking paths was actually under practice. It is stated that as a precondition the innovation process and associated system building activity will have to come out of the mindset of open economy and market friendliness. Transnational actors will not incorporate environment and climate friendly non-market calculations and strive for the establishment of a development state under the social control of people and of local actors with the ability to build on the multiple sources of initiatives of the people as a whole to provide for transformative innovations.

Democratic political dispensations, state governments, trade unions, environmental movements and peoples' science movements pursuing democratic politics will have to be given their space through the politics of selective delinking to emerge as the successful political drivers of building of transformative capacity of STI policies and practice in order to play a critical role in the shaping of the innovation process in the directions favourable to climate and environmentally and socially just development pathways. It is quite clear that to realize its ambition the transformative frame of innovation system building would require selective delinking and substantial freedom for the local actors from the grip of transnational actors. National systems of innovations aiming to achieve technological autonomy, economic independence and political space for accommodating diversity and plurality of political philosophies are still quite important to the transition management. Contradictory influences would have to be engaged with in the course of steering and coordination and the role of governments cannot be one of just facilitators but one of transformer and entrepreneurial leadership building at the national level. To conclude the contribution views transformative spaces building as a broader political process wherein beneficial action for the creation of diversity and plurality in the ecosystem of knowledge creation can come in far more equal ways through the promotion of selective delinking from imperialism and imperial mode of living.

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Notes

[1] See the writings of Jagadish Sinha, Benjamin Zaccharia, Deepak Kumar and Dhruv Raina and Irfan Habib, Saradindu Bhaduri on colonialism and nationalism in STI to build a more detailed view of the dynamic unleashed by the anti-colonial movements in India.

[2] See also the writings of A R Rahman, and the ideas put forward in the "Science for Nation", a document released by the peoples' science movements during Bharat Jan Vigyan Jatha (BJVJ)-I in 1987 even while collaborating with the DST, GOI, and in the development of a series of documents released by the AIPSN during "Sabka Desh, Hamara Desh" campaign launched in 2015 to contest the politics of Modi Government, which are available on the website of AIPSN. See also the writings of Dinesh Abrol on pro-poor innovation, grassroots innovation and technology futures.

[3] See the divergent conclusions arrived at by Benjamin Zachariah, Jahanavi Phalkey, Arnold David and Aqueil Ahmad on the prospects of planning of S&T in India.

[4] See Om Prasad unpublished dissertation on the history of Association of Scientific Workers of India, ZHCES.

[5] See the documents of National Planning Committee, Peoples' Plan, and Scientific Policy Resolution (SPR) for the details in J. N. Sinha, Dinesh Abrol, and Deepak Kumar.

[6] See the writings of Meera Nanda which discuss the idea of Ambedkar on science.

[7] See Special issue of EPW on Gandhian embrace of the method of scientists and the writings of Meera Nanda on Ambedkar and science

[8] During the formative years of politically independent India, initially the evolution of discourse on what should be the role and contribution of science and technology took place through the columns of Current Science coming out of the Indian Institute of Science from Bangalore and in the pages of Science and Culture coming out from Calcutta (J N Sinha, 1988, Dinesh Abrol, 1986).

[9] See the mimeo submitted to SAC through NISTADS in 1989 and the publication submitted at the conference held at CDS, Kerala and available as a publication of Globelics 2006.

[10] See the reports prepared by the author, available within the NISTADS collection, on the post-independent India efforts on Technology Development for Frontier Technologies, CSIR for Rural Technologies, Pharmaceutical Industry, Aluminium Industry, Coal Utilization, Water and Sanitation development in India

[11] Lessons obtained clearly suggest that historically grown knowledge structures can be expected to support and strengthen certain economic and political interests to the detriment of others. This holds true for both, the mainstream as well as radical social movements. The politics of transformative change plays a role in the opening of spaces for the realization of technological choices, technological autonomy and peoples' democracy. Nevertheless, neither the developers of science and technology nor the users of science and technology can be expected to make completely free, rational and politically neutral choices. Knowledge concerning the assessment of prevailing and novel options is usually not complete, cannot be fully objective and is bound to be embedded in some or other subjectivity. Frontiers of knowledge, structural and institutional conditions are subject to change. False predictions and disappointments characterize the promises of science, technology and innovation.

[12] Examples of Department of Atomic Energy, Council of Scientific and Industrial Research, Indian Council of Medical Research and Indian Institutes of Technology can be cited for illustrative purpose. In the case of rural development and agriculture, the Indian Council of Agricultural Research (ICAR) was shaped by the National Education Commission (Kothari Commission) which submitted its report in 1966. The vision of Radhakrishnan Commission regarding the rural university was drastically modified to suit the Indo-American collaboration in agriculture.

[13] Translated into the priorities for S&T development import substitution and catching up in technology frontier did become the watchwords for the political-bureaucratic order

embedded S&T policy culture. Take for example the industry-market embedded interests had penetrated the ethos of political-bureaucratic order to the extent that in the commodity laboratories of the CSIR the industry provided the leadership. In fact, there existed congruence between them on account of much consensus existing between the core constituencies on how the use of S&T in planning is to be allowed. Similarly, in the case of agricultural research, the influence of Indo-American collaborations played a decisive role.

[14] The PSMs got the support from DST and CSIR laboratories. The programmes of KSSP, STD, CTD, MPVS, CERD originated in the Science and Society Programme which started with the help of the Gaon Ke Karigar and Science programme of CSIR.

[15] Analysis made shows how the first generation of scientists working mostly as outsiders in the British Scientists dominated field of low-grade coal utilization got included as insiders with the help of the big business in the domain of coal utilization research at the CSIR-CFRI laboratories. During the post-independence period the TATA Steel and Collieries-the arms of an emergent big business grouping were also allowed to govern and control the activities of CFRI for too long in the process. This kind of collaboration happened not only in the early years of post- independence period on the programmes involving mature fields of S&T but also in the eighties when the new science- based technologies emerged. The government chose not to pursue actively many doable technologies because the private sector would not pursue investment in these technologies on account of their own narrow focus on immediate profit Abrol (2010, 2011 and 2017).

[16] See the writings of D J Hess on the conceptualization of "unknown knowns" and "undone S&T".

[17] See the writings of Dinesh Abrol on pharmaceutical development, CSIR rural technologies, peoples' science movements and technology futures, 2010, 2014, 2015, 2018.,

[18] In fact, the TPIC recommendations could have very much given space for a new approach; but the approach was killed prematurely by the liberalization agenda of the economic policy bureaucracy by the year of 1989-90 immediately after the collapse of Soviet Union.

[19] In terms of its "socio-technical" frame, the Gandhian imagination followed the heuristics of upsizing by modernizing the indigenous technology. The individual producer was sought to be made competitive by upgrading the local / traditional technology. The mainstream Nehruvian thinking promoted this frame of "appropriate" / "economical"/ "commercial" sizing & designing all across the country and protected the small-scale units in several sectors using sectoral reservation. This socio-technical frame of modern small-scale unit was implemented not only in the Council of Scientific and Industrial Research (CSIR) but also in the Indian Council of Agricultural Research (ICAR). The Left tradition gave support to the ideas of promotion of public sector and protection of small-scale industry as a transitional strategy. The Left imagination encouraged the heuristics of workers' participation in the management of the state sector to build the accountability of large technical systems was accommodated in the banking sector. The PSMs have been engaged in developing the approach of multi-level systems of networked production.

[20] See unpublished manuscript of Dinesh Abrol (2006), "The challenge of transformation of innovation culture: Lessons from the making of STI policies and practice in India" in the conference organized by the Central University of Hyderabad on "Cultures of innovation" in collaboration with the Iowa University. See also the Proceedings of Globelics Conference of 2006 held in Trivandrum where the author has analysed the discourse between the advocates of liberalization and the opponents of liberalization, privatization and globalization. See also the mimeo submitted to SAC through Prof. M G K Menon on liberalization route in 1988.

[21] Companies producing Computer and electronic products, Semiconductor and other electronic components, Machinery, Chemicals and Pharmaceuticals, Transportation equipment, Motor vehicles, bodies, trailers and parts drive these centres and India's HEIs. The most recent wave in respect of the growth of engineering R&D services is bolstered by

the new-age technologies like IoT, cloud computing, artificial intelligence and product engineering demanded across verticals- industrial automation, defence, aerospace, healthcare, finance.

[22] Sunil Mani (2020): Indi's patenting record since TRIPS compliance of her patent regime, Asian Journal of Technology Innovation, DOI: 10.1080/19761597.2020.1829977.

[23] IBM was granted 9262 patents in 2019. A large number of granted patents were based on R&D conducted by the Indian affiliate of IBM.

[24] In the relocation of production and R&D the main interest of foreign companies is the access to market and cheap S&T labour. Most of these companies are taking out more foreign exchange using the provisions of stronger intellectual property rights (IPR) regime aimed at rent seeking and increasing their imports into the country through which the increase in drain of foreign exchange has seen a manifold rise in the recent times. And the value added through the structures engaged in the production of products assembled and marketed is small. There is no production from basic stage. In terms of location, the most important innovation hotspot is the city of Bangalore in Karnataka state.

[25] See N Mrinalini and P Nath (2012): Foreign R&D Centers, in Science and Public Policy

[26] Programs and policies aiming to mobilize for the building of India's NSI could have prevented the U.S from carving out an unequal division of labour to some extent. S&T personnel operating for the benefit of companies such as Microsoft, Google, Bosch, GE, Suzuki, Monsanto, Bayer and many more such companies should be treated as an internal brain drain.

[27] This report is still not in public domain

[28] In 2018, the author himself did a study for the Competition Commission of India (CCI) and estimated the scale and sources of drain taking place through the agribusiness MNCs operating in the domains of seeds and pesticides.

[29] Planetary health is an example of catalyst for achieving the goals, since it involves a new way of conceiving human health as something inextricably linked to the good shape and management of local ecosystems in which transnational actors have hardly shown their commitment. The challenge of how to catalyse change through a new approach to innovation: an innovation with and for organisations, cities and authorities interested in solving their problems, based on the use of open data, and that bets on multiple initiatives based on their probability of inducing change rather than on merits.

3

How do research and technology organisations work with mission-oriented innovation policy: The health and agriculture cases from brazil

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Abstract

This paper addresses the need for empirical studies of mission-oriented innovation policy (MOIP) in developing countries by examining the efforts of two state-owned Brazilian research and technology organisations (RTOs): Fundação Oswaldo Cruz (Fiocruz) and the Brazilian Agricultural Research Corporation (Embrapa). The paper investigates the organisational changes implemented by Fiocruz and Embrapa to survive through time and address societal challenges related to health and agriculture. Through the analysis of documentation, secondary data, and interviews, the paper aims to answer the research question of how mission-oriented research and technology organisations work in the context of a backward economy. While in developed countries the system of innovation is complex and there are different agents to work with each other on basic research, applied research, technological development, demonstration, training of researchers etc, in a backward conjuncture, this configuration tends to be less connected or strong. In both cases analysed, the organisations took over several of the activities above and created the conditions for building stronger subsystems in health and agriculture. Although both RTOs faced or still face challenges related to their relevance, their utilisation for addressing a societal challenge shows that their tasks go beyond research and involve a much wider effort, which started mostly in the public sphere and encompass gradually more of the private sector. This is an original contribution to our understanding of how societal challenges can be addressed by mission-oriented innovation policy in a Global South context.

1. Introduction

As the debate on how innovation policy contributes to tackling the current global grand challenges continues (Soete and Arundel, 1993; Freeman, 1996; Mowery, Nelson and Martin, 2010; Foray et al., 2017; Schot and Steinmueller, 2018) more information is needed from empirical studies of cases around the globe. In particular, the mission-oriented innovation policy (MOIP) approach has presented some cases in which organisations are used to address a challenge (Anadon, 2012; Sampat, 2012; Bonvillian, 2018; Breznitz, Ornston and Samford, 2018; Karo, 2018), although there is a paucity of studies of cases from developing countries.

Research organisations have been described in different literature for their importance in catching-up (Wade, 1990; Amsden, 2001; Mazzoleni and Nelson, 2007, to cite only a few), defence, health and other missions. We need to understand the role of research and technology organisations (RTOs) in MOIP, the extent to which they contribute to MOIP, and what makes them survive and progress. The survival of an organisation may mean institutional continuity and accumulation of capabilities that help it address challenges which are essentially moving targets, such as health and food security. Missions may have a defined temporal boundary, which may conflict with the intrinsic expectations of organisations and their life span. A mission-oriented organisation deals with the fact that its work is to fulfil a mission and at the same time this means pushing towards limiting its raison d'être.

Through the analysis of documentation, secondary data and interviews, this article aims at interpreting the efforts of two Brazilian research and technology organisations in the light of the mission-oriented innovation policy approach and answering the following research question: how do mission-oriented research & technology organisations work in the context of a backward economy? That is, how do they use science and technology to address societal challenges? This involves investigating the organisational changes they implement to survive through time, including management, how research is organised and how researchers are managed, for example. The cases analysed here are from different periods and sectors: the Fundação Oswaldo Cruz (Fiocruz) was originally established in Rio de Janeiro in 1900 to produce vaccines against the bubonic plague; the Brazilian Agricultural Research Corporation (Embrapa) was founded in 1973 to tackle food scarcity. Fiocruz and Embrapa are seen as successful examples of leading research organisations in the areas of tropical health and agriculture. They have survived many decades through different governments and addressed many different missions under the broad challenges of food and health.

This chapter is structured as follows. After this introduction, section 2 reviews the literature on research and technology organisations and their role in mission-oriented innovation policy in the Global North and South. Section 3 explains the rationale for the cases chosen and the methods for obtaining empirical evidence via primary and secondary data. Section 4 analyses the evidence generated about how the two chosen organisations work to implement mission-oriented innovation policy in a backward economy. Section 5 discusses the results in relation to the previous literature and concludes.

2. Literature review and conceptual framework: the role of research and technology organisations in mission-oriented innovation policy

The research on organisations whose activities involve predominantly scientific and technology[1] services is broad in scope. This reflects the wide range of activities those organisations do, but not only. Their governance is no less complex, varying from private to non-profit to state-owned. Several are also the vocabulary used to address them, although "research and technology organisation" (RTO) seems to better encompass the variety. More recently, since the re-orientation in the innovation studies field from systems of innovation to transformative innovation, there have been more contributions towards studying RTOs which tackle specific challenges, therefore going beyond the provision of services. In this section, the literature will be reviewed following this path, from more general studies of the roles of RTOs to the specific ones which are part of a concerted MOIP. By the end, it will be clearer that a) most literature focused on examples from the Global North, an issue that must be addressed if the South is part of the solution to our global challenges; b) very few have been written on the contribution of RTOs to missions; c) not much is known about how RTOs face the challenges related to accomplishing (or failing to) a mission.

There is a difference between the evolution of RTOs in the Global North and South. It was only at the beginning of the 20th century that industrial R&D became formalised in firms, as it happened, first, in the USA and Germany (Freeman, 1992). But this allowed firms in the first industrialised countries to develop R&D capabilities from within, so they did not (have to) count on specialised organisations such as RTOs for their industrial awakening and evolution (Bell, 1993).

In backward countries, firms' R&D capabilities did not evolve organically connected to other activities (engineering, production, marketing etc), but mainly from extramural support, what Bell (1993) called a "fundamental disconnection". Nonetheless, in the form of indigenous research, extramural support has been important for catching-up, especially in the fields of agriculture and health, where alien knowledge is often unsuitable for local conditions related to climate, soil, population size, prevalence of diseases etc

(Mazzoleni and Nelson, 2007). Indigenous technological and scientific capabilities are increasingly more important, argue Mazzoleni and Nelson (2007) because international trade laws impede less subtle interventions such as internal market protection and subsidies and intellectual property rights making it more difficult for imitation.

Given this difference in the evolution of firms' capabilities, the following paragraphs will address the literature starting from backward economies and late-industrialised countries, where the literature first start to attribute a role for RTOs, and then advanced economies, where later works described a different role for extramural research.

The concerns with the role and contribution of RTOs in backward countries can be traced back to at least the 1970s. Most RTOs were established from the 1950s onwards and benefited from the technical and financial assistance of international agencies (UNCTAD, 1990). Their overall role was to contribute to industrialisation processes. The methods to do so would vary: by transferring technologies from universities (Toren and Galai, 1978) or abroad (Blackledge, 1975; Utterback, 1975; Evans, 1979) or yet-to-develop new technology (UNDP and UNIDO, 1979). More specifically RTOs would contribute to industrialisation in many ways, such as national industrial planning, programming and evaluation, initiation of industrial projects, project implementation, and evaluation and monitoring of projects and programmes (UNIDO, 1980).

Early evaluation of such roles demonstrated concern with some of their vaguely defined activities and goals (UNCTAD, 1990), which failed to address priorities in a government's industrial plan (UNDP and UNIDO, 1979) and with the lack of interaction between the actors involved (Blackledge, 1975; Utterback, 1975; Toren and Galai, 1978; UNDP and UNIDO, 1979; UNCTAD, 1990).

Bell (1993) argued that most approaches to integration between RTOs and firms tried to address the issue of *connecting* them, where the former would have the role of generating new technology on behalf of the latter. For him, a more appropriate role would be, in the early stages of an industry, to help with the accumulation of R&D capabilities, but later on, it should tackle the "fundamentally disconnected structure", helping R&D to happen within firms activities: e.g. via dissemination of existing technology and best practices. This trend was found by Intarakumnerd (2011) in the case of Thailand's National Science and Technology Development Agency (NSTDA). By comparing Taiwan's Industrial Technology Research Institute (ITRI) with NSTDA he argued that the latter a) focused on the "linear model" of innovation that characterises an attempt of producing knowledge on behalf of firms and b) had no clear-cut mission, with its move towards enhancing firms' absorptive capabilities yet to be channelled into less broad capabilities. On the other

hand, ITRI had a clear mission, it developed technologies to meet industry needs and worked to disseminate results to firms, therefore stimulating the accumulation of capabilities within firms. In the Korean catch-up, the process took the shape of a reversion in the amount of national R&D expenditure undertaken within firms in the 1980s, from 20% to 80% within a decade (Bell, 1993).

The case of KIST (the Korea Institute of Science and Technology) helps illustrate how an RTO successfully plays a part in promoting a long-term national industrial strategy. The role of KIST in supporting the politically-chosen strategic industries was manyfold: to increase national R&D capabilities by setting up an R&D system and maintaining a high-skilled staff, to provide technical support for the government (policy-making and forecasting technologies for social benefit) and industries (industrial technology) and to act as a centre for technology cooperation between domestic and foreign firms (Evans, 1979; Lee, Bae and Lee, 1991).

The examples above of successful RTOs from East Asia represent in part how countries such as Japan, South Korea and Taiwan legitimised their MOIP in the public discourse (Karo, 2018). Karo (2018) argued that those economies relied on the old developmentalist rhetoric and on politicised organisations to implement national security and development missions. The effort spread beyond centralised bureaucratic agencies such as MITI (Ministry of International Trade and Industry) in Japan, the Economic Planning Board (EPB) in South Korea and the National Science Council (NSC) in Taiwan. The missions had as means science & technology autonomy and export-oriented industrialisation, which required organisations such as AIST (the Japanese National Institute of Advance Science and Technology), which presented "dynamic technological and research capabilities", RTOs such as KIST and KAIS (Korean Advanced Institute of Science), and in Taiwan ITRI (Industrial Technology Research Institute) and a network of specialised RTOs which were used to transfer technology from abroad.

Moving on to the Global North, the literature seems to also indicate a division in the role of RTOs roughly between the provision of services to industry and the acquiring of capabilities to foster innovation and promote national strategies. From the 1990s some articles explored the features of effective RTOs in their respective contexts.

In a paper reporting on an extended study of the effectiveness of eight different RTOs in Europe and Asia, Rush et al. (1995) described their roles as providers of highly specialised technical tasks and services for industry. Their success derived, the authors wrote, not from an effort to generate innovations for transfer to industry, but from focusing on activities in the “middle ground” of the innovation process: applied research, experimental development,

engineering, technical services, standards, certification and diffusion. Therefore, instead of supply-push innovations, the RTOs were demand-led.

Arnold et al. (1998) analysed nine RTOs from East Asia, Europe and North America and asserted that their activities did not substitute universities' or firms' innovative capacity, and did not simply bridge knowledge transfer from one to another. Instead, RTOs engaged in R&D projects in new technologies, collaborative projects for associations, problem-solving, diffusion of new technologies and testing to assist firms with services and in absorbing newly-established technologies which they could not access in-house. The diversity of RTOs, services and contexts led the authors to conclude that there is no unique successful model for an RTO and that it depends on the interaction with users' demands and a clear reasoned strategy.

Similarly, investigating the institutional character and nature of the knowledge produced by public laboratories under INRA (French National Institute for Agronomic Research), Joly and Mangematin (1996) argued that these were influenced by their partnership orientation with industry: some labs focused on providing products and/or services to industry, others managed to produce academic publications based on industrial demands and some even focused on fundamental research and in helping the industry with long-term challenges.

Also, the five cases of public RTOs from high-income countries studied by Intarakumnerd and Goto (2018) illustrated the role of public research in helping firms acquire capabilities that are relevant to their respective national systems of innovation - an attribute the authors claim helps to explain their successes.

In the past decade or so, the literature has returned to make clear again the connection between RTOs and grand challenges. In Arnold et al. (2010) the authors highlighted the importance of these organisations to the Framework Programmes, and that the overall annual impact of European RTOs was somewhere between €25-40 billion, without considering the long-term effects of R&D.

egarding the energy challenge, some RTOs did not get stuck in time and followed global trends and national demands to survive and increase their importance. These were the cases studied by Anadon (2012) in 3 countries, where examples such as the Carbon Trust and the Energy Research Centre in the UK, ARPA-E (Advanced Research Projects Agency-Energy) and the Energy Frontier Research Centers in the US and Chinese state-owned enterprises evolved from focusing solely on energy security in the 1970s to also encompass economic competitiveness and mitigation of bad environmental externalities.

The possibility of addressing missions is one of the reasons that make the National Institutes of Health (NIH) in the US successful, at least in surviving and securing political and public support despite the conflicts between its purpose[2], whether to focus on science or health, argued Sampat (2012). The NIH umbrella is formed by more than 20 separate centres, divisions and research Institutes (intramural research, which takes only 10% of the budget, as the main part goes to US academic institutions and medical centres). The most important way that the budget can be assigned to tackle specific mission-oriented research is through requests for applications, which are not initiated by investigators, but by Institutes in response to congressional directions.

With a greater concern in the literature with grand challenges, there have been more contributions towards studying research and technology organisations which tackle specific challenges, therefore going beyond the provision of services. There is still a lack of studies of cases investigating their role as the main actors providing scientific solutions to tackle missions, especially from developing countries. In the section below it is described how this article intends to fill this gap.

3. Methodology

3.1 Research design, strategy and case section

This study aims at deriving theoretical lessons about how research organisations work with the implementation of political missions in the Global South. The research strategy was to operate two case studies to gather empirical evidence and inductively contribute to the theoretical understanding (George and Bennett, 2005) of the mission-oriented innovation policy approach. The motivation to engage in case studies is to bring clarity to how a process works in a real-life experience, in this case, the implementation of a MOIP with the use of research and technology organisations.

The research organisations were deliberately selected given their relevance and information-rich cases. They both originated within the public sphere, were founded with clear missions, which were addressed via scientific research, and played leading roles in their areas of expertise. To illustrate this, the SCImago Institutions Ranking[3] lists both Embrapa and Fiocruz at the 1st and 2nd places in the overall Brazilian ranking of governmental research organisations. These organisations have the responsibility given by the government to utilise research to promote benefits for agriculture/animal husbandry and population health.

Moreover, previous authors in the innovation studies field have also confirmed the importance of Embrapa and Fiocruz to Brazil. They have been described as "'learning organisations' of excellence in their domains" and one of the strengths of the Brazilian system of innovation (Mazzucato and Penna, 2016), with Fiocruz being portrayed as a recognised advanced research centre

in the health sector and Embrapa as one of the reasons why Brazil is internationally competitive in the agroindustry (Suzigan and Albuquerque, 2008).

3.3 Data collection

There were two sources of data collected for the analysis. Primary data were conducted via 9 semistructured interviews with top managers of the organisations on focus and one minister, who acted in the national health and agricultural areas, summing more than 30 years of governance at the highest level. The questions are derived from a decomposition of the research objective into finer grains and are aimed at bringing evidence of the work of two research organisations to contribute to missions in the health and food sectors.

This approach is expected to bring forward the dynamic of the managerial level of MOIP organisations in receiving a mission and deciding how to address it and pass it forward to their research staff while comparing the differences and similarities between the two cases.

Secondary data was collected from the organisations' publicly available documents and other academic and historical works on Embrapa and Fiocruz.

The following section provides a small context of both organisations on focus and a descriptive summary of the main findings from the analysis of the data.

4. Findings: analysis of how the RTOs work

After collecting primary and secondary data about Embrapa and Fiocruz, it is presented here a background for the implementation and evolution of each of those organisations followed by the key features and findings from the analysis.

3.1 Embrapa

In the mid-XXth century, Brazil was experiencing fast urbanisation and middle-class expansion, which brought concerns about food scarcity (Correa and Schmidt, 2014). In 1961 the food supply crisis was exacerbated and, coupled with rising inflation, led to more social instability in the country, including looting in Rio de Janeiro (Silva, 1990). The government was under constant pressure to solve the agricultural situation. The reason for a favouring policy for agriculture was an attempt to secure an adequate food supply (controlling, therefore, the rising of the food prices), to stimulate exports of primary products and, to a lower level, to increase rural income and diminish rural exodus and regional imbalance (Lago, 2014).

The National Research and Agriculture Experimentation Department *(Departamento Nacional de Pesquisa e Experimentação Agrícola* – DNPEA) was the

organisation in charge of agriculture research before the creation of Embrapa. It showed poor features that Embrapa would have to solve: in 1972 it had 851 technicians and only 93 (11%) post-graduates; there was no good competing wage system to stop researchers from searching for better careers elsewhere; the use and collection of financial resources were not efficient; and there was little use of scientific and technological advances from abroad (Cabral, 2005).

In the early 1970s, Brazil engaged in a mission-oriented plan to secure food access and turn itself less dependent on external resources by becoming self-sufficient in food (Cabral, 2005; Correa and Schmidt, 2014). The minister of Agriculture at the time said Embrapa was "an undoubted need": to provide enough supply to the growing demand for food and to equilibrate the balance of payments by exporting grains at the time the commodities exported were only cocoa, coffee, cotton and sugar.

The Brazilian Agricultural Research Corporation *(Empresa Brasileira de Pesquisa Agropecuária* - Embrapa) was created in 1973 under the influence of a group of public workers with experience in the field. One of the main figures was Eliseu Alves, its second president, who had studied in the United States and brought from there the ideas of implementing science-based agriculture to modernise the Brazilian sector. A science-based organisation needs scientists and a small army of 1000 new graduates was sent abroad, mainly to the US, to build the human capital needed to "tropicalise" foreign modern agriculture techniques.

According to all interviewees, Embrapa was undoubtedly successful in its original food security mission which included the tasks of decreasing the cost of food, increasing the competitiveness of Brazilian crops, increasing their quality, increasing productivity, expanding the sector's land frontier, and increasing the income of the workers. In fact, it helped change the country's international market position in the area, from importer to exporter of many crops. It was able to, in brief, produce knowledge allowing satellite monitoring, software production, expand grain production eightfold (Embrapa, 2014) and the use of important parts of the territory that was previously assumed as non-fertile fields which promoted important land-saving effects on forests (Martha Jr., Alves and Contini, 2012).

The creation of Embrapa represented a reform of the national agricultural research to lower the bureaucracy level, so the Agriculture Ministry's research sectors were substituted by a new legal figure: a public enterprise, built on a private legal foundation (Cabral, 2005). It allowed them to hire researchers at a higher salary than the public sector, such as universities. The finance mechanisms were also more flexible, allowing loans from international actors such as the World Bank and the Inter-American Bank.

Taking a mission-oriented approach to identify issues with specific crops, animals and inputs direct resources towards solving them, Embrapa's task was to adapt the temperate-climate technology and knowledge obtained by the scientists abroad to the local tropical environment. This included working with a new type of soil in Brazil's savannah area called *Cerrado*; adapting species, both vegetal and animal to endure the heat but also take advantage of the high and regular luminosity.

From 1973 to 1975 Embrapa faced a period in which there was already demand for results but most units were waiting for the return of the researchers from overseas. As there was already a reasonable amount of results from DNPEA's research projects, the Corporation decided to organise, publish and make them available. Until 1979 there were around seven hundred technology packages released and they recommended actions for specific geographical areas and markets.

One of the most important features of Embrapa's organisation is its physical presence in the territory in the form of (currently) 43 thematic units. They have 3 types of foci: products, process and regions (e.g.: Embrapa Rice & Beans, Agroenergy and Eastern Amazon, respectively). This decentralised approach is argued to be paramount to keep the research close to and accessible to local producers, to keep Embrapa in tune with their demands. Moreover, there are 3 labs abroad (Labex) for scientific cooperation.

A major role in securing finance and support was played by convincing society and those with political power about the relevance of Embrapa. An effort was made to build legitimacy based on the positive results presented and to use it to construct a good relationship with the relevant actors. By the year 1980, it was responsible for half of the agricultural and livestock research in the country (Cabral, 2005).

By the mid-1980s Embrapa had achieved maturity and stability. More than 1500 researchers with post-graduation levels were working for the Corporation, of which almost 20% were PhDs. It had involvement in the national energy programme that led to research with alcohol engines; the identification of Amazon soils; the effort to incorporate parts of the Cerrado land; in Southern Brazil, the consolidation of temperate crops and fruits (such as wheat, grape and apple) and the success of bovine, swine and aviary production; in 1983 the Genetic Resources Research Centre started its biotechnology research (Cabral, 2005).

With the re-democratisation in 1985, there were internal discussions regarding its direction. The economy was not doing well and the funding for research was scarce. It became forbidden to hire more staff at that time, so Embrapa started hiring a parallel workforce, which reached a third of the total number of employees. In the 1990s the knowledge lag in comparison to international

standards increased (which led to the creation of the Labex labs). Growing importance was given to biotechnology with genome, cloning and genetically modified organisms being increasingly researched with the approval of the Biosafety Law in the early 2000s (Cabral, 2005).

Interviewees informed that the agenda became more open for bottom-up discussions. There was space for a discussion of some of the challenges generated by the original approach, allegedly a top-down approach focused on big producers that could be related to issues with soil erosion and the high use of chemicals. Therefore 3 new themes were incorporated into the general task of productivity gains. More discussions about sustainable agriculture, health and small-scale agriculture started to take place.

There was a search for adjustments towards lower impact technologies: biological nitrogen fixation, which also helps save expenses with chemical fertilisers; minimal soil tillage; and the sustainable intensification with the integrated crop-livestock-forest (ILPF, in Portuguese) production strategy.

It was the first time that Embrapa saw a process of meetings and dialogues open to all workers to take part (roughly half or around 4500 people participated). Discussions took place in every unit for almost 5 years and led to the formalisation of the II Embrapa's Guidelines in 1994 (*II Plano Diretor da Embrapa or PDE)*. This was the final product of a strategic thinking process that discussed priorities and actions for the following 4 years. There was an effort to turn research endeavours less isolated and more horizontal, at the same time that pushed for self-management of units and less centralised power in the headquarters in Brasilia (the units published their own guidelines, the PDUs).

Another important organisational change in research management happened in the 2010s with the implementation of research portfolios. Although organisation division in units has not changed, the research approach went from products, processes and regions to a more systemic and multidisciplinary view. The publication of PDUs was ceased and the units' projects had to be allocated hierarchically under the portfolios, which are currently 34 and can be understood as macro themes that encompass more specific products or processes projects. It was an effort to diminish the redundancy caused by the project model.

Regarding the question of who defines the mission and the research priorities, the interviewees described that in the beginning the mission was given by the federal government and more specifically the finance sectors, represented by the Minister of Finance Delfim Netto. The themes for the units were decided centrally in Brasilia and represented the products to supply both the internal and external markets. As the scientists arrived from the training abroad they were the main voices in choosing what was important to research to increase

productivity for each crop/activity. The private actors also influenced the agenda by voicing their demands as they were the ones putting into practice the technical advances produced by Embrapa, although some interviewees pointed out that the big agribusiness was given more space.

The main influence on the definition of portfolios is still done internally, at "Agropensa", Embrapa's Strategic Intelligence System, a division linked to the executive board. It works with studies, reports, modelling and forecasting to support the definition of long-term strategies.

At the researcher level, the choice for projects varied through time. As mentioned before, the first decades were marked by centralisation and top-down definition of themes. Inside the thematic units, the researchers were tasked with the respective themes. From the II PDE (1994) and with the introduction of portfolios in the 2010s, researchers had to allocate their work within the themes provided by the portfolio and argue that their endeavour contributes to the sustainability and competitiveness of the sector. This was enforced by merit-based competitive calls for funding.

A manager argued that the presence of a method in building a medium and long-term agenda prevents too much political interference in the themes researched. Although an executive secretary of the Ministry of Agriculture has the presidency of the Embrapa board, the approval of strategies depends on more than one individual, such as the representatives of consumers, producers and, of course, the internal staff. Moreover, due to the effort the Corporation did in establishing a prestigious name and its arsenal of reports on results, it is difficult to argue against the installed agenda.

The progress evaluation is done internally at Embrapa and on two levels. At the macro level every year a report is published with the main results and the social profit return of the public funding for Brazilian society. At the individual level, there are 2 computerised systems to follow progress. Researchers input their reports at the Ideare System while managers report at *Integro System*. Researchers, projects, units and portfolios have annual goals and are assessed to the extent they contribute to the Corporation's guidelines (PDE).

Another difference in the search for outputs of the second half of Embrapa's existence is that the Corporation started to focus more on creating assets, in diverse forms, than on introducing a final product to the market. The prospective assets are evaluated according to their TRL (technological readiness level) and if they progress they are then introduced in the market and will be combined with the assets of other actors to generate innovations.

The interviewees agreed on whether Embrapa was successful in tackling the original mission. One of the interviewees suggested that in the first 2 decades of existence, the keyword that summarises Embrapa's success is

"pragmatism". The challenges and goals were clear. The human capital was recruited among recent graduates of the best universities in land studies in the country. They were young, had already personal bonds to the land and agricultural activities and were trained overseas in the best universities with public money. This created a strong relationship between them and their task as Embrapa researchers.

Other actors also participated in addressing the original mission. The National Agricultural Research System (SNPA) encompasses all regional research organisations (the Oepas or State Agricultural Research Organisations) together with Embrapa, universities and other private research actors with the goal of collaboration in research. From the 1990s the Oepas lost a lot of financial support from their respective regional governments and Embrapa. Embrapa and universities collaborate in experiments, in the laboratories and many post-graduate students use Embrapa's infrastructure. A special collaboration with the University of Campinas is called the Mixed Research Unit, which focuses on advanced research for the development of assets.

There was an increased collaboration with private actors as they started to become more relevant in the research market. Formal collaborations include consortia such as the ones to promote technology transfer of the crop-livestock-forest integration (ILPF) method and research for the development of pasture varieties, *called Unipasto.*

Agricultural extension and technical assistance were promoted by regional organisations (many were called EMATERs) and by EMBRATER (Brazilian Company of Technical Assistance and Rural Extension), created in 1974 and closed down in 1990 when the private extension expanded its presence in Brazil.

There are differences though in views on Embrapa's relevance and mission nowadays. One view focuses on the pragmatic role to maintain Brazil's competitiveness and constantly search for improvements and productivity gains. For supporters of this view, Embrapa's relevance will never cease to exist. Another view is that private actors are already able to deliver the innovations that will supply the market and have forged ahead, turning some of Embrapa's research outdated. Being part of the public sphere and majority financed by the public treasury, the Corporation would be facing a slow death, instead of bankruptcy. One of the reasons suggested is that the later generation of researchers joined Embrapa at a later stage in their scientific career, already educated at the highest levels, and therefore not intrinsically connected to the Corporation nor the life on farms. They would be more academic and publication-oriented.

3.2 Fiocruz

The Oswaldo Cruz Foundation (Fiocruz) was founded in 1900 in Rio de Janeiro with the mission of addressing public health issues with the aid of scientific knowledge. Its task was to produce serums and vaccines against the bubonic plague that was striking the urban centres in Brazil. Currently called Fiocruz, it has had different names, such as the Oswaldo Cruz Institute (IOC), today the main research unit under the Fiocruz umbrella. It started with the name of Serum-Therapeutic Institute, but it did not take long for its first director, the bacteriologist Oswaldo Cruz, to expand the serum production activities towards medical research. Some of its main contributions to public health involve Chagas' disease, HIV, malaria, dengue, schistosomiasis and yellow fever. Today Fiocruz employs around 7500 people located in a few regional centres spread around the territory. In connection with research and teaching it provides many direct health services to the population as part of the Brazilian Unified Health System (SUS) including those related to women, child and adolescent health, worker's health and animal care. It has more than 50 laboratories focused on public health emergencies and it encompasses the National Institute for Quality Assurance in Health (INCQS) which provides quality assurance testing. The production of strategic products, such as vaccines and medication, is an important part of Fiocruz's mission. In total, before the COVID-19 pandemic, SUS bought nearly 40% of its vaccines yearly from Fiocruz, although it represented only 5% of the expenditure. It is the only Latin American producer of the vaccine against yellow fever, but it also produces reagents for the diagnosis of many diseases, including HIV.

The convincing power Cruz exerted over the authorities must have been remarkable, as it was not common for such an institutional innovation to happen in the tropics. In a visit to Fiocruz almost 100 years ago, Cockerell (1925), a foreign researcher visitor wrote that the Foundation "must have been founded and endowed by some multimillionaire, whose munificence had created an organisation essentially alien to the general spirit of the country. This supposition was entirely wrong". Cockerell highlighted that the progress of the country was conditional on the ability to prevent diseases and that Cruz acknowledged that and was efficient in demonstrating it to obtain public support for his endeavours.

A few years after its foundation, Fiocruz started to be internationally recognised as an important centre contributing to public health. This was paramount for the federal government to start financing the institute's effort at a national level at a time when a national science plan was absent (Stepan, 1976). The period under their first two and most famous presidents, Cruz and Carlos Chagas (1902-1934), is regarded as the institute's golden time. It successfully dealt with the plague, yellow fever and smallpox outbursts in Rio de Janeiro, the Brazilian capital at the time.

The period that follows was marked by crises and stagnation. It turned itself into a more pure-science type of organisation, losing its mission-oriented approach, and many considered the Institute dead, according to an interviewee. It faced strong external interference during the dictatorship (1964-1985), including the forced early retirement of 10 scientists (out of a total of 70) for political reasons. Several regional labs and research organisations spread around Brazil were incorporated into the Fiocruz umbrella.

This lasted until another big health crisis hit the country in 1973. This brought back a mission to Fiocruz, to deal with the meningitis pandemic. In 1975 there was a national vaccination campaign, using more than 80 million imported doses. In 1976, searching for national self-sufficiency, Fiocruz tried to internalise the conditions to address possible future diseases. Two factories were created, one for drugs (*Farmanguinhos*) and another for vaccines (*Biomanguinhos*, today one of the largest vaccine production centres in Latin America).

The great institutional turn happened, though, in 1985, following the general political changes in the country brought by the re-democratisation process. It allowed internal cohesion for a new management style with a bottom-up approach. Under Sergio Arouca, Fiocruz implemented the "Internal Congress", a representative body responsible for deliberating on the definition of the 4-year strategic plan, as well as on organisational matters. It allows the representation of the whole set of workers at Fiocruz (around 15 thousand people, including temporary ones) by elected delegates.

This method for the definition of the pluriannual plans is regarded as the "secret for the success" of Fiocruz by one of the interviewees. Although it is a slow process it guarantees continuity and gives minor possibilities for political interference in the agenda.

The definition of research priorities was done without formal grounds up until a top-down decision of the presidency in the 1990s. Until then the budget was allocated according to historical divisions among departments. It was then redesigned to be based on the scientific merit of projects. The PAPES (Program to Support Strategic Research in Health) was an innovation first implemented by the use of a special budget at the discretion of the president of Fiocruz. An external committee was summoned to assess the quality of the project submissions and their potential contribution to public health. This represented the institutionalisation of the mission-oriented approach that started to take place in the 1970s, but now also in the research efforts. It was a return to purposeful research done at Fiocruz. As suggested by an interviewee, it was a return to Pasteur's quadrant, although it faced strong internal opposition and scepticism. Currently, PAPES evolved into the Inova Fiocruz Programme.

Financial support for use-inspired basic research in health was rare also outside Fiocruz. The National Council for Scientific and Technological Development (CNPq), the agency under the Ministry of Science and Technology responsible for the promotion of scientific and technological research, would not allocate funds to purposeful research in the health sector. The internal organisational change promoted at Fiocruz also led to an external change. In the 2000s was created the Department of Science and Technology (DECIT), an analogous agency to CNPq, although under the Ministry of Health.

Although Fiocruz is under the management of the Ministry of Health, the modern version of the latter was created much later than the former, in 1953. Also, formally, Fiocruz has a seat on the Ministry's board, and can therefore influence it. But perhaps most important, due to its seniority and recognition, Fiocruz is seen as the "thinking head" of the Ministry, so the direction of influence goes much more from the former to the latter, as one interviewee has put it. One example used to describe this relationship was the case of the arrival of HIV in Brazil, which was first neglected at the federal level, but then Fiocruz was able to convince the Ministry about the urgency of prioritising actions towards the matter.

The definition of priorities, as in the case of HIV, obeys exogenous events. An interviewee said that Fiocruz does not need to search for priorities as "they do not even knock at the door, they simply break in". This was the case of the plague at the beginning of the 20th century and COVID-19 recently.

5. Discussion and conclusion

Both Embrapa and Fiocruz were created from a direct federal intervention to deal with an urgent challenge. Their missions were clear, at least in the beginning and they knew their tasks. This was already a feature that distinguishes them from many of the organisations studied in the literature in the Global South (UNDP and UNIDO, 1979; UNCTAD, 1990).

Although in both cases this was a top-down decision, they managed to, at some point, obtain a degree of liberty from the government to decide internally the research priorities to better address their missions. This fact allowed them more stability in one hand, extending their survival, but on the other hand might have contributed to isolating them from a broader societal discussion of their purpose, which is an important source of threat to their continuation.

For Embrapa, it has been more difficult recently to guarantee a general consensus for their work (Navarro, 2018). But there was an effort from the beginning of the institution to create an environment for public acceptance of Embrapa's activities. The Communication Sector was in charge of releasing results and activities to the public through, many types, of close partnerships

with the big media. "There's no doubt that the good image that it enjoys nowadays, is due in great part to the excellent work of Embrapa's communicators" (Cabral, 2005, p. 164, own translation). For Fiocruz the occurrence of more immediate societal threats such as diseases and epidemics has brought high societal approval of their purpose, even though it is not as explicit as Embrapa in reporting their evaluation and return to society.

They both increasingly interact with other organisations in their industries, contributing to strengthening their subsystems of innovation. This was not always true, because many of the actors are only present now because of their work. Fiocruz and Embrapa combined training of researchers, basic and applied research, and technological development. In developed countries, the system of innovation is filled with agents that take care of each of these steps. Lacking them, a backward economy was improved by the creation of an organisation that could encompass all of them.

Both RTOs faced or still face challenges related to their relevance, but their utilisation for addressing a societal challenge shows that their tasks go beyond research and involve a much wider effort, which started mostly in the public sphere and encompass gradually more of the private sector.

Although the argument against public intervention in the economy may be able to highlight inefficiencies in governments choosing products or firms to support, it loses its strength when it comes to the state's role in identifying societal needs and paramount economics sectors and acts towards addressing them (Mazzoleni and Nelson, 2007; Mazzucato, 2021). The examples of the public RTOs Embrapa and Fiocruz contribute to support the importance of public support for research in the fashion of a mission-oriented innovation policy approach to address challenges in a backward economy, where the variables influencing food security and health are location-specific. The rationale for their role must be interpreted as a type of policy that goes beyond the accusations of "picking winners" (Mazzoleni and Nelson, 2007).

As a limitation, it is important to alert that the primary data was obtained from interviews with the high echelon of management of the organisations and may not reflect the general understanding of other actors involved in the process. This is less concerning for our main research endeavour of understanding the managerial decisions affecting the work of the organisations but biases the reflections upon how well the work was done.

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Notes

[1] "Scientific and technological activities (STA) can be defined as all systematic activities which are closely concerned with the generation, advancement, dissemination and application of scientific and technical knowledge in all fields of science and technology, that is, the natural sciences, engineering and technology, the medical and agricultural sciences (ns), as well as the social sciences and humanities (ssh)", as defined in the Frascati Manual (OECD, 2015).

[2] Conflicts present also in Gulbrandsen (2011) where it is discussed the hybrid position of RTOs, in between science and non-science (leading to conflicts between academic versus civilian cultures) and in between public and private organisations (leading to crowding-out accusations).

[3] The SCImago Institutions Rankings <https://www.scimagoir.com> classify academic and research-related organisations in a rank according to an indicator which combines statistics of research performance, innovation outputs and societal impact. It allows discrimination for the sector where the organisation stands (university, government, health, private, non-profit, other).

4

Assessing India's progress in developing institutional mechanisms to foster translational innovation ecosystem for molecular diagnostics technologies

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Abstract

The study examines India's efforts to create an institutional mechanism to support the development of the Molecular Diagnostics (MoDs) Translational Innovation System, which has the potential to revolutionize the healthcare system. However, there are significant challenges hindering the performance of the two critical translational blocks of ecosystem, T1 and T2, such as lack of coordination among stakeholders, limited funding, poor infrastructure, and regulatory challenges. The study recommends the adoption of a "*Mission-Oriented Responsible Innovation System*" framework that can provide a sustainable ecosystem for the successful translation of MoDs technologies in India's healthcare system. The framework is mission-driven and grounded in responsible innovation principles, ensuring that the development and implementation of MoDs technologies are done in a socially and ethically responsible manner.

Key Words: *Translational Ecosystem, Institutional Mechanism, Molecular Diagnostics, T1&T2 Translational Blocks, Mission-Oriented Responsible Innovation System*

Introduction

The study aims to evaluate India's efforts to establish an Institutional mechanism to support translational innovation ecosystem for the development of MoDs technologies. MoDs are the promising biomedical technologies that holds the potential to revolutionize the healthcare system by providing an early, accurate, and sensitive diagnosis for many diseases. The successful translation[1] of these promising biomedical technologies in healthcare system is highly dependent on various crucial factors like significant investment in infrastructure, training, and regulation to ensure that these tests can be performed reliably and efficiently. These crucial factors define the performances of two critical translational blocks of innovation ecosystem, T1 and T2. T1 represents the transfer of new understandings of disease mechanisms gained in the laboratory into the development of new methods for diagnosis, therapy, and prevention, and their first testing in humans. T2 involves the translation of results from clinical studies into everyday clinical practice and health decision-making in the community and ambulatory care setting (Woolf, 2008).

Both T1 and T2 blocks of biomedical translation research ecosystem in India is currently hindered by significant challenges perceived in the system. One of the primary challenges is the lack of coordination among different stakeholders in the healthcare system, including researchers, healthcare providers, policymakers, and industry. The lack of collaboration and coordination impedes the translation of research into practical applications (Sung et.al., 2003). Another significant challenge is the limited funding for translational research. Despite several initiatives by the government, funding for research remains inadequate, which limits the scope and depth of research and impedes the development of new innovations (Nair et.al., 2015).

Poor infrastructure, including inadequate diagnostic facilities and laboratory equipment, is also a significant challenge that hinders research and its translation into practical applications. Regulatory challenges are another issue that hampers the progress of translational research in India. The regulatory framework for biomedical innovations is not well-defined, leading to delays and uncertainties in the approval process (Đorđević et.al., 2015). There is a lack of focus on commercialization of research products in the Indian healthcare system. This leads to limited resources being directed towards the development of marketable products, which in turn hinders the growth of the industry.

MoDs is an emerging biomedical technology in India that is becoming increasingly important in the healthcare system, especially after the COVID-19 pandemic. MoDs has been declared as the gold standard test by the World Health Organization (WHO) for the detection of the infection in humans, making it a critical tool in the fight against the pandemic (Kabir et.al., 2021). Additionally, MoDs can also be used for the detection of other highly burdened

diseases in India such as tuberculosis, cancer, neurological disorders, cardiovascular diseases, and various genetic disorders, which are part of the "Grand Challenges" in healthcare (Anjum et.al, 2021). The successful translation of MoDs in healthcare system is need of an hour to address the grand challenges posed by highly prevalent diseases and to attain the sustainable goals in healthcare. As pointed in above that the biomedical translational innovation ecosystem in India is already struggling with serious system challenges, in such a scenario the translation of MoDs requires a robust ecosystem that can address the persistent system with in a responsible manner. In this context, the study undertakes the analysis of the institutional mechanisms that are contributing in the formation of innovation ecosystem of MoDs translation blocks T1 and T2, and identifies the factors fostering and hindering the performances of T1 and T2.

Finally, the study recommends the adoption of a "Mission-Oriented Responsible Innovation System" framework. This framework is designed to effectively deal with the existing grand healthcare challenges and provide potential context-specific solutions. It can provide a sustainable ecosystem for the successful translation of MoDs technologies in India's healthcare system. This framework is based on a mission-driven approach that is designed to deliver tangible results and achieve specific goals. It is also grounded in responsible innovation principles, which ensure that the development and implementation of MoDs technologies are done in a way that is socially and ethically responsible. By adopting this framework, India can overcome the grand challenges in the biomedical translational research ecosystem and successfully translate MoDs technologies into the healthcare system.

The rest of the paper is organised into four sections. Section 2 provides the research objectives, section 3 provides analytical framework and methodology, section 4 provides analysis of TIS functions for the development of institutional Mechanisms in the Formation of Translational Block T1. Section 5 provides analysis of TIS functions for the development of institutional Mechanisms in the Formation of Translational Block T2. Section 6 discusses on whether the institutional mechanisms developed so far are significant in dealing the grand healthcare challenges of the country and fostering the translation ecosystem for MoDs technologies. Section 7 concludes by providing the suggestion for the adoption of mission oriented responsible innovation system for fostering sustainable translational ecosystem and dealing the grand healthcare challenges.

2. Research objectives

The study aims to achieve three primary research objectives:

1. To examine the institutional mechanisms established for the development of Translational Block T1.

2. To investigate the institutional mechanisms established for the development of Translational Block T2.

3. To evaluate whether the institutional mechanisms established for the development of translational blocks are suitable for addressing the specific diagnostic needs in India, including the ability to tackle major healthcare challenges.

Additionally, the study seeks to recommend the implementation of a mission-oriented and responsible innovation framework that takes a comprehensive approach to direct the innovation ecosystem towards social needs.

3. Analytical framework and methodology:

The study aims to understand the development of institutional mechanisms for the translation of MoDs technologies. To achieve this, the study uses the Technological Innovation System (TIS) Framework (Bergek et al., 2008; Hekkert et al., 2007; Markard and Truffer, 2008). The TIS framework helps to identify the different actors and institutions involved in the development of the ecosystem for MoDs technological translation, as well as the networks and linkages between them. By analysing the translational ecosystem for MoDs through the TIS framework, the study seeks to understand the kind of institutional mechanisms that have been built for the formation of translational blocks T1 and T2. The TIS analysis undertaken captures the activities involved in dealing with the context-specific needs of addressing grand healthcare challenges. Hence, the study focuses on technological innovation systems (TIS) as socio-technical systems that are focused on the translation and use of a particular technology. By considering both the technical and social components of healthcare systems, TIS approach can help to identify the strengths and weaknesses of the ecosystem. This will help in providing the effective solutions for addressing the system weaknesses and can promote the process of technological translation in more sustainable manner.

The TIS framework consists of seven essential functions, but in this study, the analysis of five key TIS functions has been undertaken. These five functions were used to assess the performance of the actors involved in shaping the institutional mechanisms for development of translational ecosystem of MoDs technology. The study identifies how two translational blocks i.e., T1 & T2 were formed, with each block being guided by a specific TIS function, as illustrated in the accompanying Table 1

Table 1: TIS Functions and their role in the formation of translational blocks T1 & T2

Translational Blocks	**Technological Innovation System Functions**	**Responsibilities**
T1 (Represents the transfer of new understandings of disease mechanisms gained in the laboratory into the development of new methods for diagnosis, therapy, and prevention, and their first testing in humans)	Guidance of the search	This function refers to activities within the innovation system that can positively influence the visibility and clarity of the specific needs of technology users
	Resource mobilization	This function captures mobilization of resources such as human and financial capital, and other complementary resources needed for the proper functioning of the innovation system.
	Knowledge development and Diffusion	This function analyses the knowledge development for the establishment of a technological ecosystem
T2 (Involves the translation of results from clinical studies into everyday clinical practice and health decision-making in the community and ambulatory care setting)	Knowledge Diffusion	This function analyses the knowledge translation within the technological innovation system.
	Legitimation	The function essentially captures activities to counteract the resistance to change upon introduction of an innovation. Legitimacy is an issue of social acceptance and compliance with relevant formal and informal institutions.
Source: adapted from (Bergek et al., 2008; Hekkert et al., 2007; Markard and Truffer, 2008).		

Based on the need of analytical framework the study employs quantitative and qualitative information and follows a multi-dimensional design methodology (i.e., mixed method). It uses multiple data sources to provide a comprehensive landscape analysis by using bibliometrics, scientomatrics methods and literature review for the analysis of location, size, volume, and type of translational knowledge that has been produced through research publications, extramural research projects, funding patterns for research, pattern of research collaborations, contributions of different actors active in formation of MoDs translational building blocks. For the fulfilment of the requirement of the each TIS functional analysis the study uses following databases from the period (2000-2020) to capture the performance of innovation actors:

(a) Research Publications in MoDs were extracted from Elsevier's abstract and citation database called 'SCOPUS'.

(b) Projects supported through Extramural Research Projects (EMR) Funding is collected from the National Science and Technology Management

Information System (NSTMIS) database for 2000 to 2019, made available by the Department of Science and Technology (DST), Government of India. The 'Extramural R&D Projects' database on NSTMIS website was analyzed with the filter for the Directory of Extramural R&D projects set to 'Subject'. Medical Sciences as sub-area was selected for analysis to retrieve the details on 'Project Title', 'Funding Agency', 'Investigator name', 'Institution Name', 'Address'.

(c) The datasets on patents are obtained by using Patents cope search tool by the World Intellectual Property Organization (WIPO) was used to get an overview of the Indian Patent landscape around MoDs technologies. Also, the search engine http://www.ipindia.nic.in/, has been used that is supported by Department of Industrial Policy and Promotion (DIPP), Ministry of Commerce and Industry, Government of India. The data on patents was collected from 2000-2020.

(d) Further, the websites search and study of annual reports of Industries, research institutes, universities and departments of government have been done for the period from 2000-2020.

4. Institutional mechanisms for the formation of translational block t1: analysis of tis functions

T1 translation, also known as the "bench to bedside" stage, involves the translation of basic scientific discoveries into preclinical models and early-stage clinical trials. During T1 translation, researchers aim to identify and develop new therapies, interventions, or diagnostic tools based on promising basic research findings. This stage is critical because it helps to ensure that basic research findings are translated into effective treatments that can improve patient outcomes. T1 translation can be a lengthy and challenging process that involves extensive collaboration between academia, industry, and government partners for the development of required specific knowledge to foster the technology translation. This section analyses the activities undertaken in the performances of three TIS functions for the development of institutional mechanisms towards knowledge development for the formation of T1.

4.1 Guidance and direction of search function

During the 1990s and early 2000s, the Translational research in India was not the foray of public researchers. The private sector had considerable interest in translational research but had little or no access to existing technologies and professionals with diverse skill-sets that could consolidate technologies for later-stage product-oriented development. In addition, when science has moved from upstream to mid-level, the need to combine ethical practices, benchmarked product performance, process and product validation, regulatory validation and efficient product delivery strategies became important issues to

be considered. In order to find sustainable solutions to these challenges, the Department of Biotechnology (DBT), Government of India, initiated focus on translational research around 2005. As such, in the area of biomedical healthcare technology, the Translational research was started and fostered by the TIS function *guidance and direction of search* by the efforts of DBT.

The initial focus of DBT's was confined to a couple of disease segments and more focus was in agriculture. However, in past few years, DBT has created a sustainable framework for various biomedical fields that focused exclusively on translational research. One such framework is DBT 's Grand Challenge Programmes, announced in 2007 as part of its National Biotechnology Development Strategy (NBDS)[2]. Under NBDS the initial focus of DBT is to develop specialised human resource and a specialised centre for promoting translational research to provide dedicated facilities and networking opportunities in the area of biomedical healthcare technologies. In the following sub-sections, the strategies adopted by the DBT to foster establish institutional mechanisms for the formation of T1 translational block:

4.1.1. Human resource development: Establishment of regional centre for biotechnology (RCB)

RCB was established in partnership with UNESCO in the year 2006 to create human resources for translational research in the advanced area of biotechnology. RCB is set out as a biotechnology University with a unique canvas of specialised doctoral and masters programmes, domain specific training programmes and high-quality research, and development in priority areas aimed at producing highly specialised cadre of scientists capable of translating research to actual practice for societal benefits. The purpose of such interdisciplinary programmes is to educate students at the interface of various disciplines that permits explorations in translational discipline. The centre is also opened to industry for enhancing their skills in specific areas. Domain specific programmes are designed to create highly specialised scientists for technology development in the relevant areas. An important focus of expertise building is promoted in the area of regulation, product development, scale- up, manufacturing sciences and bio-entrepreneurship.

At present, the centre consists of faculties and scientists with potential for intellectual leadership and passion for both research and teaching in all cutting-edge areas of biotechnology. The centre has provision for visiting professorship, adjunct professorship, re- entry grants and young investigator awards. Scientist working in other national/international institutes and universities are selected for a period of five years to contribute to the mission of the centre as adjunct faculty. Some visiting faculty positions are also offered for Indian as well as foreign nationals. Post-doctoral training opportunities are available for young scientists from the region to work under the mentorship of the faculty of RCB.

RCB, in overall terms, is contributing to the system building activities for human resource development through education, training and research in biotechnology with contributions from other countries and academic institutions of the region and provides a meeting place where innovation, enterprise, and industry is expected to foster and develop.

4.1.2. Establishment of translational health science and technology institute (THSTI): A specialized centre to promote translational research

Established by DBT in early 2009, the THSTI is an autonomous institute located at Faridabad near New Delhi. THSTI seeks to create an institutional environment for multi-disciplinary research to translate technological advancement into medical innovations for affordable healthcare solutions. The main novelty is that it provides opportunity for collaboration among research institutions, hospitals, and companies with common governance to encourage practicing doctors to work with basic researchers and engineers for commercialisation. THSTI is modelled on the Harvard-MIT Health Sciences and Technology (HM-HST) programme for multi-disciplinary research founded in 1970, which integrates science, medicine, and engineering in its academic and research activities to solve human health problems. THSTI is benefiting from a partnership with HM-HST, to oversee its development, and to mentor and train its faculty. Since inception, it has built a series of labs and niche centres including a Vaccine and Infectious Disease Research Centre, a Paediatric Biology Centre, a Clinical Development Services Agency, and a Centre for Bio-design and Diagnostic.

4.1.3. Facilitating knowledge translation through global consortia

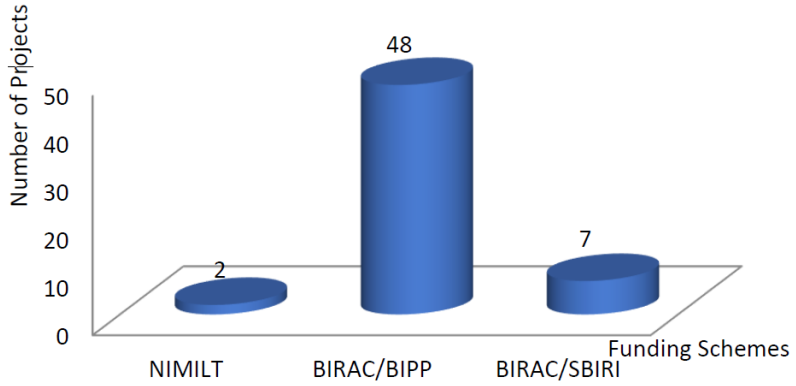
DBT conceived a span of global partnerships for Indian researchers to collaboratively learn and adopt best practices in technology generation, translation, and commercialisation. DBT promoted global collaboration to elevate Indian research competency to global standards like The *Indo-Swiss Collaboration in Biotechnology,* which is a is DBT's longest established bilateral R&D program, jointly funded and steered with SDC (Swiss Agency for Development and Cooperation), *Indo-US Vaccine Action Program (VAP).* The main aim is the development of joint R&D projects for new and better vaccines against major communicable diseases of importance to India; encompassing laboratory-based research, epidemiological studies, field trials, vaccine quality control, and delivery of vaccines. In the area of biomedical healthcare technologies for medical diagnostics development, the main programme is Wellcome Trust, UK. The *Wellcome Trust-DBT India Alliance* is a 5-year £80 million equally funded competitive biomedical research fellowship programme across the full spectrum of biomedical sciences. Initiated in September 2008, it was modelled along the line of Howard Hughes Fellowship, the largest privately-funded science education initiative in the US, and was designed to

support scientists at key stages of their research careers in fields of neurosciences, cell biology, cancer diagnostics, genetics, and infectious diseases prevalent in the developing world. Similarly, the *R&D for Affordable Healthcare* initiative was launched in July 2010 to support translational research projects that deliver safe and effective healthcare products for India and other low and middle-income countries at affordable costs. This is intended to address the funding gap from venture capitalists requiring sufficiently large demonstrable market. The scheme covers projects involving any aspect of technology development for healthcare, including diagnostics therapeutics, vaccines, medical devices, and regenerative medicine. Another such initiative is DBT-Academy of Finland and TEKES in the area of medical diagnostics.

4.2. Resource mobilisation

The Government, under the GSPOA programme, constituted various funding mechanisms to promote ecosystem for translational research by encouraging public private partnerships (PPPs). This includes New Millennium Indian Technology Leadership Initiative (NMITLI) of Council of Scientific and Industrial Research (CSIR), Drugs and Pharmaceuticals Research Programme (DPRP) and Technology Development Board (TDB) of Department of Science and Technology (DST), Biotechnology Industry Partnership Programme (BIPP) and Biotechnology Industry Research Assistance Council (BIRAC) of Department of Biotechnology, Small Business Innovation Research Initiative (SBIRI) of DBT. The total numbers of projects funded for MoDs translation under these schemes are shown in Figure 1. It is evident that DBT's BIRAC is the leading agency for funding and promoting translational research.

Figure 1 : Number of MoDs projects funded under various funding schemes (2000-2020)

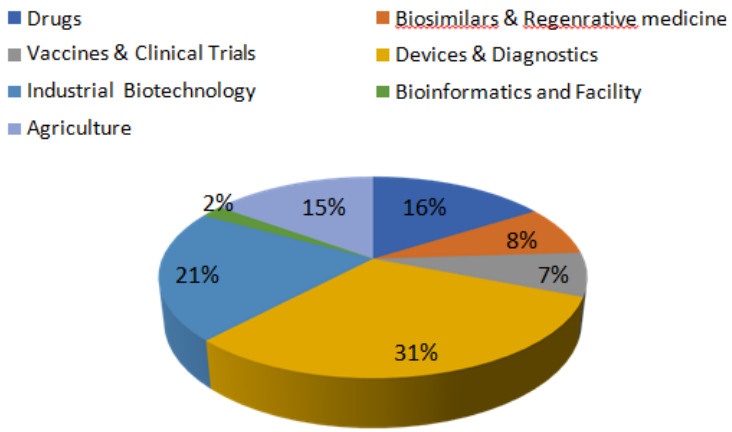


Source: Authors calculation based on the Annual Reports of DBT, DST and CSIR

4.2.1. Contribution of BIRAC in promoting translational research in the area of MoDs

Since its inception, BIRAC has been continuously supporting and expanding affordable products and processes specifically catering to wide spectrum end-user applications and innovations. Being a biotech development agency, BIRAC has been in the process of funding emerging technologies with translation potential for promoting the start-up ecosystem so as to align with the goals of "Make in India" and "start-up" India. Covering the entire span of biotech arena right from pre-proof of concept till commercialisation, BIRAC has been supporting innovation through schemes such as Biotechnology Ignition Grant (BIG), Small Business Innovation Research Initiative (SBIRI), Biotechnology Industry Partnership Programme (BIPP), Contract Research and Services Scheme (CRS) and Social Innovation programme for Products: Affordable and Relevant to Societal Health (SPARSH) and Industry Innovation Programme on Medical Electronics (IIPME). Theme wise projects supported by BIRAC from 2012[3]-2020 are shown in Figure 2.

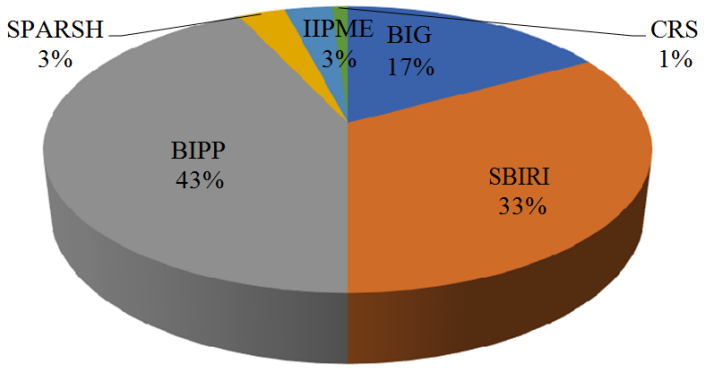
Figure 2: Ratio of theme wise projects supported by BIRAC (2012-2020)



Source: Authors calculation based on BIRAC extramural project database

Medical devices and diagnostics sector (31 percent) accounted for the largest number of projects being supported. This sector has the potential to shorten recovery times and make certain procedures less invasive to help disease management and treatments. The current product affordability of medical technology is a major barrier for the market to be able to achieve its anticipated potential growth and BIRAC is funding many enterprises to overcome the high-cost barrier. BIRAC also promoted the "Make in India" wave and invested around Rs.223 Crore in Devices and Diagnostics. The fund distribution under various BIRAC schemes to support medical diagnostics and a devices project in 2012-2020 is shown in Figure: 3, among these through BIPP and SBIRI major funds have been released to support PPPs.

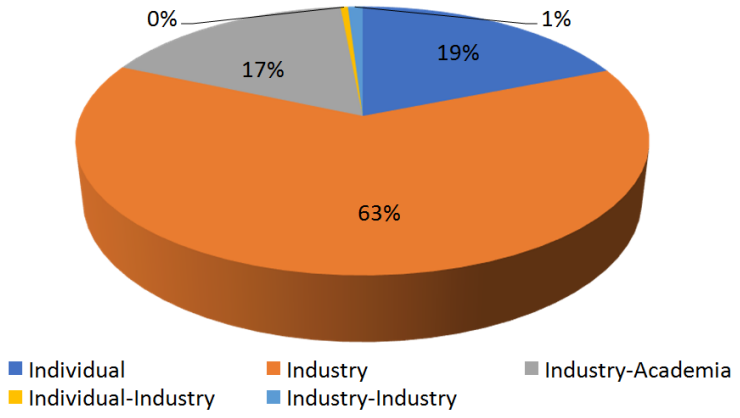
Figure 3 : Ratio of funds distribution under various schemes of BIRAC (2012-2020)



Source: Authors calculation based on BIRAC extramural project database

In the recent period, BIRAC is trying to build the ecosystem of partnerships and collaborations through various schemes (Figure 4) to facilitate translational ecosystem. It is encouraging that the academia and Industry is collaborating in many disciplines and complimenting each other for the success of projects. However, the proportion is still very low (17 percent) and there is a need to foster system building activities to develop much greater academia-industry interaction which is critical for the development of translational research ecosystem.

Figure 4: Distribution of BIRAC beneficiaries (2012-2020)



Source: Authors calculation based on BIRAC project database

4.3. Knowledge creation and development function

Innovation activities of knowledge development TIS function is supported by two innovation system functions, namely; 1) Guidance and Direction of Search and 2) Resource Mobilisation. Strategies adopted by the actors under the Guidance and Direction of search to create specialised human resource and centres and resource mobilisation has created an ecosystem that has initiated

and supported the system building activities for creation and development of knowledge in the area of translational research.

4.3.1. Establishment of centre for bio-design and diagnostics (CBD)

CBD, established in 2009, is a dedicated lab of THSTI for the innovation and development of Medical Diagnostics. The mission of CBD is to create medical technology innovation for affordable healthcare utilising the biodesign concept that utilises inputs from clinical-care settings to innovate or improve existing designs and support services that extend from strategic bench work to commercialisation. The centre also promotes an effective translational route for basic findings into routine applications through a multidisciplinary approach, combining new biomarkers, novel technological concepts, and clinical insights. The following research programmes focused on the development of affordable technologies in the area of MoDs were initiated by CBD.

(i) Stanford – India Biodesign programme initiative at All India Institute of Medical Sciences (AIIMs) and Indian Institute of Technology (IIT), Delhi; several prototypes have been developed and refined by the team of Stanford-India Biodesign programme.

(ii) Healthcare Technology Innovation Centre (HTIC) has been established by the department in 2012 at IIT, Chennai. The vision of HTIC is to develop technologies that create, impact and drive innovation in healthcare.

(iii) Biodesign- Bioengineering initiative has been implemented at Indian Institute of Science (IISc), in collaboration with St. John's and Fortis Hospital, Bangalore. The aim is to carry out research in the area of bio design and bioengineering.

(iv) A national biodesign alliance has been established by the department with various partners such as IIT Delhi; AIIMS-Delhi; Regional Centre of Biotechnology (RCB)-Faridabad; International Centre for Genetic Engineering and Biotechnology (ICGEB)-Delhi; IIT-Madras; IISc-Bangalore and Christian Medical College (CMC)-Vellore, to coordinate with the biodesign programmes in the country.

(v) A Memorandum of Understanding (MOU) is signed between THSTI and University of Turku for creation of an Indo Finnish Diagnostic Research Centre. The goal of the Indo- Finnish Diagnostic Research Centre (IFDRC) is to complement and enhance the research capabilities of Indian and Finnish scientific networks from academia and industry in the area of diagnostics.

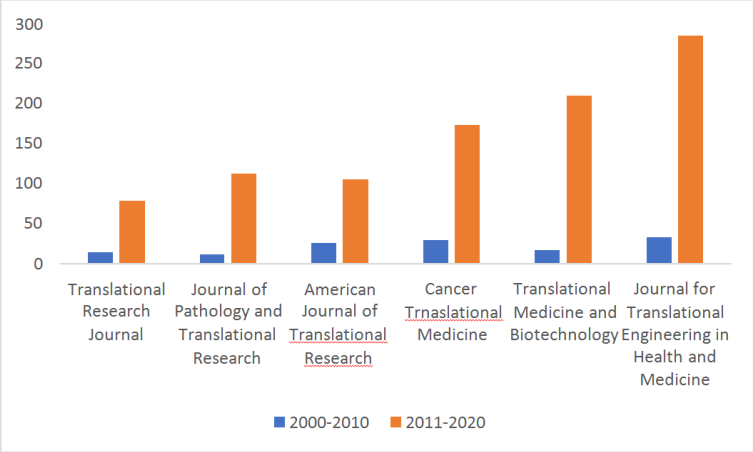
Currently, CBD's is contributing towards knowledge development and diffusion for MoDs translation research in the following areas: (a) In-vitro diagnostics, (b) Rapid, simple and sensitive test modules for multiplex testing

of infectious disease in blood banks, (c) Developing a Rapid Test for Diagnosis of Celiac Disease (CD), (d) Development of novel sample processing for simple and rapid diagnosis of TB, MDR-TB and XDR-TB, (e) Development of human recombinant antibody library platform, (f) Multi-analyte assay for acute coronary syndrome (ACS) diagnostics, (g) Diagnostic assay for KIM-1: Human Urinary Renal Dysfunction Biomarker, (h) Detection of novel Protein Biomarkers for early diagnosis of pregnant women at the risk of preterm birth, (i) Development of a diagnostic panel for Acute Febrile Illness, (j) Development of a technology platform for simple and efficient production of recombinant antibodies. Upcoming sub sections provides the details analysis of knowledge development and diffusion for the development of translation ecosystem for MoDs technologies.

5.3.2. Knowledge development through publication activities

The study observes that the knowledge creation by Indian authors in translation research area of MoDs has witnessed significant increase since the mid-2000. For instance, analysis of top six peer-reviewed Translational research reveals sharp increase in translational research publication from 2011-2020 relative to 2000-2010 (Figure 5).

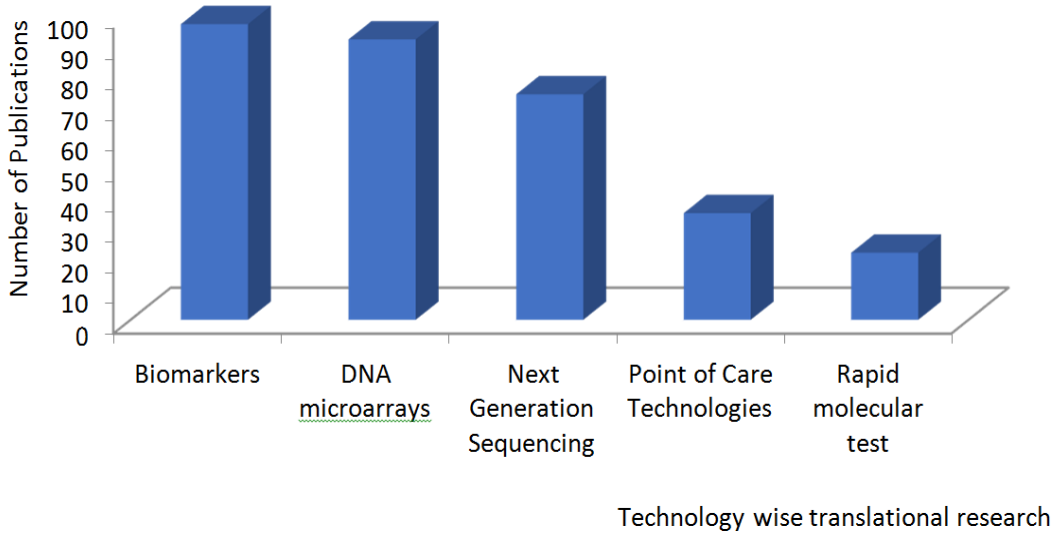
Figure 5: Indicator of Knowledge Creation: Total Number of Research Paper Published in Major Translational Research Journals by Indian Researchers (2000-2010 and 2011-2020)



Source: Authors calculation based on the data collected from Scopus database

Further publication activities are analysed from 2006-2020 as this period showed significant development in knowledge production. Thematic area-wise distribution of MoDs research papers reveals that the focus of knowledge creation by the Indian researchers is in the disciplines of biomarkers, next-generation sequencing, point of care technologies, rapid molecular test, and DNA microarrays (Figure 6). This is a significant achievement for dealing the grand healthcare challenges.

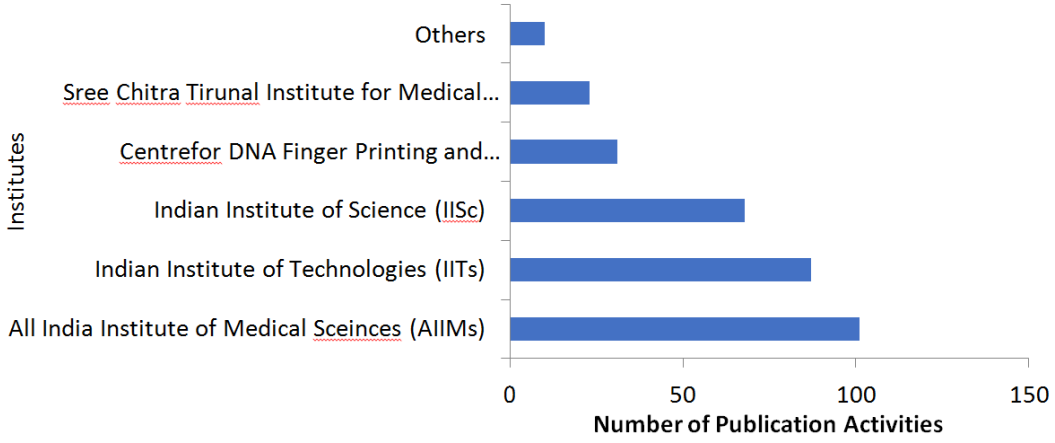
Figure 6: Technological area-wise distribution of translational research papers by indian scientists (2006-2020)



Source: Authors calculation based on the data collected from Scopus database

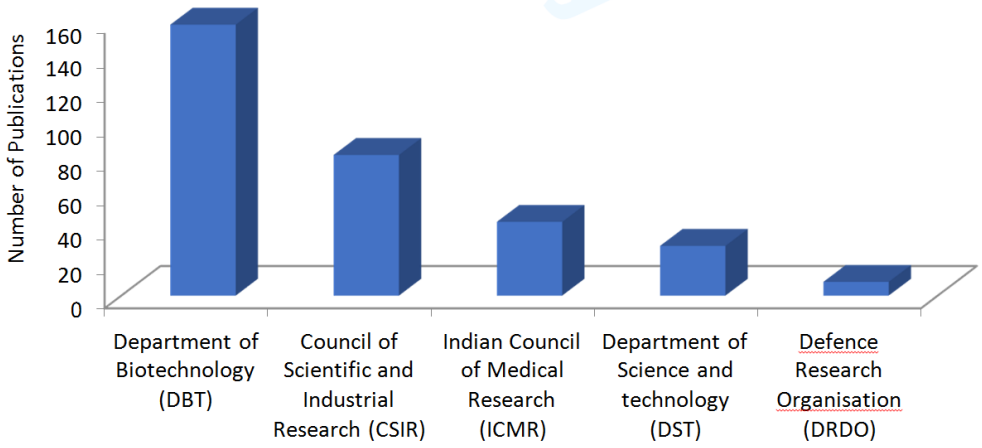
In terms of location of knowledge creation units, the dedicated institutes involved in the creation of translational ecosystem research for MoDs are AIIMS in Delhi, IITs, IISc, Centre for DNA Finger Printing and Diagnostics (CDFD), and Sree Chitra Tirunal Institute for Medical Sciences and Technology (ShreeChitra), these institutions contribute to 90 percent of the total knowledge produced (Figure 7). DBT is the major national funding organisation supporting translational research for MoDs, along with CSIR, Indian Council of Medical Research (ICMR), Department of Science and Technology (DST) and Defence Research and Development Organisation (DRDO) (Figure 8).

Figure 7 : Location of translational research: major institutes in India (2006-2020)



Source: Authors calculation based on the data collected from Scopus database

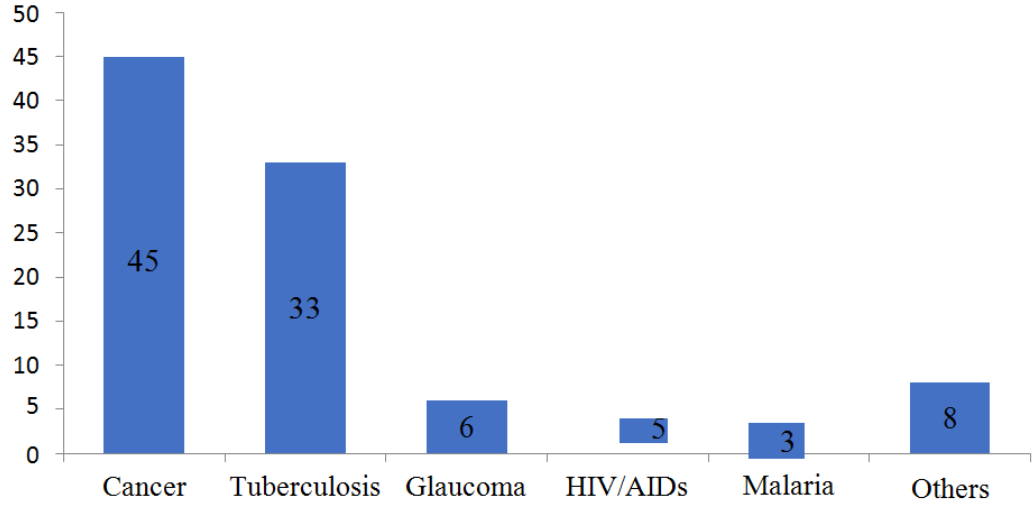
Figure 8: Top Five Funding Organisation Supporting Translational Research (2006-2020)



Source: Authors calculation based on the data collected from Scopus database

In terms of needs and application for which knowledge creation and development for translational research is embedded, our analysis indicates that most of them are concentrated towards diseases such as tuberculosis, cancer, glaucoma, HIV and malaria. These five major disease areas covered almost 90-95 percent of the total research publications in the area of the translational research (Figure: 8).

Figure 9: Embodiment of Translation Research According to needs and applications (2006-2020)



Source: Authors calculation based on the data collected from Scopus database

Some of the significant knowledge development to address grand healthcare challenges through publication activities in the area of MoDs are listed below:

(a) Development of Tuberculosis MoDs

- CDFD is working in the area of identifying markers and developing techniques for detecting mutations which confer drug resistance against M. tuberculosis.

- JALMA has developed two rapid gene amplification assays based on strain specific amplified rDNA restriction analysis (ARDRA) targeting ribosomal gene region of M. tuberculosis. These techniques help in quick identification of M. tuberculosis and can differentiate the type of Mycobacterium infection.

- AIIMS has developed a PCR technology based on devR gene. The technology comprises of a unique universal sample processing (USP) methodology for processing of any type of clinical specimen for the laboratory diagnosis of pulmonary and extrapulmonary TB, which improves the detection of the pathogen during PCR amplification.

- Dr. Lal Path Lab, New Delhi; and Specialty Ranbaxy Laboratory Ltd., Gurgaon, provides services based on PCR techniques using in-house designed primers.

(b) Development of Tuberculosis Cancer MoDs

- Jaslok Hospital, Mumbai; AIIMS, New Delhi; RCC, Thiruvananthapuram; and Gujarat Cancer Research Institute, Ahmedabad, are jointly evaluating MDs techniques for oral cancer. The techniques involve PCR amplification of the sixteen established gene markers and telomerase activity. The molecular analysis has been undertaken and the data is being analysed.

- Another study to assess alterations in oral subcutaneous fibrosis cases via-a-via control has been done using P53 expression, proliferation and apoptosis as marker at Ragas Dental College and Hospital (RDCH), Chennai.

- Several translational studies with potential to be used for head and neck cancer management are done at the Tata Memorial Centre, which comprises the Tata Memorial Hospital (TMH) in Mumbai and the ACTREC at Navi Mumbai. The Centre is well equipped to carry out research requiring analysis by CGH, PCR, RT-PCR, dHPLC, microarray methods and proteomics.

- At the Cancer Genetics Clinic of TMC, Mumbai, a registry of familial and multiple primary cancers has been established. The clinic offers medical and genetic evaluation of individuals and families suspected to be having

inherited predisposition to cancer. The clinic has achieved the following translational research objectives: 1) Evaluation, counselling and DNA banking for individuals with suspected inherited cancer predisposition as part of the hereditary cancer consortium, 2) Initiation of a study on the prevalence and spectrum of BRCA1/BRCA2 mutations in hereditary breast/ovary cancer families, 3) Detailed assessment of various environmental and hereditary factors, and molecular studies of carcinogen metabolising enzymes and DNA repair capacity in individuals with multiple primary neoplasias.

- At LV Prasad EYE Institute (LVPEI), Hyderabad, six different mutations in the RB1 gene, which are responsible for Ratinoblastoma have been identified. Six different PCR-RFLP MDs methods for identification of the mutations have been developed and standardised.

- Vision Research Foundation (VRF), Chennai has developed a molecular cytogenetic technique to identify chromosomal alteration (leading cause of cancer) using FISH method.

- Indian Institute of Science (IISc) has developed AP-2 (a transcription factor) in tumour cell line. The role of this marker for cancer diagnosis is being further studied. Genomics studies at IISc have identified potential markers for gliomas, a type of brain tumour.

- Cancer Institute, Chennai, has identified a mutation in BRCA1 and BRCA2. This has been developed as a marker for diagnosis of breast cancer using sequencing technique. Genetic predisposition to breast cancer among Indian women was studied in Kidwai Memorial Institute of Oncology (KMIO), Bangalore, by confirmation sensitive gel electrophoresis for BRCA1 and 2 mutations.

- A low cost method has been developed at National Institute of Cancer Prevention and Research (NICPR), Noida for detection of HPV including co-infections from cervical swabs. This method detects the five most prevalent HPV types commonly associated with cervical abnormalities.

(c) Development of glaucoma MDs

- Shankar Netralaya, Chennai has developed MDs, based on existing biomarkers to detect predisposition to cataract for the Indian population. Currently, Glaucoma is the second major cause of blindness, affecting 67 million people worldwide.

(d) Development of malaria MDs

- AIIMS, New Delhi is developing MDs based on multiplex PCR, which identifies the infectious pathogen with high sensitivity and can differentiate amongst the different species.

(e) Development of HIV/AIDS MDs

- AIIMS has developed a matrix RT-PCR test which can detect as low as 100 copies of the virus in the sample. The technique is designed in such a way that approximately 1000 samples can be handled simultaneously. AIIMS has also developed a RT-PCR based quantitative technique for detection of the viral load in the human body. Both the tests are based on HIV-1 subtype C. Patents for both the technologies have been filed by AIIMS.

5. Institutional mechanisms for the formation of translational block T2: Analysis of TIS functions

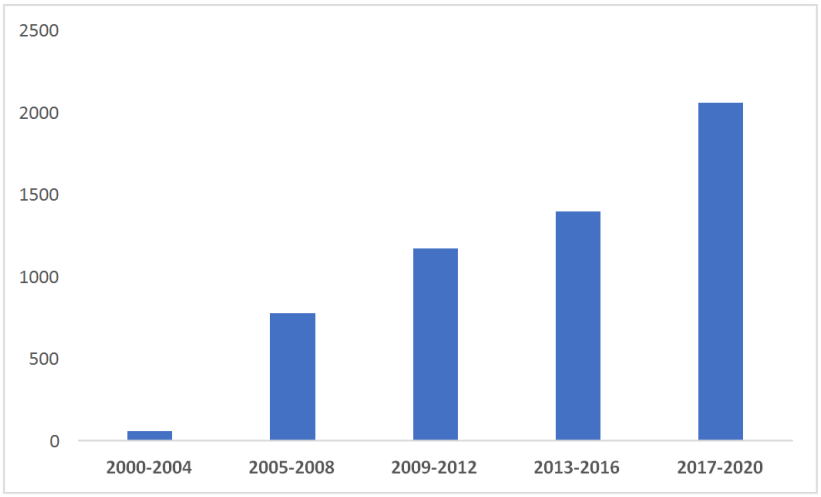
Once a new treatment or intervention has been shown to be safe and effective in clinical trials, it can progress to the T2 translation stage. T2 translation, also known as the "bedside to practice" stage, involves the dissemination and implementation of the new treatment or intervention into routine clinical practice. During this stage, researchers and healthcare professionals aim to evaluate the real-world effectiveness and safety of the new treatment or intervention, identify any potential barriers to adoption, and develop strategies to promote widespread adoption of the new treatment or intervention. T2 translation is critical to ensure that patients benefit from new treatments and interventions that have been shown to be effective in clinical trials. This section analyses the activities undertaken in the performances of the two TIS functions to build an institutional mechanism for the formation of T2.

5.1 Knowledge diffusion function

5.1.1 Formation of translational research networks

Pattern of research collaboration through publication activities illustrates that over the period, collaborative research has increased the R&D activities of MDs (Figure 10). Figure 11 indicates that among them, both intra-institutional and inter-institutional collaborations are the major ones, which is a significant sign of knowledge sharing and coordination among various innovation actors that could result in the development of a strong and vibrant innovation system for translational research.

Figure 10: Cumulative collaborative research publications in MDs: By selected Periods



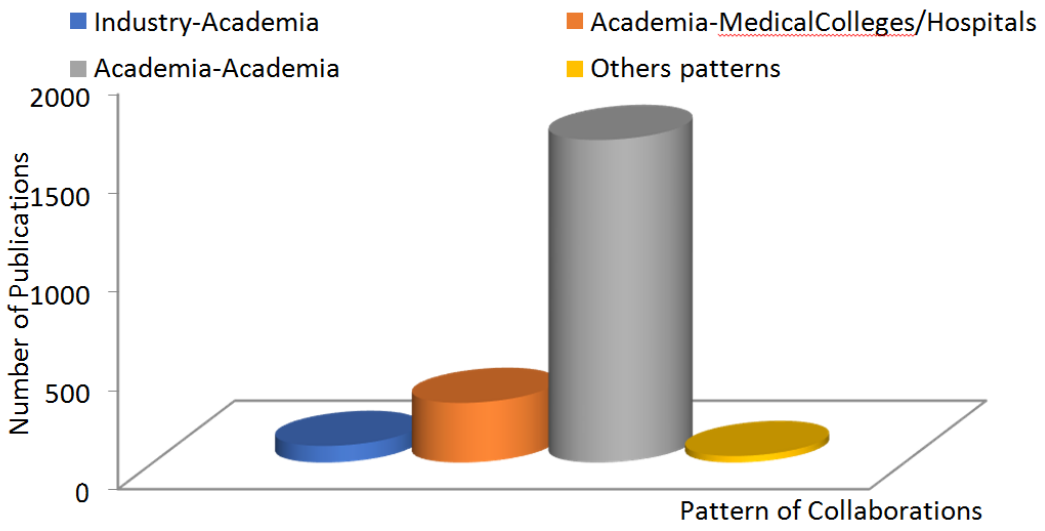
Source: Authors calculation based on the data collected from Scopus database

Figure 11: Ratio of Intra and Inter institutional collaborations in MDs: -2006-2020 (%)

Source: Authors calculation based on the data collected from Scopus database

However, further assessment of the pattern of collaboration (Figure 12) does not seem to be encouraging as the collaboration between industry-academia and academia-medical colleges/hospitals are relatively less, even though these collaborations are critical for the promotion of translational research in the country. Industry-academia interactions are required for the translation of basic ideas into products and, in this case, the interactions between academia-medical colleges/hospitals are of prime importance in MoDs. This is crucial since these types of collaborations involves the interaction between researchers and clinicians that enhances the understanding of researchers about the clinical aspects of the diseases and the clinicians would understand the role of molecular biology for the disease detections.

Figure 12 : Ratio of intra and inter institutional collaborations: 2006-2020 (%)

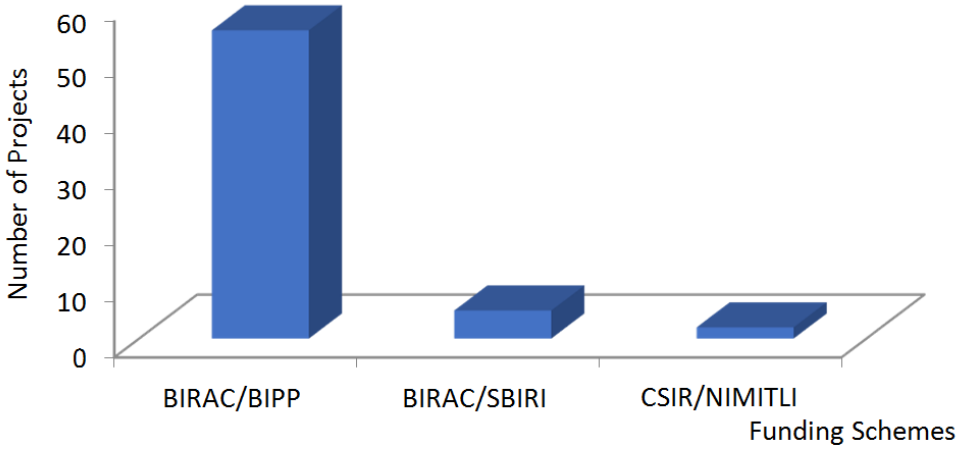


Source: Authors calculation based on the data collected from Scopus database

5.1.2. Knowledge diffusion through public private partnership (PPP)

Analysis of system building activities contributing knowledge diffusion through PPPs indicated that DBT and CSIR are contributing through promotional funding schemes such as BIRAC/SBIRI and BIRAC/BIPP and NMITLI of CSIR. These schemes are allocating funds for promoting PPPs in the area of therapeutic, vaccine and diagnostic development for the diseases of national importance. Currently, to support system building activities for MDs, BIRAC/SBIRI is supporting five projects, BIRAC/BIPP supporting fifty projects and two projects are supported by CSIR/NMITLI, as indicated by Figure 13.

Figure 13 : Pattern of technological focus of collaborative activities (2006-2020)



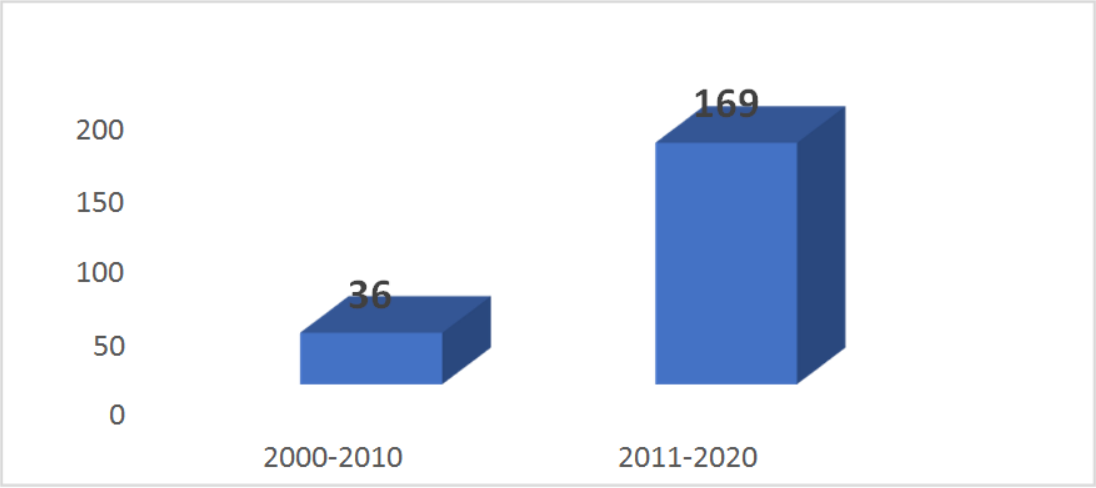
Source: Authors calculation based on the data collected from Scopus database

Thus, the analysis of system building activities for the formation of innovation, Knowledge Diffusion innovation system function indicate that major support to shape these activities is supported through Resource mobilisation system function. Initiatives undertaken in the form of various funding schemes to support collaborative research and PPPs are playing a significant role in the development of ecosystem for knowledge Diffusion for translational research. Analysis showed that over the period, system building activities have evolved but are relatively immature to meet the larger demand of the grand challenges.

5.1.3 Knowledge diffusion through patenting activities

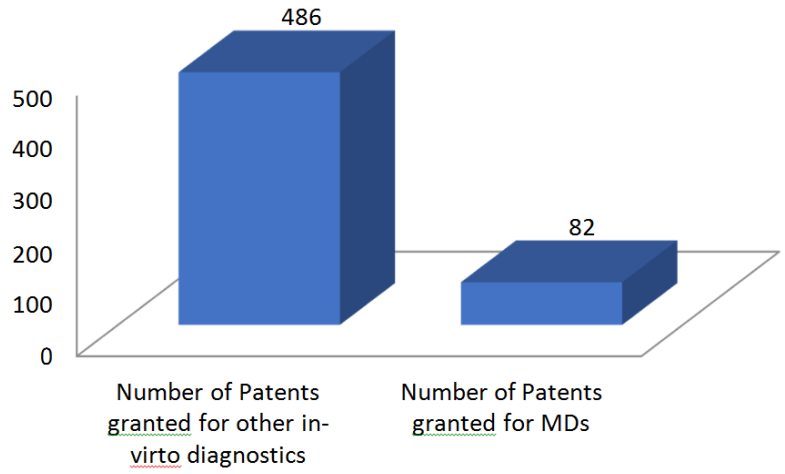
Patents are one of the important indicators to analyse the volume of translational knowledge produced, as these are the outcomes of the translated basic research activities. Patents play a critical role in incentivising the substantial investment required to translate the results of basic research into high quality, commercially available diagnostic tests that meaningfully affect people's lives (Holman, 2014). However, in this sub-section the study focusses only on the volume and type of patents granted for MoDs in India to understand the status of translated research and do not address the larger debate of patents being incentives or barriers in innovation.

Figure 14: Total number of patents granted in the area of MDs: 2000-2020



Source: Authors calculation based on the data collected from Indian Patent Office database

Figure 15: Comparative analysis of total patents granted for In-Vitro diagnostics and MoDs: 2000-2020

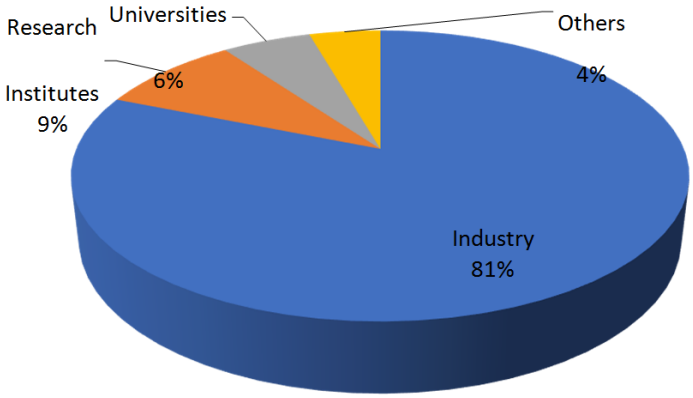


Source: Authors calculation based on the data collected from Indian Patent Office database

For the empirical analysis, the study uses the patent data collected from the Indian Patent Office database (IPO) during 2000-2010 and 2011-2020. The study observes that the granted patents in the area of MoDs have increased from 36 to 169 in the past ten years (Figure 14), Although encouraging, these numbers are insignificant in comparison to the total granted number of patents for other in-vitro diagnostics (Figure 15). This reveals that there might be lack of competence, capabilities or interest among innovation actors to generate innovative outcome of Translation research in the form of patents.

Analysing further, it is revealed that that currently the maximum number of patents are granted to industry (81 percent) of the total granted patents (Figure 16), whereas the public sector research institutes and other innovation actors such as universities, medical colleges, etc., lag behind in receiving granted patents (only 19 percent). The analysis of number of patents filed showed that industry has filed a maximum number of patents than other research institute or innovation actors. This further confirms the lack of innovative capabilities in translational research compared to other form of actors.

Figure 16 : Number of patents granted for different actors (2000-2020)



Source: Authors calculation based on the data collected from Indian Patent Office database

In terms of nature of patents, it is revealed that the maximum number patents granted are in the area of processes such as sequencing a particular gene, enhancing the amplification techniques, identification of new DNA sequence or nucleotide sequence, these covers routine translational research. Patents granted in the area of novel diagnostic kits or method which covers the novelty like cost-effectiveness, near patient testing (POCs), decreasing turnaround time (rapid molecular tests) or the development of novel biomarkers are considerably low.

5.2 Institutionalisation and legitimation function

The development of Translational research requires a well-functioning and comprehensive governing institution and legal structure. MoDs are sub-categorised as In Vitro Diagnostic (IVD) assays. Central Drugs Standard Control Organisation (CDSCO) is the primary medical regulatory organisation in India. Since 2006, the Ministry of Health and Family Welfare (MHFW) along with DBT and DST is trying to restructure the regulation of medical devices in India. However, the innovation activities for the regulation of other MoDs are still needed to be properly regulated and implemented for the well-being of the society. Various initiatives have been undertaken by DBT to support and foster regulation of MoDs are discussed in following sub sections:

5.2.1. Establishing required regulations

As the policy focus moved towards mid-level research to validate technologies and products, DBT has begun establishing regulations and compliances framework to ensure process and product safety and technological relevance. There was a consequent need to enlarge the pool of professional regulatory administration specialists by collaborating with other regulatory agencies in countries that have established robust regulatory mechanisms. DBT's efforts

have focused on establishing a sound system of regulation for pursuing research in agriculture biotechnology, bio-medical discovery-led clinical validation, and animal health-focused products. DBT established several frameworks for regulating the safety and efficacy of these technologies, with some of these regulations formulated on their own and some in collaboration with other national regulatory bodies. The various regulations, rules and acts introduced include: Recombinant DNA Safety Guidelines and Regulations, 1990; Revised guidelines for safety in Biotechnology, 1994; Revised Guidelines for Research in Transgenic Plants and Guidelines for Toxicity and Allergenicity Evaluation of Transgenic Seeds, Plants and Plant Parts, 1998; Guidelines for Generating Pre-Clinical and Clinical Data for r-DNA Based Vaccines, Diagnostics and other Biologicals, 1999; Guidelines and Standard Operating Procedures (SOPs) for Confined Field Trials of Regulated Genetically Engineered (GE) Plants, 2008; and Protocols for Food Safety Assessment of Foods Derived from Genetically Engineered Plants, 2008.

DBT has proposed the Biotechnology Regulatory Authority Bill 2009 to establish an independent, autonomous, statutory agency to regulate the research, transport, import, manufacture and use of organisms and products of biotechnology. Another initiative relates to creating a system of reward mechanisms for technology transfer and providing a legal mandate for technology generating agencies to license them to enterprises. This legislation, proposed on the lines of the Bayh Dole Act of USA, is intended to bring greater focus to the technology management process for publicly generated technologies. The Public Funded R&D (Protection, Utilisation and Regulation of Intellectual Property) Bill, conceived in 2007, is expected to be taken up for enactment by the national lawmakers in Parliament.

5.2.2. Creating institutional mechanisms for effective governance

There was a perceived need by DBT to create an institutional mechanism that would accelerate translational research, covering project conceptualisation, creation, management, monitoring, and engagement of all involved partners, including domestic, international, public and private. Such institutional mechanism is expected to ensure transparency, speed of execution and effectiveness in management of successful translational research programs.

A project management entity was conceived for each of the initiatives. Wherever needed, a special purpose vehicle (SPV) was created for the management entity to ensure efficiency, speed and transparency in governance and administration. Institutional frameworks were conceived and developed to suit the rules of engagement in mid-level research focused on the generation of affordable goods and services. The SPVs were tailor-made to the requirements of each initiative, depending upon the longevity and the depth of multi-party engagements in such initiatives. Each SPV had a distinct model of project

management that focused on research effectiveness, resource management and governance. Specialists with project management ability and consultancy organisations with experience in global project management were retained to support the establishment of management structures that would provide able governance mechanisms. IP management, technology management functions, creation and adoption of project management tools, capacity to train scientists in effective grant writing, and several other non-research related interventions required external talent to be sourced.

DBT's initial efforts to create SPVs arose from its bilateral engagement in global research partnerships. In their initial years of engagement, co-investors with DBT insisted on project management being vested with management entities based in the industrialised country partner country due to the project management skills they brought in. The bilateral engagements helped to create independent governance mechanisms with representation of experts, including scientists, administrators, and technology management specialists from partnering countries. The engagements required collaborating partners to define a structured way the funds would be deployed, research projects managed, and the results reviewed. Based on an examination of some of these governance models, they did not have a typical structure but were tailor-made to meet the needs of specific partnerships.

The discussion so far on the Guidance and direction of search indicate that it has become the precursor for the evolution of system building activities for the development of translational base in MDs. Various initiatives and strategies undertaken by DBT under this innovation system function have contributed to the ecosystem building that shaped and supported the system building activities undertaken for the performance of other innovation system functions like resource mobilisation, knowledge creation and development, knowledge diffusion and Institutionalisation and Legitimation. Realization of importance of translation research specific system building activities for the development of the advanced biomedical technologies has directed system-building activities towards the country's specific healthcare needs. In Section 6, the study analyses how far the strategies adopted by the government for building institutional mechanisms to promote T1&T2 translational blocks is able to foster and strengthen the translational ecosystem for MoDs.

6. Assessment of institutional mechanism for fostering sustainable translation ecosystem for MoDs technologies: A discussion

Previous sections on building institutional mechanisms for T1 and T2 translation blocks indicates the importance of creating an environment for multi-disciplinary research to translate technological advancements into medical innovations for affordable healthcare solutions. The two institutions, the Regional Centre for Biotechnology (RCB) and the Translational Health

Science and Technology Institute (THSTI), which were established by the Indian government to promote translational research in the country. The Indian government has also established funding mechanisms to promote public-private partnerships (PPPs) to encourage translational research. There are several global partnerships that the Indian government has established to promote translational research. These partnerships aim to elevate Indian research competency to global standards and promote collaborations for joint R&D projects.

The Indian government has made significant efforts to promote translational research by establishing institutions, funding mechanisms, and global partnerships which are significantly contributing in the development of T1& T2. However, the analysis reveals that translation ecosystem formation for MoDs technologies are in very initial stage of development. The challenges include ineven distribution of funding towards funding medical device projects over medical diagnostic projects, with only 17% of funding allocated to MoDs projects. Additionally, funding is heavily concentrated on a few disease areas, which is not engouraging sign for addressing the grand healthcare challenges. In knowledge creation activity there is not any significant sign of development of reagent which are very important component of MoDs development, as India is currently import-dependent in this area. One can see only a small number of products/technologies commercialized in the Indian market. Academia-industry interaction is critical for the development of translational research, but the current proportion of collaboration is low at 17%, and more efforts and financial resources are needed for the development of MoDs innovation system.

Additionally, the formation of T2 translation stage involves the dissemination and implementation of a new treatment or intervention into routine clinical practice. The study focuses on the activities undertaken to build an institutional mechanism for the formation of T2, including the knowledge diffusion function, PPPs, and patenting activities. It has been found that while there is an increase in intra and inter-institutional collaborations, there is a lack of collaboration between industry-academia and academia-medical colleges/hospitals, which is critical for promoting translational research. PPPs in the form of funding schemes are playing a significant role in the development of an ecosystem for knowledge diffusion, but the system building activities are relatively immature to meet the larger demand of grand challenges. Patents play a critical role in incentivizing investment, but the volume of patents granted for medical devices is insignificant compared to other in-vitro diagnostics, which reveals a lack of competence, capabilities, or interest among innovation actors to generate innovative outcomes of translation research in the form of patents. Institutional mechanism for well-functioning and comprehensive governing institution and legal structure.

Overall, the examination of TIS functions suggests that the government's endeavours to establish institutional mechanisms for creating a translational ecosystem for MoDs technologies are promising. However, progress has been sluggish, and the ecosystem remains in its early stages even after 20 years. This lethargic pace is not sufficient to address India's significant healthcare challenges, and the translational ecosystem is currently facing numerous obstacles, including inadequate funding, regulatory limitations, insufficient infrastructure, research fragmentation, and a lack of commercialization. Overcoming these obstacles will necessitate a collaborative effort from the government, industry, and academia to establish a supportive ecosystem for translational research. Emphasizing increased funding, simplifying regulatory procedures, improving infrastructure, promoting collaboration, and providing incentives for commercialization can create a favourable environment for translational research to thrive in India.

7. Conclusion

In the conclusion the study suggests for the adoption of a "Mission-Oriented Responsible Innovation System" framework for addressing the grand healthcare challenges by providing a sustainable ecosystem for the successful translation of technologies into India's healthcare system. By adopting this framework, India can overcome the hurdles in the biomedical translational research ecosystem and successfully translate MoDs technologies into the healthcare system. The framework can effectively deal with the existing grand healthcare challenges, providing potential solutions that are context-specific and sustainable. It can create a supportive ecosystem for the successful translation of MoDs technologies into India's healthcare system while ensuring responsible innovation practices are followed. The mission oriented responsible innovation system framework will help in priority setting and providing potential solutions in integrated and holistic manner through various steps:

Firstly, this framework is mission-driven, which means that it is designed to achieve specific goals and deliver tangible results. By setting clear objectives and outcomes, the framework can help prioritize the allocation of resources towards research and development of MoDs technologies that are most relevant to addressing India's healthcare challenges. This will help in overcoming the challenge of fragmented research and lack of focus on the most pressing healthcare problems.

Secondly, the framework is based on responsible innovation principles, which ensure that the development and implementation of MoDs technologies are done in a way that is socially and ethically responsible. This means that the framework will take into account the concerns of stakeholders, including patients, healthcare providers, and the wider society, in the development and

implementation of new technologies. It will also ensure that the research is conducted in a transparent and accountable manner.

Thirdly, the framework can help in addressing the challenge of lack of funding by prioritizing the allocation of resources towards the most promising research projects that align with the mission-oriented goals. This can also help in incentivizing private sector investment in translational research by providing a clear framework and roadmap for the development and commercialization of MoDs technologies.

Fourthly, the framework can help in improving the regulatory process by promoting collaboration between different stakeholders, including the government, industry, and academia. This will help in streamlining the regulatory process and ensuring that the development and implementation of new technologies are done in a way that meets the regulatory requirements.

In summary, the adoption of a "Mission-Oriented Responsible Innovation System" framework can provide a sustainable ecosystem for the successful translation of MoDs technologies in India's healthcare system. By prioritizing research towards addressing the most pressing healthcare challenges, promoting responsible innovation principles, and improving collaboration and funding, the framework can help in overcoming the challenges of the biomedical translational research ecosystem and successfully translate MoDs technologies into the healthcare system.

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Notes

[1] Translation process involves translating the findings of basic research into new medications and approaches for disease prevention, diagnosis, and treatment.

[2] DBT adopted this approach inspired by the Grand Challenges for Global Health initiative to solve key health problems in the developing world announced by Bill Gates in 2003, and supported by the Bill and Melinda Gates Foundation, the US National Institutes of Health, the UK Welcome Trust and the Canadian Institutes of Health Research.

[3] BIRAC is established in 2012 therefore here the data has been analysed from 2012

5

Exploring the role of responsibility for the deployment of civilian unmanned aerial vehicles (UAVS) in Indian agriculture: A responsible innovation perspective

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Abstract

Responsibility has always been a central theme in the ethics of technology. It is always challenging to hold anyone responsible for the adverse effects of the technology. The whole process of taking responsibility is quite difficult as it consists of a long chain starting from the R&D of a technology to its final use; also, the involvement of many people in the process makes it complex. In India, the deployment of civil UAVs in agriculture is in its initial stage. It is hard to pinpoint on an individual or a group of people for taking responsibility for deploying civil UAVs in Indian agriculture. Advanced technology, like UAVs, is quite onerous for humans also. Hence, knowledge and control are essential for taking responsibility for precondition-level technology. This study is set out to explore the role of responsibility for the deployment of civil UAVs in Indian Agriculture with the help of a responsible innovation perspective. Two research questions follow this objective, *how does the responsible innovation (RI) framework helps identify the definition of responsibility in the context of civilian UAVs in Indian Agriculture?* And what kind of responsibility is created for deploying civilian UAVs in Indian Agriculture? To accomplish this, an extensive literature survey was conducted with the help of literature survey questionnaires, and in-depth interviews were conducted in person or by Zoom. The findings indicated that various departments handle the deployment

of civil UAVs in a participative manner. The collaboration between actors and stakeholders promotes different conceptions of responsibility, such as accountability, virtue, role, capacity, obligation, liability, care, and blameworthiness. The study implies that it is vital for stakeholders to work together to develop a set of guidelines and best practices that would mitigate any potential negative impacts.

Keywords: *Responsibility, Civil UAVs, Indian Agriculture, Technology, Responsible Innovation*

1. Introduction

Civil UAV technology can be a real game-changer considering the issues with the agriculture sector and how it is introduced. Once the technology enters the market, it develops and becomes part of the co-evolution of technology and society (Rip & Kemp, 1998). Technology brings novelty, but over time, it brings challenges and causes unforeseen and unintended (social) consequences. Because of that, technological development is often hard to govern(Poel, 2020). There are various factors because technology is not purely technical or partly social such as technological complexity and scale(Collingridge,1992), technological momentum(Hughes, 1994), and in terms of path-dependence and lock-in(Arthur, 1989). Also, if the technology brings novelty, it is an opportunity to lead to new options. On the other hand, it creates potential threats that lead to unintended and undesirable risks or side effects(Poel, 2020). So, it is important that someone take responsibility for handling these potential threats and understand the opportunities that can lead to new options.

In the early phases of new technology, there is the possibility of technology being malleable, but because of a lack of knowledge about its social impact, it is impossible to take it in the right direction, and when the knowledge is available, society adopts the technology, and it is difficult to change it. Through anticipation and deliberation (through stakeholder involvement), it is possible to address the forward and backward-looking responsibilities. Many popular articles and books about Artificial intelligence (AI) and machine learning exist. Also, the recent work published by Nick Bostrom on *Superintelligence* (Bostrom, 2016) argues that the machine brain surpasses the human brain in general, and it could replace the human as the dominant life form on earth. Interestingly, civil UAVs cast a good economic impact. Still, it also creates conflict at some level and might be hard to control because governments lack focus on deploying UAVs responsibly.

There have been several national and international incidents in the past, like the Bhopal tragedy (1984), the Chernobyl disaster (1986), the space shutter Challenger disaster (1986), the Endosulfan tragedy of Kerala (2001), etc., which shows accidents are unpredictable and unavoidable. These types of disastrous incidents raise severe questions about the responsibility aspect of technology.

Similarly, there are concerns related to the usability, application, and risks associated with civil UAVs; for instance, the inappropriate application of pesticides can affect the whole ecosystem by coming into human contact (direct or indirect) and hence entering the food chain. Also, chemical spray can pollute the soil, air, ground, and surface water directly or indirectly (Agnihotri, 1999). Additionally, the lack of training or technical knowledge about civil UAVs can lead to mismanagement or malfunctioning of drones resulting in an accident.

In such situations, the primary question is, "Who is responsible to whom?" The lack of clarity makes it difficult to trace the actors who could be held accountable/responsible. A large number of actors involved in the process (as a regulator, producers, and consumers) are reprising their respective roles at different stages where the success of one stage depends on the other. Hence the second question is "responsible for what," which is related to the actor's role, subject, and task of monitoring, regulating and maintaining, etc. The third question arises "What type of responsibility," i.e., Individual or collective responsibility, legal or moral responsibility (Grinbaum & Groves, 2013; Van de Poel & Nihlén Fahlquist, 2012; Van de Poel & Sand, 2021). Therefore, with the help of a responsible innovation framework, the study aims to elaborate on the importance of accountability and responsibility at every stage of the innovation process in responsibly deploying civil UAVs in Indian Agriculture.

This study is set out to explore the role of responsibility for the deployment of civilian UAVs in Indian Agriculture with the help of a responsible innovation perspective. Two research questions follow this objective, *how does the responsible innovation (RI) framework helps identify the definition of responsibility in the context of civilian UAVs in Indian Agriculture? And what kind of responsibility is created for deploying civilian UAVs in Indian Agriculture?*

To examine the research questions, this paper will proceed as follows: The paper describes the theoretical framework used for the study in section 2. Section 3 explains the methodology, representing the data to be collected and methods to be used. Section 4 illustrates the paper's results and discussion, comprising the analysis part of the paper with various information. The further section on the conclusion will briefly summarize the paper.

2. Theoretical framework

The selected framework can be justified after extensively reviewing the literature on a system of innovation and several system approaches. For a

framework to be adopted, the selected one must be able to fulfill the research objectives and answer the framed research questions. All the tested system approaches, such as NIS, RIS, SIS, RI, etc., do not cover the responsibility aspect of the specific technology because of their operational limitation. Various innovation processes have flourished and gained popularity, but the concept of RI (Owen et al., 2013; Singh & Kroesen, 2012; Von Schomberg, 2011) is different from others in its truest sense as it provides innovators with a systematic and logical framework to generate innovations that are not only socially desirable and ethically acceptable but are environmentally friendly too. Hence, Responsible innovation (RI) was selected as a theoretical framework. RI is relatively new and still evolving in different directions; it considers collective responsibility while focusing mainly on the innovation's social, economic, and environmental sustainability. The other approaches to innovation ignore the accountability and responsibility factors and fail to explain how accountability and responsibility will be assigned and distributed among the actors involved, thereby giving less importance to social-environmental values. Responsible innovation is the only incremental approach in the whole innovation system that can prevent and discard innovation's negative and failing aspects by simply including co-responsibility and societal acceptance of innovation. A Responsible innovation framework is to be adopted for this study, and it will be able to fulfill the research objectives and answer the framed research questions. In the next section, 2.1, this study will explore the RI definition given by various scholars.

2.1 Responsible innovation

There are various definitions of RI that can be found in the literature review. According to von Schomberg, *Responsible Research and Innovation is a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the (ethical) acceptability, sustainability, and societal desirability of the innovation process and its marketable products (to allow a proper embedding of scientific and technological advances in our society)* (Von Schomberg, 2011).

Schomberg's definition is widely used in the revised literature review of RI. According to Stilgoe (2013), a part of Schomberg's definition is connected to the European Union's policy processes and values. Though this definition by von Schomberg is accepted in most RI papers, it has also been criticized by Davis and Laas (2014). For Davis and Laas, the definition is marred by five problems, namely- the absence of "knowledge", concentrating only on "mere technical inventions", claiming that an "innovative process" should end in "marketable products", making societal desirability an independent category, and vagueness of the final phrase "in our society". After some time, Schomberg defines RI as "*a design strategy which drives innovation and gives some "steer" towards achieving desirable societal goals*" (Von Schomberg, 2013).

Then came different definitions, which gave further insights into the RI framework and highlighted various aspects of it. Singh and Kroesen explained RI as "*…being caring or ensuring care for certain values for social, economic, and environmental sustainability by engaging in anticipation, reflexivity, deliberation, responsiveness, and participation for bringing up any change in any idea, product, process, method, way of doing business, technology, etc., in order to bring them into a specific market or use them in a society*" (Singh & Kroesen, 2012). Singh and Kroesen advocated for being careful towards certain social, economic, and environmental values by including increased participation as an important dimension where more and more stakeholders give their opinions and participate in the societal acceptance of an innovation. Another definition found in most of the reviewed literature is Stilgoe's definition which provided a broader interpretation: '*…taking care of the future through collective stewardship of science and innovation in the present*' (Stilgoe et al., 2013). He focused on collective responsibility and care for the present as well as for the future. Stilgoe et al. (2013) also discussed two other dimensions, "reflexivity and responsiveness." He also explains that RI views responsibility as the central theme of science and innovation practice (Stilgoe et al., 2013).

Different reasons explained the emergence of responsible innovation. For example, there are a few examples of developed countries like the USA; RI came from a discussion about the impacts of nanotechnology development. In Europe, RI emerged in response to strong public rejection of controversial biotechnologies such as genetically modified organisms (Vasen, F.,2015). In developing countries like India, RI was introduced by Singh and Kroesen(2012) in the case study of renewable energy adoption in India.

After going through the various definitions and work done by scholars, this paper attempts to conclude the definition of RI that fulfills this study's objectives and research questions. Next, section 2.2 elaborates on the adopted definition for this study.

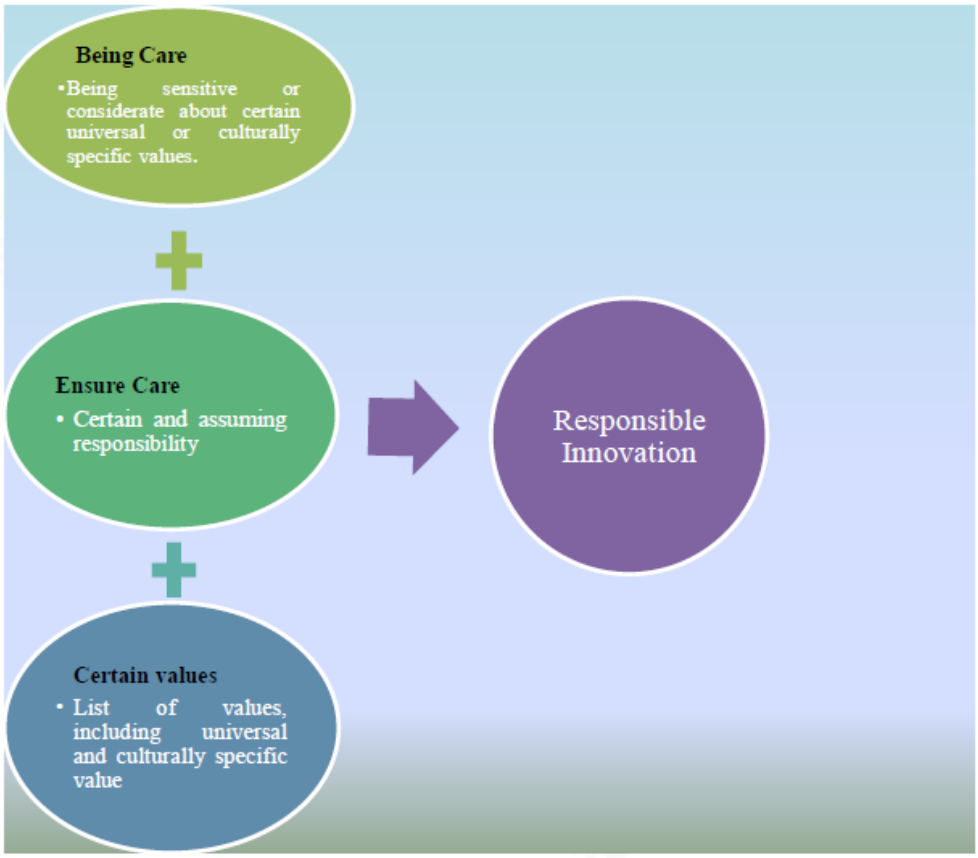
2.2 The working definition of RI adopted for this study

Extensive literature is available on responsible innovation, but according to the research objectives and questions of the study, the definition proposed by Singh and Kroesen(2012) (already explained in section 2.1) can be used as the working definition for analyzing our case study in this paper. This study will explain the conceptual components mentioned in the definition in the upcoming paragraphs.

There are several studies on RI, but only a few covers the parameters of responsibility, and the definition given by Singh and Kroesen is one of them. He focused on three conceptual components of responsible innovation, which

provides more understanding of the concept of responsibility. Those three conceptual components of RI are explained in Figure 2.1.

Figure 2.1: Conceptual components of RI by (Singh & Kroesen, 2012)



Also, Singh and Kroesen (2012) define five dimensions of responsible innovation as- anticipation, reflexivity, deliberation, responsiveness, and participation. These will be elaborated on in the coming sections.

The definition by Singh and Kroesen (2012) is thus adopted as a theoretical framework for the study. Singh and Kroesen (2012) define "being careful towards certain social, economic, and environmental values by including participation as an important dimension where more and more stakeholders give their opinions and participate in the societal acceptance of an innovation. They also explain different dimensions from the perspective of developing countries like India.

After selecting the working definition for this study, section 2.3 explores the concept of responsibility.

2.3 A review of the concept of responsibility

It was in the eighteenth century when the term "responsibility" surfaced and gained much attention. Responsibility in its "political sense" refers to the relationship between the rulers and their constituencies. In contrast, "judicial sense" refers to the obligation to repair damaged or suffering punishment (McKeon, 1957). It originated from the Latin phrase *re-spondere*, meaning "to respond or *to promise a thing in return for something* else, *to offer or present in return* (Cicero, MT, 1942); it means to answer, reply, or respond (Patrão Neves, 2015).

During the nineteenth century and most of the twentieth century, responsibility was defined in different literature. Strydom identified responsibility in sociology literature and described it as a "new cultural frame which occupies the central place vacated by rights and justice." The reason behind such prominence is the increasing social saliency of issues like safety, security, risk, and danger (Strydom, 1999). The notion of responsibility is relevant to the rise of free, rational, autonomous individuals (Gil, 1980). The individual referred to here is the one who makes decisions and takes associated risks. The responsibility, therefore, has always had a strong linkage to risks, and its growing importance seems linked to the increasing saliency of uncertainty (Pellizzoni, 2004). In simple terms, the duty performed by an individual and their obligation towards some work is called Responsibility (Ubois, 2010).

Although Van de Poel has emphasized responsibility in his work, most research carried out by Poel is focused on moral responsibility. He described the different conceptions of responsibility, such as cause, role, authority, capacity, virtue, obligation, accountability, blameworthiness, and liability(Van de Poel & Nihlén Fahlquist, 2012). According to Van de Poel and Sand, two ways to explain responsibility are descriptively and normatively. In descriptive meaning, responsibility is identified as cause, role, authority, or capacity(Van de Poel & Nihlén Fahlquist, 2012; Van de Poel & Sand, 2021). While in its normative meaning, responsibility identifies with virtue, obligation, accountability, blameworthiness, and liability (Van de Poel & Nihlén Fahlquist, 2012). Further responsibility is classified into two classes- a) the evaluation of an act or character trait in terms of praiseworthiness or blameworthiness; b) the prescription in terms of an obligation to do something or to see to something or to take care of something(Van de Poel & Sand, 2021). The literature on Responsibility by Poel also acknowledges the backward and forwarding looking Responsibility, individual and collective responsibility, and discusses the problem of many hands (PMH), which according to him, seems a possible obstacle to taking responsibility for the risks in our modern society(Van de Poel & Nihlén Fahlquist, 2012).

In literature, the idea of responsibility can be conceptualized in different ways. Hart was the first author to distinguish different Responsibility conceptions (Hart, 1968). He mentions four main conceptions of responsibility: *role* responsibility, *cause* responsibility, *liability* responsibility, and *capacity* responsibility (Hart, 1968; Van de Poel & Nihlén Fahlquist, 2012). Hamilton also defines three versions of responsibility: blame (liability) for rule-breaking, reliable performance in the role, and diffuse obligation (Hamilton, 1978). Maria Patrão Neves describes the philosophy of responsibility, which is focused on the issue of liberty, while law focuses on the "conscience," "liberty," and "responsibility." (Patrão Neves, 2015).

In legal terms, "responsibility" is defined as an obligation, established by law, to answer for a "done act" caused by the person in question (who is to blame) and to repair any injury it may have caused (imposing penalty measures or sanctions)(Patrão Neves, 2015) or as an approach, it can be defined as moral problems into legal one(Ladd, 1991). These features are well translated by the word "accountability" (Patrão Neves, 2015). Similarly, accountability and liability for the consequences of their action are also known as Responsibility (Pennock, 1952). McKeon also describes three related dimensions of responsibility. First, the "external dimension in legal and political analysis," in which the state imposes penalties on individual actions and officials and governments are held accountable for policy and action. The second is the "internal dimension in moral and ethical analysis," in which the individual considers the consequences of his actions and the criteria which bear on his choices. The last is the "comprehensive or reciprocal dimension in social and cultural analysis," in which values are ordered in the autonomy of an individual character and the structure of civilization(McKeon, 1957). Responsibility in innovation processes has to move 'upstream,' many projects aim to develop tools that actors at the stream's source can use to consider ethical and social values (Koops, 2015). The study has covered the reviewed literature on the concepts of responsibility till now, and the next step is to understand the different facts of responsibility.

Two critical elements originated to understand the facts emerging from responsibility. First is "imputability," defined by Jonas and Weber as the possibility of tracing an action back to an agent as its causal factor. Bradly explain responsibility and accountability in terms of imputability (Bradley & Bradley, 1988). Levy-Bruhl substituted imputability for accountability (Lévy-Bruhl, 1884). Imputation has two aspects: one relative to the power and dominion of the agent, according to which a good act is laudable and a wrong action is blamable, by which a good act is rewardable, and a bad act is punishable (McKeon, 1957). The second one is "answerability or accountability" (Grinbaum & Groves, 2013), explain as a norm that imposes on the evaluation of the effects of an action, as in self-defense, and can make someone answerable

for someone else's action (Pellizzoni, 2004). Responsibility in the accountability sense relates to justifying one's conduct before a judge (Schwartlaender 1982), to the duty and capability to answer the question: 'Why did you do it?' (Lucas, 1993). Accountability ensures answerability for undesirable actions or duties (Mishra & Singh, 2018). Accountability derives from the respondere, "to respond" (Grinbaum& Groves, 2013). Van de Poel and Sand define accountability as an action for which an agent is held responsible, 'belongs to,' or is 'owned by' that agent. He considers an agent to be an 'instigator of an act.' The agent has to be free in a relevant sense, be able to form her intentions and be aware and responsive to the moral demands(Van de Poel & Sand, 2021).

In the philosophical literature, responsibility has focused on backward-looking responsibility and moral responsibility, particularly blameworthiness. They claim that several conditions should be met for someone to be adequately held or fairly responsible such as moral agency, causality, wrongdoing, freedom, and knowledge(Van de Poel et al., 2015; Van de Poel & Nihlén Fahlquist, 2012). In public administration literature, Max Weber explains "Ethics in responsibility" in his work The Profession and Vocation of Politics (Weber, 1919). He established the difference between an "ethics of conviction," meaning the agent chooses means and action of their actions independently, and "ethics of responsibility," meaning the agent recognizes themselves as responsible for the predictable consequences of their actions (Weber, 1919). Ethics of Responsibility helps attain the desired consequences of the empirical world (Patrão Neves, 2015). It is now well established from a variety of studies that responsibility has a vast literature, and different concepts of responsibility will help this study to understand the responsibility of actors better, but before that, it is also essential to cover the literature on responsibility in developing countries from the RI perspective. The following section, 2.4, elaborates on the study concerning developing countries.

2.4 Responsibility defined in developing countries through RI perspective

Responsible innovation is relatively new and still evolving in developing countries. To understand the concept of responsibility from a developing country's perspective (Singh & Kroesen, 2012), this study needs some special issues to understand responsibility better.

Responsibility is defined in RI literature through India, Indonesia, Kenya, etc., countries- based case studies. This section will cover all these studies and indicate the parameters of responsibility with the help of Table 2.1.

Table 2.1: List of studies from developing countries that define the parameters of Responsibility

Author	Case studies	Parameters of Responsibility
(Singh & Kroesen, 2012)	Case of renewable energy adoption in India, Kenya, and Surinam	Economic, Social, and Environmental Responsibility
(Zahinos et al., 2013)	Case of "Automotive Industry"	• Duty, liability, and obligation • To be responsible
(Setiawan & Singh,2015)	Case of "*Adoption of Solar PV in Telecom Towers in Indonesia*"	• Duty or and obligation liability
(Mishra & Singh,2018)	Case of *adoption of e-rickshaws in Delhi*	The capability of fulfillingthe obligation
(Chamuah & Singh, 2022)	Case of '*civilian unmanned aerial vehicle (UAV) innovations for Indian crop insurance applications*"	• Ensure accountability of actors, stakeholders, and outcome of the innovation • Accountability and liability
(Mishra, 2022)	Case of "*Smart Energy Network for Electric Vehiclesin Delhi*"	• Use responsibility as a value • Forward-looking Responsibility • Backward-looking Responsibility
(Prabha&Singh,2023)	Case of "*Sustainable Biofuelsin India*"	• Focus on the Forward- looking Responsibility of stakeholders.

(Source: The Author)

3 Methodology

This study aims to analyze the case use of the deployment of Civilian UAVs in Indian agriculture. The role of responsibility in the deployment of civilian UAVs analyses with the help of the RI approach and its different dimensions. This paper uses a qualitative and exploratory- based approach because civilian UAVs are nascent in India, and the governance structure is evolving. With the help of literature survey questionnaires (LSQ) (Chamuah & Singh, 2020), the gathered literature is systematically reviewed in formulating the research problem and questions of the study. The research objective was substantiated by conducting in-depth interviews with the stakeholders. Stakeholders were contacted through LinkedIn, and official emails and snowballing techniques were used. Interviews were conducted face-to-face using an alternative medium

like Zoom to collect qualitative data. The stakeholders were selected based on their active participation in deploying UAVs in Indian agriculture. Stakeholders included were MNCFC, DGCA, RARI, NECTAR, MoA&FW, Agriculture Universities, and certain UAV companies like Iotech, Drone destination, Aeronica, etc. Each stakeholder's role in the deployment process is elaborated in Table 3.1. Some data were gathered through secondary literature sources like newspapers, journals, FICCI reports, NITI Aayog reports, conferences, and talks organized by the government are covered with the help of YouTube videos, LinkedIn, etc. The interviews were conducted depending on the availability of the respondents. Due to Covid19, getting approval for interviews from government offices and stakeholders hardly responded to emails took a long time. The author also participated in Bharat Drone Mahotsav 2022. It was a great opportunity to meet all the stakeholders under one roof, attend various talk sessions and get valuable insights about UAVs in Indian agriculture.

Table 3.1: Stakeholders involved in the deployment of UAVs in Indian agriculture with their respective roles in the innovation process

Type of stakeholders	Participants name	Description	Role in deployment process
Policymakers	Ministry of civil aviation, MA&FW, FICCI	Actively involved in making rules and regulations for responsibly deploying UAVs in Indian agriculture	• Make policies and guidelines for the implementation of UAVs in Indian agriculture. • Organizing different workshops, fairs, and talks to spread awareness regarding deploying UAVs in agriculture.
Project scientists	Agriculture universities	Actively participating in the use of UAVs on the field	• Exploring the possibilities of using UAVs in the field with different agriculture applications
Private companies/ institutes	IoTechWorldAvigation Pvt Ltd, Hubblefly, Asteria, Omnipresent, skymet, etc.	Directly involved in selling and promoting the UAVs in the public	• Helping in selling the technology to the public • Collaboration with government
Farmer organisations	FPOs and customer hiring centers in different states	Directly involved with farmers to help them purchase or rent the technology on the ground.	• Supporting and helping farmers to adopt UAVs at affordable rates
Government institutes	MNCFC, RARI, NECTER, Krishi Pant Bhawan (Raj),	Directly or indirectly working with the government in the	• Working with the government in data collection and data analysis

(Source: Author's compilation)

4 Result and discussion

The deployment of civilian UAVs in Indian agriculture can bring numerous benefits, such as crop imaging, spraying of seeds, fertilizers, and pesticides, monitoring crop cutting experiments (CCEs) and crop damage, crop yield estimation, and soil assessment. However, it is essential to identify and address the various responsibilities of deploying these technologies to ensure their safe and responsible use. Here in this paper, we identify the parameters of responsibility with the help of literature on Responsible innovation framework by developing countries. There are five dimensions of RI as the guiding mechanism to achieving the goal and ensuring certain values can be embedded (Setiawan, 2018). Each innovation has to pass through these dimensions to become responsible innovation (Singh & Kroesen, 2012). This study will use these dimensions of RI and identify the concept of responsibility.

4.1 Parameters of responsibility in the context of civilian UAVs in Indian agriculture

This section will explore the first research question on *how does the responsible innovation (RI) framework helps identify the definition of responsibility in the context of civilian UAVs in Indian Agriculture?*

Table 4.1: Summary of how the dimensions were followed through the responsibility

Dimensions	Methods used	Type of Responsibility	Parameters of Responsibility
Anticipation	Applies foresight or future studies methods such as futures workshops, scenarios, cross-impact/structural analysis, Delphi, key technologies, multi- criteria analysis, stakeholder mapping, and road mapping. (Zahinos et al., 2013)	Focuses onForward-looking Responsibility	Responsibility as Virtue ObligationDuty
Reflexivity, Deliberation, Responsiveness, and Participation	Methods used for technology assessment such as workshops, consensus conferences, impact assessment, forecasting, scenario development and analysis, multi- stakeholder workshops, impact analysis, Delphi, decision analysis, risk assessment, road mapping, discussions, peer review, simultaneous engineering, analogies, content and discourse analysis (Zahinos et al., 2013).	Forward-looking Responsibility and Backward-	Responsibility as Duty Virtue Obligation Responsibility as Accountability Blameworthiness Liability

	Participation define as involvement of different stakeholders (Singh & Kroesen, 2012). Methods used as group discussions, interviews and workshops, webinars, web-based workshops, and real-time collaboration platforms (Zahinoset al., 2013)	looking responsibility	

(Source: Author elaboration from secondary literature)

Table 4.1 shows the five dimensions, and the method required to pass through these dimensions is explained in the table. A method helps identify the type of responsibility; on that basis, this study identified the parameters of responsibility.

These parameters of responsibility are considered indicators to identify the definition of responsibility in deploying civilian UAVs in Indian agriculture.

***Please note that this paper is currently in a progressive stage, as we are still awaiting responses from several stakeholders before we can present a complete analysis. The data presented in this paper is partial and subject to change as additional information becomes available. This paper will be fully updated and finalized before the final paper submission date.*

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6

Transformative innovation capabilities in practice: Insights from case studies of innovative social and solidary economy, small scale rural agro industries in El Salvador

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Abstract

I focus my critical reflections on the emergence of innovation capabilities, processes, and systems in relation to development outcomes and transformative challenges in El Salvador, Central America. I will ask the critical question: to what extent can the capabilities of the coalitions of actors involved in the emblematic cases studied be characterized as "transformative innovation capabilities" why or why not? I develop a novel theoretical framework to address the existing gap in understanding the nature of transformative innovation capabilities. This framework is applied to an exploratory analysis of two emblematic case studies of actor coalitions involved in creating innovative social enterprises, small scale rural agro industries, striving to be genuinely economically competitive and contribute to social inclusion and ecosystem regeneration. I focus on the emergence and dynamic evolution innovation capabilities of coalitions of different types of economic, state, and civil society actors to promote the innovative social enterprises in two cases of small scale rural agro industries, growing, processing and comercializaing organic cashew (APRAINORES) and raw non – centrifuged sugar (ACOPANELA).

1. Introduction

The emergence of the transformative innovation policy (TIP) approach is disrupting the systems of innovation for development landscape of academic discourse and engagement with policy practice. It draws on multi-level systems theory to advance a theoretical and methodological framework, a 'transformative' theory of change (TToC) that hinges on the achievement of 'transformative outcomes'. It is designed to guide innovation policy, facilitating multi stakeholder experimental policy engagements, underpinned by co-creational processes at the programme/project level, to give directionality to longer term efforts to achieve aspirational transformative change (Ghosh et al, 2021; Schot et al, 2018).

Key learnings from the previous five years of work by the Transformative Innovation Policy Consortium (TIPC) articulate the need to better understand the essential nature and the full range of what can be understood as transformative innovation capabilities. The insights reveal that researchers and policymakers working on TIP need certain sets of capabilities. Although some capabilities may be shared, others may be specific to researchers (who are active facilitators of TIP policy experiments), or to policymakers or funders (who connect experiments to other political initiatives).

Although, there is no clear conceptualization of "transformative innovation capabilities" as such, in the TIP related literature (personal communication with Johan Schot, 2022, Carolina et al, 2022), we build off the work of Penna, Schot, Velasco and Molas-Gallart (2022) on institutional capacities and capabilities for 'transformative mission-oriented' policies. Important insights are taken from discussion of "transformative innovation" at an organizational level (Farrington, 2018; McGrath, 2013 cited in Price, 2016) and the governance of transformative innovation processes (Borras and Edler, 2014).

I address this gap in understanding through an exploratory analysis of the emergence and evolution of the "transformative innovation capabilities" of coalitions of actors in El Salvador, involved in innovative territorial development alternatives in post Peace Accord El Salvador

The Peace Accords represent a transition from the violence of civil war to the generation of conditions of greater hope and opportunities for socio-economic structural transformations in the democratic space that these negotiations created. Diverse types of coalitions of territorial actors emerged from these conditions, accumulating capabilities for collective action, to create a diversity of territorial development initiatives, frequently with support from different types of national and international "development support organizations" (Van der Borgh, 2009).

Among these initiatives, a subset are local economic development initiatives. Some of these initiatives have evolved over time, strengthening their territorial embeddedness in the territorial systems of actors and their capabilities for autonomous governance and self-sufficiency; as well as their capabilities to integrate their business activities into national and international value chains, horizontal networks with other similar initiatives and different types of supporting organizations. These types of local economic development initiatives are diverse, exhibiting significant heterogeneity in their processes of historical emergence, the configuration of the coalitions of actors involved, the scope and nature of their business operations, as well as their localization in rural, peri-urban and urban contexts. However, these initiatives have managed to innovate, introducing novelty of significant importance in their technological, productive, organizational, business management and governance processes, to produce goods and services, as well as their commercialization in dynamic new national, and sometimes, international markets, working in conjunction with networks of supporting actors for their business development.

Social economy enterprises, with associative governance and a logic that emphasizes the wellbeing of labor over capital accumulation (Castillo Romero, 2018), have emerged from an important number of these processes. Frequently these social economy initiatives, also emphasize innovation for the inclusive development of women and youth, and environmental sustainability as defining characteristics of their actions.

The social enterprises are related to different types of economic activities, including the production, processing and commercialization of coffee, cashews, honey, panela (raw sugar) and cacao, shrimp and fish cultivation, artisanal manufacturing of a diversity of products, as well as savings and loan cooperatives, housing cooperatives, etc. There are also agricultural cooperatives created through the Land Reform and others, that managed to survive the civil war to re-emerge in the post Peace Accords period. Their diversity offers and significant potential for interactive learning and collaboration to generate synergies based on complementarities, in a process to strengthen their contributions to positive territorial transformations.

The organizational practices of the economic initiatives, but also the other types of organizations that form part of the task network coalitions of actors, reveal innovation capabilities to coordinate and synergistically integrate what I argue are their essential functional competencies for: i) reflexive and interactive learning, making synergistic connections between people with a diversity of endogenously generated and exogenously mobilized and assimilated innovation relevant knowledge, ii) making connections and team working in external networks of diverse types of actors to mobilize specialized knowledge, technologies, financing and other innovation relevant recources, and iii) conforming and managing an internal organizational and institutional

configuration that facilitates the coordination of diverse actors and processes in innovative initiatives (2007, 2009 y 2019, and Cogo 2012).

The two case studies presented are emblematic of this specific group of social enterprises, located within wider local economic development dynamics in two rural territories located in proximity to intermediate level cities.

One is ACOPANELA de R.L., the Cooperative Association for the Agro-industrial Production, Procurement, Marketing, and Financing of Panela Producers from the Jiboa Valley began its operation in 2004 with 17 producer members. The Cooperative's initial purpose was to commercialize the panela product at a fair price to guarantee a better quality of life for the producers and consequently avoid the disappearance of panela as a traditional local product (interview, ACOPANELA's ex-president, 2011). This included developing a product with 'ethnic' Salvadoran characteristics that could meet export quality standards. While motivated to innovate they had only limited knowledge of the market and technological opportunities that were emerging in parallel (Cummings and Cogo 2012, citing RIMISP 2008).

The second initiative is the APRAINORES association of small-scale organic cashew producers that own and manage an industrial processing plant, exporting cashew nuts to the organic and fair-trade niche markets in Europe and the United States. The cashew trees are integrated into diversified agroforestry systems that provide organic fruits to be dried by women's entrepreneurial venture and exported to Austria (2001, 2007, 2009, and Marroquin-Garcia 2020).

My conceptualization of transformative innovation capabilities, at the micro (organizational) and meso (network coalition) levels builds on ´ anthropological actor centered approach for to understanding the structure – agency dynamics that explain the emergence and evolution of innovation capabilities in coalitions of actors promoting these and other innovative local economic development initiatives in Central America.

I situate my theoretical and empirical contributions at the nexus of the emergent critical knowledge dialogue between key authors from the GLOBELICS systems of innovation and the Transformative Innovation Policy Consortium; relating innovation capabilities to the achievement of sustainable, regenerative, and inclusive "development", as a transformative process change in El Salvador on the periphery of the periphery of the Global South.

2. Analytical framework

2.1 Key elements of the transformative innovation policy approach

The development of our conceptual framework for transformative innovation capabilities takes as starting point that the object of transformative action within the TIP approach is generally broader in scope than the systems of innovation approach as it has been developed by GLOBELICS and others. The TIP approach broadens the underlying rationale or innovation policy logic, "moving from market and innovation system failures to more comprehensive frameworks that better reflect the characteristics of transformative innovation". These can be understood as "transformative failures" (citing Woolthuis et al., 2005) and include "directionality, demand articulation, policy coordination, and reflexivity failures (Weber and Rohracher, 2012); and demand-side, supply-side, and user-supplier interactions failures (Chicot and Matt, 2018)" (Haddad et al 2022: 21).

'Directionality' failure, in particular, relates to the lack of direction and priorities of the innovation process towards transformative change and calls for new agenda-setting routines (Kuhlmann and Rip, 2018; Weber and Rohracher, 2012). According to Robinson and Mazzucato (2019, p. 938), "fixing directional failures require articulation of broad societal and socio-economic challenges for which concrete actions can be supported to contribute towards desired transformative change". As such, one of the main challenges related to directionality remains in translating grand challenges into concrete problems (Robinson and Mazzucato, 2019 cited by Haddad et al 2022: 21).

Giving directionality to a portfolio of innovation policy mix and developing concrete program and project initiatives like the emblematic social economy initiatives I analyze aimed at systemic transformations, is a challenge that involves a much wider "constellations of actors", and demands greater attention be given to asymmetric power relations between actors in society, especially between those that have vested interests in the maintenance of current unstainable socio – technological regimes and those coalitions of actors that are advocating for more sustainable alternatives; "directionality implies building shared visions and for that, power and agency play an important role. […]" (Haddad et al 2022: 21).

This highlights the need to put the transformation of currently unsustainable socio-technical regimes through the design and implementation of an innovation policy mix for sustainable human development that also creates the necessary mechanisms for a just transition, addressing the need for "transformative equity". There is a clear need to "shift focus from economic growth to phasing out unsustainable regimes (Alkemade et al., 2011)", emphasizing that "a broader societal policy agenda encompasses several policy

domains apart from economic and industrial policies, such as energy, health, labour, agricultural, food security, environmental and climate change policy (Cagnin et al., 2012; Coenen et al., 2015a; Crespi, 2016; Diercks et al., 2019; Scordato et al., 2018)". The TIP approach argues for embedding transformative policies "in other social domains", such as those involved in sustainable and socially inclusive watershed management included in the scope of the Living Catchments project, which involves different technologies, multiple actors, and several social and behavioral innovations. One main challenge related to this broadening of policy domains is the greater need for both vertical and horizontal coordination between different policy areas and levels of government (Haddad et al 2022: 22).

In order to address the challenges posted by widening the scope of innovative practice to more explicitly focus on the transformation of systemic elements of unsustainable socio – technological regimes, the TIP approach advocates for the creation of Transformative Innovation Policy Communities of Practice of state, business, and civil society actors, as a key mechanism to give directionality to transformative change.

The configuration and dynamic functioning of a TIP Community of Practice requires significant capabilities on behalf of the coalitions of actors that are actively involved in this activity of building, widening, and deepening interactive learning and collaboration with the CoP with the general aim of giving transformative directionality to innovation policy for sustainable development over time.

Within the context of a co – constructed understanding of the complex problems, causes and effects of the unsustainability of existing socio – technical systems within key actors of a TIP CoP, a crucial step towards generating transformative innovation experimental practice is developing a context-dependent Theory of Change that sets out as aspirational goal for achieving transformative change and how the project or policy experiment will achieve the desired change, and under what conditions.

The TIP approach to developing transformative theories of change addresses a generalized dissatisfaction with the status quo of planning public sector innovation for development policies, programmes, and projects. This is especially challenging in the context of weak and fragmented systems of innovation and state capabilities in general to promote more sustainable development. It implies identifying addressable social/economic/environmental problems and developing a course of action in response to the perceived problem. It is motived by a desire to achieve a positive transformation of this problematic situation through a change process entailing various interventions.

From a formative evaluation perspective applied to the design and implementation of a TIP experimental initiative, a Theory of Change (ToC) provides an explanation of how and why it is believed that the activities related to a given policy tool or project intervention with achieve its expected results and aspirational goals. "It defines the expected relations between the resources invested in an intervention and their effects, and the assumptions under which we expect such effects" (Molas- Gallart, et al. 2021: 434). The transformative theory of change is specific to each TIP experimental initiative, framed within the general theory of change articulated in the multi-level perspective" and the more specific formulation of the expected transformative outcomes explained below.

There are three crucial steps to develop a specific ToC which require specific functional elements of transformative innovation capabilities:

- "Identify the level of the transformative innovation policy experiment to be planned and conducted, and the main actors involved (Project, programme or policy mix level)
- Determine the key evaluative dimensions to be assessed (inputs/resources, activities, outcomes and outputs)
- Define a context-specific ToC: Codify the paths and linkages between the elements developed above, specify how the identified inputs and activities would bring about the desired transformative outcomes, and link these outcomes to the ideal impacts" (Williams: 2021: xx).

A key element of a transformative theory of change are "transformative outcomes". Based on a review of the sustainability transitions literature and interactions with policymakers within the TIPC project implementation process, Ghosh et al (21: 741) propose twelve Transformative Outcomes "across three macro-processes that underpin socio-technical change through multi-level interaction: (1) building and nurturing niches; (2) expanding and mainstreaming niches; and (3) unlocking and opening up of regimes".

In developing our conceptualization of transformative innovation capabilities, we focus on the four TOs associated with the building and nurturing of niches, in our case the Living Catchments project understood as an emblematic case of an emergent niche of experimental practice to implement the South African transformative innovation policy mix (Ghosh et al, 2021: 742):

- ❖ Shielding: Offering protection for niche experiments and normalising these protection measures. Broadening: identifying, testing, and developing strategies to protect niches covering multiple system dimensions, encompassing a wide range of experiments and more diverse alternatives. Deepening: align various shielding measures, across system dimensions and across geographies.

- Learning: Induce first- and second-order learning in niche experiments. First-order learning focuses on improving what actors are doing while second-order learning questions frames and assumptions of structures and activities. Broadening: including more dimensions of the system in first- and second-order learning processes and incorporating different forms of knowledge (e.g. beyond technical knowledge from a single discipline), involving multiple actors (diversity and trust) and aspects of sustainability. Deepening: creating opportunities for challenging assumptions (about preferred solutions, problem definitions, and whether and how they contribute to sustainability).
- Networking Create high-quality opportunities for collaboration between actors, strengthening their networks. Broadening: convening joint activities with enough flexibility around which multiple actors can congregate and mobilise, and acknowledging diverse beliefs, values, and concerns. […] Deepening: enhancing the mobilising power, mutual trust, and coordination among the actors involved in niches ensuring the stability of actors–networks over a longer period. […]
- Navigating expectations: Create spaces for articulating expectations around societal challenges and appraising these expectations to enhance their credibility (among niche actors), quality (providing more evidence), and stability (expectations are not questioned anymore). Broadening: allowing a diversity of actors to voice their expectations around landscape challenges, regime ability to respond, and promise of niches to provide solutions. Requires accepting and making explicit tensions and conflicts of interest among expectations. […] Deepening: developing credible expectations by aligning landscape, regime, and niche expectations of niche and regime actors and supporting this alignment with concrete evidence.

While Ghosh et al (2021) recognized importance of strengthening the capabilities of the actors involved in the complex experimental TIP processes to achieve these transformative outcomes, they do not discuss their nature or conceptualization more specifically.

2.2 Innovation capabilities

As a point of departure for our conceptualization of transformative innovation capabilities, innovation capabilities as such, are synergistic combination of its learning, external networking, and internal coordination capabilities to dynamically assimilate exogenous technologies and other innovative resources into their innovative efforts to transform their production, marketing and business management systems (s, 2007). This argumentation is reflected in the approach proposed by Robert et al (2010) and Erbes et al. (2010) to understanding the innovative performance, strategies and capabilities of firms in a Latin American context are directly related to a contextually specific

combination of absorptive capacity[1] and also the connectivity capacity of firms as "mutually reinforcing".

> Organisations with high absorptive capacity tend to be more open and sustain a higher density in their relations. At the same time, the density of relationships (the connectivity capacity), helps develop a greater capacity for absorption and therefore the organisation is exposed to significant flows of knowledge of learning and develop new skills. (Robert et al. 2010, p.6–7)

Further clarification of what innovation capabilities are is provided by Lawson and Samson (2001, 383– 384, 389). They define innovation capabilities as special kind of higher order capability that enables the firm to 'integrate', 'mold and manage' multiple strategic capabilities of the firm 'to continuously transform knowledge and ideas into new products, processes, and systems for the benefit of the firm and its stakeholders'. In a complementary sense, Koivisto (2005: xx) argues that the innovation capabilities of a firm emerge from creating a synergistic relationship between the firm and its environmental context, especially related firms and markets. In this sense, he argues that the "innovative capability of the firm is functionally definable in two ways: as an integrative capability or function of the firm and as a communicative function of the firm. Integrative function refers to the production of innovation and communicative function to the diffusion of innovation".

In synthesis, innovative capabilities of coalitions of organizational actors are the dynamic abilities they possess to mobilize and creatively apply a diversity of endogenous and exogenous resources to innovative practice, generating different kinds of innovations to achieve their aspirational goals, while embedded within enabling and constraining power relations. As such, innovation capabilities are dynamic capabilities of the highest level, integrating a set of synergistically related strategic capabilities in firms (Atoche-Kong and Dutrenit, 2010; Kiovisto, 2005; Lawson & Samson, 2002; Teece & Pisano, 1994) and other types of organizational entities.

Innovative practice for achieving these goals is emergent from a context-specific combination of knowledge based absorptive capabilities and organizational networking capabilities to mobilize innovation relevant resources from exogenous agents (Robert et al, 2010, citing Erbes, Robert and Yoguel, 2010); and dynamically assimilate them into the organization´s endogenous knowledge bases, organizational configurations and routines, technological production processes, etc. Innovative practices emerge from a synergistic combination of endogenous generation of novelty within the organization´s systemic dynamics, and the dynamic assimilation of exogenous elements, (2007, 2009, 2015, 2019).

The organizational practices of the economic initiatives, but also the other types of organizations that form part of the task network actor coalitions, reveal innovation capabilities to coordinate and synergistically integrate their essential functional competencies for: i) reflexive and interactive learning, making synergistic connections between people with a diversity of endogenously generated and exogenously mobilized and assimilated innovation relevant knowledge, ii) making connections and team working in external networks of diverse types of actors to mobilize specialized knowledge, technologies, financing and other innovation relevant resources, and iii) conforming and managing an internal organizational and institutional configuration that facilitates the coordination of diverse actors and processes in innovative initiatives (2007, 2009 y 2019, and Cogo 2012).

In relation to the task of expanding this conceptualization the extent to which transformative innovation practice is emerging in El Salvador, in the types of emblematic cases studies, it is relevant to note that the innovation capabilities of firms and task network actor coalitions are generally applied to specific innovative processes in economic initiatives as these evolve over time in specific enabling or constraining socio institutional, territorial contexts. A key question is thus to what extent the coalitions of actors involved in these emblematic case study initiatives are making a tangible contribution to wider more systemic processes of change in the territories where they are located, and if so, how to characterized their emerging transformative innovation capabilities.

In the following sections I further elaborate on key elements related to interactive learning and the dynamics assimilation of exogenous innovative knowledge, into existing socio – technological systems of production and commercialization, from a systems of innovation perspective, as the basis for discussing these dynamics in relation to the emergence of transformative innovation capabilities and practices in the South African context.

2.3 Interactive learning spaces, networking and dynamic assimilation

Coalitions of actors embedded in territorial and sectoral innovation systems, especially in marginalized territories of countries in the GLOBAL South, like South Africa, where the distances from the center of innovative knowledge increase, both in geographical, but also cognitive terms (Loasby 2001, 2002, 2003), face a significant challenge to explicitly deal with the identifying, contacting, negotiating or leveraging this knowledge, and then dynamically assimilating it (Bell 2007, Muller 2005), into their endogenous, territorially embedded networks of knowledge diffusion and application, as a complement to their own in depth more tacit knowledge bases (2007, 2012). In this process the role of intermediate organizations is important, as Cassiolato and Lastres (2002), emphasize in some Local Production and Innovation Systems[2] studied in the MERCOSUR countries. The complexity of the associational

governance of these knowledge assimilation processes must be explicitly addressed, especially the relative power of those intermediate institutions bridging or even gate – keeping actors that facilitate (or could limit) them (Szogs, Chaminade and 2010; see also Guiliani xxxx in relation to actors playing this role in geographically delimited economic clusters).

The concept of interactive learning spaces or places developed by Sutz and Arrocena focuses our attention on the collective learning process involved in creating innovative practice (2000, 2002, 2004). They argue that "The combination of knowledgeable people and the opportunities to solve problems making use of knowledge is a form of collective action. The places where these actions take place can be named 'interactive learning places', for what occurs in them is the gathering of different people, knowing different things, that interact in the search for solutions to problems and, in so doing, learn, that is, acquire new knowledge" (2004b: 9). The creation of diverse mechanisms which serve as "interactive learning spaces", facilitating innovative knowledge flows, as well as establishing informal social relations, has proved to be an important vehicle of confidence and spontaneous cooperation. This is important for the strengthening of the networks and the creation of further closeness (organisational, cognitive, and cultural) amongst enterprises and the other innovation system actors (Sutz and Arocena 2002)

Loasby's (2001, 2002) emphasis on the interaction between actors with a diverse knowledge bases, reflected in divergent conceptions of problems and solutions for innovative practice, further highlights the importance of constructing synergistic learning connections between local producers and NGDO technical staff, also between industrial workers, plant management and business support personnel. The formation of interactive learning spaces (Sutz and Arrocena 2000, 2002) and making innovative connections between their dissimilar knowledge bases built up through experience and different types of informal and formal education, has the potential to overcome the limited frameworks of thought that each possess as to the problems and challenges faced by the initiatives and the development of alternatives to meet these challenges. The inability to do so represents a "waste" of potential resources and is generally problematic, as reflected in several conflictive situations already discussed (cited in 2007: 184-5)

The interactive nature of innovation processes reveals the importance of networks and networking capabilities for innovative practice. Networks may be conceptualized as any repeated and reasonably stable pattern of interactions between a particular set of actors. Two important characteristics of networks are their stability in time and efficiency in satisfying the objectives defined for their creation and maintenance. A well-functioning network generates synergy or self-catalyzation dynamics based on compatibility between products and

services (knowledge and so on) which the different actors have to offer to the collective effort (Saviotti, 1997).

The capabilities of key people and units within firms to develop networks with similar people and units embedded within other firms and other types of non-firm actors, is a source of access to superior complementary innovation relevant resources. These networking connections can increase the effectiveness of innovative efforts by effectively reducing costs that would be involved in developing knowledge internally, reducing risks due to greater understanding of the external environment through discussion with partners, achieve economies of scale joining with other producers to solve similar innovation problems or enter the market together, obtaining the financial resources and technologies embodied in machinery and so on to apply in innovative efforts and so on. The question of the nature of the resources that network partners possess and the capabilities needed to leverage them for use in innovative efforts are thus fundamental for the analysis of innovative practice (Lawson and Samson, 2001; Smart et al,, 2007). The information flow and the construction of shared knowledge in networks can result in a shared view of the future that reduces the risk perceived in investments to innovate, orienting the organization and collective effort toward this future state (Carlsson and Jacobsson, 1997).

Local, context-specific, traditional and largely tacit knowledge must be recognized as a basis for innovation in many 'traditional' economic activities such as panela production and marketing. As Lundvallet al (2002) and Johnson and Lopez (2010), argue, it is important to understand the capabilities needed to effectively mobilize such knowledge in innovative initiatives – not devaluing, un-learning or creatively destroying it. An equally important realization, however, is that this knowledge is frequently insufficient to innovate. Thus, networking capabilities and the construction of mechanisms to facilitate knowledge/technology transfer, reception, adaptation, and improvements are very crucial.

Following Bell (1997, p.65, p.69), we focus our case study analysis on the dynamic assimilation of imported or transferred exogenous technology, understanding technology in a broad sense to include the constitutive elements of the TIP approach and methodology.[3] Of specific relevance to our work is Bell's recognition that achieving dynamic technological assimilation is generally not the work of an individual firm but requires 'the development of change-generating interactions between enterprises that are linked in "supply chains", "networks" and "systems" as well as with various intermediary organizations and specialized technological institutions' (1997, pp.76–77).

Technological innovation, especially in marginalized territories or by marginalized populations in countries of the Global South, frequently

dependent on exogenous transfer processes and can be understood as part of a larger process of evolutionary diffusion and localized adaptation of externally technologies developed. From the global perspective these adaptations can be considered incremental innovations or even digressions compared to use of designs under more "optimal" conditions; however, from a local perspective the technological transformations introduced in localized systems can be considered radical, involving high degrees of uncertainty and significant capabilities for the dynamic assimilation of exogenous components (Bell 1997; Muller 2003).37

This emphasis on knowledge acquisition through interactive learning, furthermore, maintains implicit the importance of networking capabilities necessary to establish, exploit and maintain linkages with external resource providers and learning partners. Also implicit is the importance of internal coordination capabilities necessary for the dynamic assimilation of external knowledge and other resources into the technological system. External networking and internal coordination practices related to innovative endeavors certainly require a diversity of general and specific more tacit and contingent knowledge. However, there is a definite relational and organizational component to innovative practice that cannot be reduced to the knowledge of how to carry it out (2007:46).

Bell defines *dynamic assimilation* of imported or transferred exogenous technology as its integration into a process of technical change and innovation within the importing firms and economies. A general classification of the types or degrees of technological assimilation includes operational, replicative, adaptive and innovative, i.e. the capability for endogenous technological development (1997: 65, 69; see also Muller 2003, cited in 2007: 61).

In characterizing the advances towards dynamics assimilation in a given firm or group of firms, Bell also suggests that it is important to "move beyond a concentration on such things as improving process efficiency or the development of local (re) production of production equipment" but also the "production related dimension of increasingly creative technological assimilation" beyond the boundaries of the original product or product category. In addition, he stresses two additional dimensions. "The first relates to building up the capabilities needed to capture a greater share of the overall value added—for example, undertaking a greater proportion of design and marketing activities." The second, is the development of technological competencies in the area of the initially acquired technology, which permit diversification out of that area—both diversification upwards to more complex types of similar products, and diversification 'sideways' to different, but related, categories of product. In the longer run, this assimilation or learning process may create the basis for the capability to diversify over greater 'distances'—perhaps 'backwards' into the production of machinery and

instrumentation, 'forwards' into downstream products, or further 'sideways' into more distinctively new products and markets" (1997: 70).

In applying these concepts, Bell argues that it has become increasingly evident that "dynamic technological capabilities are cumulatively built 'upwards' from simpler to more complex design, engineering, and managerial competences, not 'downwards' from R & D." This process of building the capabilities necessary for the dynamic assimilation of exogenous technology, "is not just a matter of mastering the use and development of product and process 'hardware.' The organizational dimensions of industrial technology are also critically important." Especially important is establishing a continuous process of organizational adaptation and development that then can play "a significant role in stimulating the search for, and facilitating the implementation of, continuing adaptations and improvements in product and process 'hardware'" (1997: 74-76).

Achieving this process of dynamic technological assimilation is also generally not the work of an individual firm but requires "the development of change-generating interactions between enterprises that are linked in 'supply chains', 'networks' and 'systems' as well as with various intermediary organizations and specialized technological institutions" (Bell 1997: 76-77). This requires the development of specific "associational capacities" by the firms in order to actively take advantage of the multiple exogenous resources available to them through networking (Helmsing 2001, citing Cooke and Morgan 1998).

Transformative innovation capabilities

Transformative innovative practice is similar in many ways, but also significantly different from the innovative practices referenced by the authors of the systems of innovation for development approaches, and thus we must adapt this innovation capability framework to fully account for these differences.

A first major difference is that the object of transformative innovative practice is the development of transformative initiatives by determined coalitions of actors in niches, and that in relation and coordination with other similar coalitions working in networked niches, eventually are able to scale up their practices and gain the power to generate transformative change at the scale of determined socio – technological regimes. The mechanisms for generating this process of transformative change are integrated into the formulation of transformative theories of change that are experimentally implemented as TIP initiatives in niches and then as coordinated networked practices between coalitions of niche actors. Key elements of the theory of change are articulated as the 12 transformative outcomes of the TIP approach.

Therefore, we propose a conceptualization of transformative innovation capabilities as collective capabilities of coalitions of actors: the dynamic abilities they possess to mobilize and creatively apply a diversity of endogenous and exogenous resources to generate and experimentally implement a transformative theory of change, generating transformative innovation practices necessary to achieve their proposed transformative outcomes and thus their aspirational goals for transformative change. The emergence and evolution of these dynamic collective capabilities at the highest level of the closely coordinated and networked practices in the TIP initiative coalitions, integrate a set of synergistically related strategic capabilities in the different actor, while embedded within enabling and constraining power relations of their social context.

With reference to Cumming´s conceptualization of innovation capabilities we re-frame the ideas of functional innovation capabilities as the specific combination of interactive learning, networking and the specific organizational configurations and powers of the coalition actors needed to achieve their proposed transformative outcomes. These capabilities are expressed in the specific practices associated with achieving each of these transformative outcomes in determined socio – institutional contexts that both enable and constrain the expression of these capabilities. The specific capabilities of the coalitions of actors that enable the achievement of the transformative outcomes are understood as functional transformative innovation capabilities.

As a key component of a transformative theory of change, the process of formulating and working together to achieve Transformative Outcomes, should serve as "a compass" to reflexively guide the collective actions of the TIP coalitions towards the achievement of their aspirational impact goals. These transformative outcomes and the process to co – create them within the coalitions of key actors participating in each TIP initiative, requires skilful facilitation and orchestration of group dynamics. Special competencies are required to ensure the quality of the facilitated knowledge dialogues between actors with heterogeneous knowledge bases and unequal power relations to make sure that the co – created transformative outcomes "provide articulation of key ideas and give a shared language" to their collaborative work, in a way that recognized and deconstructs the basis for unequal power relations within the coalition.

The facilitated process of articulating the transformative outcomes frequently implies functional capabilities to mix different activity streams at the micro local - community, meso-regional territorial and macro national / international levels of networked actions, and thus must face the challenge or generating effective democratic multilevel governance mechanisms to enable greater synergy, as well as capabilities to positively transform potentially conflictive tensions that might arise in this process.

The integrated practice of "formative evaluation" as key aspect of transformative innovation practice implies functional capabilities to design and implement a reflexive process for proactive monitoring and periodic evaluation of the degree to which the confluence of the collective TIP coalition activities are advancing (or not) in constructing their articulated transformative outcomes, to understand why or why not this is happening and how to better orient activities towards this end, or conversely find value in emergent trajectories that could lead to modifying these outcomes. The team facilitating and all active participants must create the "space and time for interactive reflection to engage in "deeper" learning on experimental practice". This implies influencing organizational decision makers to not only allow for but to actively promote the creation of these interactive learning spaces.

The collective process of designing the context specific transformative outcomes for TIP initiatives, must also include the strategic capability for prospective analysis to identify the "triggers that need to be unlocked or enabled to elicit a larger process that, in the long run" in order for niches to upscale and synergistically relate to other niche actor coalitions in order to have the potential to generate systemic transformational changes. More specifically, how to identify and transform the systemic, structural causing the intersectional social – economic – cultural – territorial social exclusions and environmentally unsustainable socio-technical regimes, into mechanisms that instead enable actor coalitions to strengthen their capabilities to positively create dynamics for social inclusion and "transformative equity" towards their own individual and shared visions of substantive wellbeing, as well as the regeneration of ecosystems in a variety of rural to urban landscapes.

In synthesis, the transformative capabilities of coalitions of actors involved in TIP initiatives require the skilled facilitation interactive learning spaces to transform what the heterogeneous multi layered coalitions of actors (organizations and people) know and are capably of implementing in practice, networking with other societal actors of relevance in order to achieve their aspirational goals. Also, to co – create the institutions, norms and social and political practices and real rules of thumb involved in doing this, as well as the shared vision, values and culture emerge and evolve around the initiative as it synergistically related to others, along the road to achieving their aspirational, mid to long term goals for transformative change.

The functional transformative capabilities necessary to achieve the 12 transformative outcomes articulated in TIP theory and practice are related to and characterize three macro processes in the proposed theory of transformative change (aspirational impact goals) and specify what happens in each of these three macro processes that enable this change to happen in the way that is collectively envisioned by the core coalition of actors involved.

This initial effort at conceptualization and experimental application in analyzing the extent to which the coalitions of actors promoting the emblematic innovative economic initiatives is limited to the first series of functional transformative innovation capabilities are necessary to generate outcomes directly related the transformative action of building and nurturing niches through the facilitation of knowledge dialogues and collective decision-making and experimental practice to achieve tangible results based on available resources, learn through reflexive praxis and move forward together.

The expected transformative outcome is the existence of a democratically self-governing coalition of actors who have learned to facilitate their own knowledge dialogues, in relation to other territorial communities, social and economic organizations and other "development" regime actors like the municipalities, as well as relevant exogenous actors. Through the facilitated knowledge dialogues new actors and ways of doing and organizing practice are introduced into territorially delimited and contextualized interactive learning spaces. Shared understandings of the complexities of the evolving local reality, drive collective decision-making and transformative action to achieve the transformative theory of change. The niches should demonstrate a trajectory towards institutionalization, and be characterized by determined, flexible but relatively stable actor configurations, reflective, democratic governance mechanisms, formal and informal institutions "rules of the game" that orient, incentivize expected behavior.

The functional capabilities include shielding of the emergent process of niche configuration and initial consolidation by contributing to the creation of a safe space for this novel knowledge dialogue, interactive learning and collective decision-making and action dynamics to take place, among the diversity of participating actors, taking advantage of their accumulated experiences identified to hve transformative potential.

Networking, between local actors to consolidate local actor coalitions, and then enroll the exogenous system of innovation actors, to novel create multi actor coalitions with the necessary knowledge and resources to generate substantive transformative actions to strengthen the aspirational impacts of the already and future prioritized actions. The functional networking capabilities relevant for transformative innovation are strengthened through learning by doing and reflecting on this practice. Networking capabilities are applied to identify and strategically enroll and work with relevant exogenous actors, as well as influence decision makers to invest complement resources to strengthen the transformative impact of the actions carried out by the niche multi – actor coalitions. The tangible outcomes of this process include the strengthening networking capabilities in local actor coalitions and sustained interaction through at least one cycle of experimental action during the life of the project, that demonstrates a sustainable future trajectory towards the aspirational goals

articulated for the project, with a high quality of interaction with synergistic results, and also demonstrated capabilities to proactively address tensions with conflictive potential to positively transform them in line with collective aspirations.

A central purpose of a transformative initiative is to enable the creation of the interactive learning spaces that need to exist in order to enable the deeper level of mutual understanding, the communicative exploration of the diversity of their knowledge bases and the creation of innovative options as alternatives for transformative action. This implies specific functional capabilities to facilitate dialogues for the interactive sharing knowledge and experiential wisdoms horizontally, to co – create the novel, shared understandings of the localized complexity of the structural problems being addressed, the obstacles and needs related to a new practice as well as challenging related values and assumptions that people might have in relation to the activites with greatest potential to be implemented. In this sense, the co-created knowledge should be actionable as the basis for collective decisions to prioritize investment of limited resources in activities that demonstrate the greatest transformative potential and thus the continuation of experimental reflexive implementation of the theory of transformative change. The TIP Formative Evaluation approach implies capabilities of the project team to facilitate an ongoing critically reflexive evaluative praxis to learn and introduce necessary adjustments to action towards the desired outcomes, or indeed to adjust these expected outcomes in relation to emergent niche dynamics.

Finally, the facilitated practice of knowledge dialogues is expected to generate the deeper level of shared understandings that allow for the emergence of shared narratives to describe what these novel coalitions of actors are going together, and their shared visions of their aspirational goals and how they expect to achieve them. This involves the co – creation of a theory of change among the people and organizations of the local actor coalition, and then be able to articulate this to motive other system of innovation actors to enroll themselves in this collective effort and actively engage in the knowledge dialogues, decision making and collective actions to transform the problematic territorial reality. This communicative capability is crucial to explain and justify their actions to other actors, especially decision makers who hold power over resources deemed relevant to strengthen the planned transformative innovation experimental initiatives. This activity of "navigating expectations" both defines and enables the niche's potential path towards transformative inclusive and sustainable territorial development. The tangible outcomes are the initial, intermediate, and final articulation of a transformative theory of change, the articulation of shared narratives, visions, and goals through the active involvement of a variety of stakeholders in this process.

4. Results and discussion: Critical analysis of the cases of cashews and granulated panela in El salvador[4]

4.1 ACOPANELA and granulated panela from the valle de Jiboa

Analytical description of innovation capabilities

The accumulation of networking capabilities in ACOPANELA to realize the potential synergies between the cooperative's members and their innovation network partners, explains to a large degree the effectiveness with which ACOPANELA has been able to innovate. The development of granulated panela as an innovative product was a cooperative effort that none of the individual trapiche owners could have achieved individually. Collectively they would also not have been capable of doing this without their external innovation networking connections.

ACOPANELA's networking capabilities could be seen as the most important resource, and network construction the most important process in the innovative upgrading of panela production. Capabilities to establish and manage connections with key members of their innovation network are integral aspects of what can be understood as the cooperative's innovative capabilities. In achieving innovative upgrading of the panela production and marketing systems, a synergistic relationship was formed between ACOPANELA's learning and networking capabilities to:i) develop and leverage the endogenous knowledge base to access innovative knowledge from exogenous knowledge providers, identify and capture innovative technological alternatives as solutions to performance problems, locate and harness resources to implement technological change, iv) initiate a process to dynamically assimilate these exogenous elements into innovative initiatives.

A significant innovation activity in ACOPANELA's productive operations was the selection, acquisition, and assimilation of an appropriate technology to produce granulated panela. This 'new facility' innovation was new to the Salvadoran and Central American market context. With this innovative leap ACOPANELA has caught up in terms of technology use with others in the global value chain, although in terms of realized production capability and commercialization the cooperative and El Salvador are still relatively insignificant players.

ACOPANELA's networking capabilities compensated for average or potentially below-average technological know-how of the panela producers integrated as cooperative members. The panela producers and the skilled workers they hired were experts in the production of traditional solid panela– with a highly developed largely tacit knowledge base. However, they had limited knowledge of what was involved in upgrading their production processes to meet international standards and they had not yet discovered granulated panela.

Overcoming these setbacks required heightened collaboration among them and with exogenous actors, the framework for which was provided by ACOPANELA.

Networking capabilities were also central to upgrading ACOPANELA's *marketing practice*. This upgrading process began with an initial exploration and learning-by-doing phases followed by a progressively more refined search for new and more dynamic markets, and direct negotiations with buyers. On the national market, potential buyers at supermarkets provided some hard lessons as to the requirements for product presentation in developing granulated panela as a marketable product. Interaction with buyers from bakeries stimulated learning as to how to differentiate potential customers regarding their product needs and thus willingness to pay for ACOPANELA's added value. Entrance into export markets provided some even harder lessons concerning product hygiene. ACOPANELA's entrance into more dynamic markets was facilitated by different external networking partners. The key to this facilitation was the commitment of the cooperative to following up on their initial contacts, developing new ones and finding the best buyers that are willing to pay their added value.

Finally, ACOPANELA has also demonstrated significant networking capabilities to mobilize knowledge and financial resources to invest in business upgrading and efforts to innovate in panela production and marketing. ACOPANELA's emerging capabilities in this area are reflected in the development of their strategic relationship with the IADB and in managing simultaneous negotiations with the multiple actors involved.

In analyzing networking capabilities in relation to innovative practice it is important to establish what types of relationships, with what types of network partners, were relevant for what aspects of the cooperative's innovative efforts? Also, what capabilities were required to develop and manage these relationships in favor of these innovative efforts?

ACOPANELA's networking capabilities can be classified into two general kinds: those applied to relationships between ACOPANELA and exogenous actors that possess complementary innovation resources and those applied to the consolidation of the cooperative's internal functioning. ACOPANELA's current and potential networking capabilities applied in relationships with external actors can be differentiated into four networking functions.

Identifying and leveraging the transfer of knowledge resources, in the form of technical assistance and training, but also interactive learning through interchange visits, participation in fairs and so on; identifying and leveraging of financial resources, and continued interaction with financiers (banks, cooperation agencies and so on); dentification of markets and potential buyers,

establishing relationships with these buyers to negotiate contracts and then managing the continued relationship with them as clients; political negotiations with power brokers to influence or participate in the construction of public policy on a local level (that is, development planning, municipal investment decisions and so on), national level (sectoral development policy and program development) or as applied to international commercial agreements (as was the case with ACOPANELA's ultimately unsuccessful negotiations to include panela as a 'nostalgic' artisanal product, not subject to sugar quotas).

ACOPANELA's networking capabilities applied to the creation and consolidation of the organization can be differentiated as follows:

- identification, motivation and integration of members into the organizational structure;
- improving the organizational functioning of the task network (developing and implementing regulations and other formal institutional set-ups, improving quality of relations and resolving conflicts between members);
- mobilizing members' resources to be applied to innovative practice, for example, solving production problems to take advantage of market opportunities.

Analysis of the quality of ACOPANELA's key networking relationships that have been directly relevant for innovative practice substantiate Blomqvist and Levy's (2006) focus on trust, commitment and communication as substantive components of collaboration or networking capabilities.

Trust – 'based on beliefs about what an actor can do and how he or she will behave in future-oriented relationships containing risk' (Blomqvist and Levy, 2006, p.39) – can be seen as the foundation for the organizational consolidation of ACOPANELA as an associative agro-industrial business venture. Compared to the more disperse group of panela producers organized in the ACOPADES[5] cooperative that did not survive its initial project-supported phase, ACOPANELA's members were concentrated in a few municipalities in the Jiboa Valley and knew each other previously. The key to organizational success – which is still limited – has been to demonstrate the capability to produce positive results for its members and be consistent in its search for resources to develop market-oriented innovations. Thus, certain members – but not all – have come to trust ACOPANELA as a solid 'business partner' and are thus motivated to make the investments needed to sell through ACOPANELA.

Trust can also be considered the basis for ACOPANELA's progressive development of an innovation network, off of which it has managed to leverage the specialized knowledge and significant financing needed to fuel their innovative efforts. Equally important as the specific skill with which they were

able to negotiate agreements, has been the ability to fulfill their commitments and produce tangible results as agreed upon with the external agents that committed resources to ACOPANELA's development. In this sense, ACOPANELA has proven to be a competent implementing organization for complex development projects financed by the Inter-American Development Bank (IADB) and agencies of the Salvadoran Government, as well as a good credit risk paying off a significant volume of loans from commercial banks. This achievement positions them well as a partner for 'future- oriented relationships containing risk' related to financing.

Commitment is the second component of collaborative relationships as related to networking capabilities. On the one hand, it is possible to see how 'evaluations and expectations about the future economic potential led to rationally based instrumental [or calculative] commitment' by those cooperative members that are active in investments for upgrading production and willing to sell through ACOPANELA to obtain higher, more stable prices, along with delayed payment. Similarly, ACOPANELA's behavior has stimulated calculated trust and thus commitment is demonstrated by its innovation financers (IDB, public export promotion fund FOEX and commercial bank). 'The emotional dimension in a close collaborative relationship' for example between members of ACOPANELA's leadership and their project representative in the IADB, can be argued to provide 'status and meaning, and enhances the actors' willingness to nurture and care for it' (Blomqvist and Levy, 2006, pp.39–40).

Communication is a final component of relationships fundamental for innovation as it 'signals partners' collaborative intentions towards each other, promotes collaborative processes, smoothes relationship building, and facilitates the creation of a supportive and respectful atmosphere between the collaborating parties' (Blomqvist and Levy, 2006, p.40, citing Morgan and Hunt, 1994). Being effective communicators in this sense would be essential to building trust and thus commitment from key actors in ACOPANELA's innovation network. For example, ACOPANELA has learned to communicate project results through reports and during field visits providing the positive surprises that motivated the IADB's representative. Also, how ACOPANELA's leadership presented their emerging experience in their first trip to Colombia, inspired collaborative trust and commitments first from the associated panela producers and then CIMPA that helped them develop their innovative projects.

What are ACOPANELA's networking capabilities?

Based on the ACOPANELA case study analysis we argue that ACOPANELA's networking capabilities represent a specific combination of i) the knowledge applied to making and managing networking relationships, ii) the organic personal and organizational relationships in and of themselves that emerge between actors and develop over time, iii) the quality of these relations based

the ability to establish trust, commitment and communication; and iv) the resource base necessary to support what could be understood as the transaction costs of networking practice.

The knowledge component is a complex combination of at least three distinct kinds of knowledge bases: i) *knowledge of the field*, in this case, panela production and marketing in order to talk intelligently about *what* is needed to innovate and *why*, and also judge the relevant knowledge that external actors have to offer, ii) *know who* the relevant actors are with whom to connect for different reasons (technical knowledge, financial resources from actors like the IADB, territorial development programs, non-government organizations (NGOs) and banks, commercial intermediaries and final consumers of panela products and so on) and where to locate them, and iii) *know how* to establish and negotiate relationships in order to motivate the different actors to make a contribution to the innovative effort, leveraging resources off of external actors, or motivating actors to join and contribute as task network members.

The *organic organizational component* of the networking capabilities applied to innovative efforts in the ACOPANELA case can be understood as including the personal relationships built up over time and all that they imply in terms of mutual understanding and trust. For example, the specific characteristics of the relationships that directly influence the results of specific interactions, such as that established between the person in charge of marketing and the person in charge of purchasing in a bakery or export/import firm, or between ACOPANELA's president and the specialist from the IADB who negotiated the cooperative's inclusion in the second call for mini-FOMINs that eventually financed technical assistance component for plant implementation.

However, it is also clear that these relationships frequently have an institutionalized organizational framework in which they occur, which both enables and constrains the outcomes of specific interactions; for example, the institutional contexts of ACOPANELA and FOEX, both enable and constrain, what the president of the cooperative and the director of FOEX are able to agree upon and take forward into practice at any given time.

The *resource base* includes such costs as for travel to Colombia to make contacts with panela producers, negotiate technical support from CIMPA to develop and provide technical support for ACOPANELA's innovative efforts, and then the complicated negotiations to get the innovative caldera for the new plant built and shipped on time to El Salvador.[6]

How and why innovation capabilities are emerging

Analysis of the emergence and development of ACOPANELA's networking capabilities suggests that the personal and organizational learning processes necessary to network skillfully; building the organic linkages of personal and

organizational network relationships; and building the trust, commitment and effective communication that define the quality of interaction that occurs within these relationships, as well as mobilizing the resources necessary for networking practice takes significant time, effort and skillful coordination of these different elements.

Networking capabilities emerge and are developed in their full cognitive and organic dimensions through an incremental process that is fundamentally linked to networking practice. Networking capabilities are thus emergent properties of networking practice between actors with complementary capabilities. ACOPANELA's networking capabilities have emerged and developed through participation in interactions sustained in relationships based on progressively greater levels of mutual trust, commitment, and effective communication. ACOPANELA learnt how and why to establish new linkages and strengthen existing ones in different types of relationships, each of which has its specific relevance for innovative efforts in determined contexts.[7]

However, available evidence suggests that there does not seem to be a conscious process of building networking capabilities as such, as part of ACOPANELA's business development strategy. Their actions were focused on searching for innovative alternatives to solve business performance problems, locate and leverage the relevant knowledge for better manufacturing or product development, for example, and/or embodied technologies such as the special boiler for the granulated panela plant. There was then a process to coordinate organizational actions to assimilate these exogenous elements into their localized technological systems. Finally, they also explored, negotiated entrance, and positioned their innovative products in new dynamic markets and themselves as a reliable supplier.

This suggests that there is a high degree of firm- or network-specific tacit knowledge involved in networking practice especially within fragmented and local IS. In addition to being tacit some of this knowledge will also be collective, as it will be highly embedded in the organic relationships existing between the actors who are interacting. These features highlight the special value of this capability for ACOPANELA's innovative practice, making it hard to replicate and thus, a potential source of competitive advantage.

Networking capabilities thus deserve special attention in the analysis of innovation in traditional agro- industries such as panela. There are special networking challenges posed by linking the strong tacit knowledge base of producers developed over centuries of productive practice, with external innovative knowledge of alternatives. Also, the identification, capture and dynamic assimilation of exogenous technologies into the localized technological systems poses a measure of challenge. The fundamental importance of networking as part of market exploration and commercialization of innovative

products, as well as the mobilization of financing to make technological innovations viable, also deserves some attention.

4.2 Innovative capabilities of APRAINORES task network actors

The emergence of the deeper innovative capabilities of interactive learning and networking in the APRAINORES initiative, has depended on the realization of synergies between the potentially complementary actions of a triangle of key actors: the leading NGDO CORDES, the progressively autonomous business leadership (board of directors) and management team, and the producers and workers who are the cooperative owners of this social enterprise. The role of CORDES was initially crucial as the promoter of its creation, through various development projects with external funding and intermediation with external network knowledge providers. However, over time the APRAINORES elected leadership and their management team have assumed decision-making autonomy.

The emergence of the innovation capabilities of the APRAINORES task-network has depended on the development of learning mechanisms to accumulate different types of knowledge from experience and reflection on productive and commercial practice, as well as searching for exogenous knowledge from sources including actors involved in scientific exploration. Especially important has been the ability to recognize and make connection between the different knowledge bases being accumulated through these mechanisms, thus generating new options and developing them in innovative practice.

In essence, the task-networks' innovative capabilities are emerging through an incremental process of learning through participating in and reflecting on innovative practice. Innovative capabilities can thus be considered as emergent properties of social interaction in the concrete processes by which discrete technological systems are transformed, as well as interaction between APRAINORES and other territorial and extra territorial exogenous actors.

Networking capabilities are learned or acquired through repeated practice. Diverse types of networking relationships are key to obtaining different types of external knowledge and other resource inputs, each demanding somewhat different networking capabilities for establishing and maintaining. Networking practice thus implies the development of specialized, mainly context specific, tacit knowledge concerning how and why to engage in diverse types of longer term and more complex network relationships or more contingent and temporal linkages.

Innovative capabilities frequently have important dynamic collective aspects. Interaction between the actors involved is a necessary characteristic of innovative practice, which in turn is embedded in specific organizational

structures or network contexts. The individual capabilities of the APRAINORES task-network actors, as this coalition has evolved over time can be seen as opportunities that may or may not be taken advantage of in innovative processes. The overall innovative performance of these initiatives depends on the quality of interaction between the knowledgeable actors involved, and the particular nature of the interconnections between them, within and across organizational boundaries in each task-network and with key exogenous actors. Thus, innovative practice depends on their collective vision of the outcome and the coordination of their individual capabilities to achieve the expected results. In this case, the construction of a shared vision and coordinated action has required proactive facilitation.

The dynamic assimilation of exogenous technological alternatives has required skillful coordination of capabilities at the nexus between the external inflows of diverse kinds of knowledge, frequently embodied in cooperating actors and also technologies (for example a succession of specialized machinery imported from Brazil for cashew nut processing), and the internal learning dynamics of the people involved in implementing the proposed innovative alternatives.

Different actors have become enrolled in different ways at different times within the evolving APRAINORES task network and external network relationships. The evolving web of internal and exogenous, inter-personal and interorganizational network connections provide the organizational conduits through which the diverse resources for implementing technological innovations flow and are thus key aspects of the task-networks' collective innovative capabilities.

The emergence of the capabilities involved in APRAINORES dynamically integrating the diverse endogenous and exogenous resources necessary for innovative practice cannot be understood adequately only as an interactive learning process. The emergence of these complementary capabilities in practice also requires the creation of specialized organizational and institutional configurations. The importance of establishing external networking connections, generating motivation and the enrollment of key actors, the articulation of expectations and the coordination of complementary actor capabilities, the construction of internal organizational configurations, etc., reveal the complexity of the actions involved in dynamic assimilation of exogenous technological alternatives. The deeper innovative capabilities of APRAINORES´s task-networks have emerged from and are expressed through this interactive social practice, and thus, depend on the specific nature of the organic linkages and the more intangible qualities of the relationships between the actors engaged in these social interface situations.

The most important intangible, cognitive aspects of the key relationships between actors within the APRAINORES initiatives, and between them and

exogenous actors, identified through multiple observations over time, are: i) mutual understanding and shared language codes necessary for effective communication; ii) complementary motivations to engage in joint practice over time; iii) conventions of social inclusion and reciprocity, building from non-exploitation to synergy; iv) reliability concerning the fulfillment of agreements and trust in the expected application of capabilities to resolve problems in agreed-upon ways, and v) agreed-upon co-responsibility in terms of assuming the risks involved in innovative activities (see Cooke 2002).

These aspects can be understood as the specific *institutional basis for the relationships* from which deeper innovation capabilities have emerged in APRAINORES. The institutional basis for these relationships is socially constructed over time and is reflected in tacit understandings of what constitutes appropriate behavior as well as more explicit formalized agreements that orient interaction. The *organizational basis for the relationships* from which APRAINORES´ innovative capabilities of GBL's actors have emerged, is reflected in the particular configuration of linkages between the actors involved, and the way these are structured in relation to networking and learning. In the case of individuals, their engagement in collaborative innovative practice is mediated by the organizational configurations in which they are embedded, and the relationships established between their respective organizations —if their relationship crosses organizational boundaries.

The energy required for this complex process has been provided by catalytic agents enrolling and facilitating the coordinated expression of the complementary capabilities of diverse endogenous and exogenous actors, however, its sustainability depends on the strengthening of the connections and synergies emerging between them in the development of GBL's innovative economic initiatives.

4.3 Transformative innovation capabilities

The innovative practices in the two cases are primarily focused on the dynamic assimilation of exogenous innovative knowledge and other innovation relevant resources to drive endogenous technological product and process innovation as well as strengthen their democratic governance and generation of quality work for people associated that characterize them as social and solidary economy initiatives.

However, in both cases there is a progressively more explicit aspirational goal to eventually be able to scale up their practices and gain the power to generate transformative change in relation to the dominant unsustainable extractive agricultural practices of sugar cane for industrial sugar production, extensive cattle production, etc. The strategies for generating this process of transformative change are not explicit or yet integrated into the formulation of

transformative theories of change, but rather emergent from their current practices to maintain, remain resilient in the face of multiple challenges like the multi-dimensional COVID-19 crisis and climate change, but also look to strengthen their positioning as a viable alternative to these competing economic activities.

In both cases, the economic initiatives created by the coalitions of actors demonstrating, to a greater or lesser extent, innovation capabilities, represent examples of "transformative social innovation" as defined by Haxeltine et. al. (2016) as "processes in which changes in social relations between the diverse endogenous and exogenous actors involved, implying new forms of doing, organizing, positioning and / or knowing, that challenge, alter or replace institutions and established (and/or dominant) institutional arrangements, in determined specific contexts"; Salvadoran territories in this case. Their innovative performance is not exclusively, nor in some cases, principally technological, productive, or commercial, but organizational and relational in national and international networks for interactive learning and cooperation. They challenge and look to transformer the institutional rules of the game of spurious competition based on labor exploitation, to be competitive based on cooperation, complementarity, and synergy in their task network coalitions, with support from their external network partners. They tend to prioritize the quality of work, especially those characterized as social and / or solidarity enterprises, as well as gender and age equality, and environmental sustainability. I characterize these initiatives in this way, at the same time recognizing and important heterogeneity in capabilities and the scope of their activities.

I consider these initiatives to be innovative "niches" with a potential to contribute, in a modest way from the micro – localized territorial origins, to processes of socio-economic and technological change that Schot and Kanger (2018) conceptualize as transitions in techno-economic paradigms. These initiatives have emerged from the kind of window of opportunity for these types of changes to occur created in the Salvadoran context by the Peace Accords and the subsequent inflow of international development cooperation, complemented in some cases by public policy funding. See in in a wholistic way, some have passed form an initial phase that the authors call *"start-up"*, to an "acceleration" phase, involving more families, deepening their embedding in territorial systems of actors, demonstrating their capabilities of resilience and proactive response to previous crisis situations, managing to survive and continue to grow through multiple crisis related to initial impacts of climate change such as floods and droughts, as well as earthquakes and extreme insecurity. Thus far, those I have knowledge of, are also demonstrating resilience and proactive response to the COVID-19 crisis.

The emergent transformative innovation capabilities of the respective actor coalitions promting these two emblematic initiatives have enabled **the building and nurturing what can be understood as niches** with further transformative potential through interactive learning to dynamically assimilate exogenous innovative knowledge and other innovation relevant resources, and collective decision- making and experimental practice to achieve tangible results based on available resources, learn through reflexive praxis and move forward together, generating resilience and a proactive response to multiple crisis.

The transformative outcome is the existence, in each case of a democratically self-governing coalition of actors who have learned to facilitate their own development processes, in relation to other relevant system of innovation and other "development" regime actors like the municipalities actors, on a regional sub-national, national and international level. Their networking connections to international centers for excellence in the development and diffusion of innovative knowledge in their respective global value chains, are especially revealing of their capabilities.

Although there is evidence of territorially delimited and contextualized interactive learning spaces, to generate shared understandings of the complexities of the evolving territorial (subnational), national and international realities, that enable to constrain their innovative efforts, strengthening reflexivity in their practices and the articulation of a more explicit theory of change to upscale and contribute to more systemic transformative change, are challenges yet to be overcome.

The niches have demonstrated a trajectory towards institutionalization, positioning their economic activities positively in international regimes of organic, fair trade and export quality certifications, gaining local, national and international recognition. They are also both characterized by determined, flexible but relatively stable actor configurations, reflective, democratic governance mechanisms, formal and informal institutions "rules of the game" that orient, incentivize expected behavior.

The proven resilience and emergent institutionalization of these two niches of social and solidary economy initiatives of small-scale rural agroindustry, have become emblematic examples of alternatives to the prevalent bad development regimes, through activities that could be understood as **shielding** of the initial process of niche configuration and consolidation. The conformation of solid networking relations with local state, municipal authorities, with international financial and "development" cooperation organizations, as well as national and international market actors, has represented a key contribution to the creation of a safe space for these novel and potentially transformative niches to continue to exist when many other similar initiatives do not, and continue to gradually diversify and upscale their operations,

Over time they have strengthened their **networking** capabilities, as a key component of their overall dynamic innovative capabilities, building flexible but ever consolidating coalitions with endogenous and exogenous actors, to leverage necessary knowledge and other resources relevant to generate substantive transformative actions to strengthen the aspirational impacts of the already and future prioritized actions.

These functional **networking** capabilities relevant for their emergent transformative innovation practices are being strengthened through learning by doing and a basic level of critical reflecting on this practice. In both cases, they have revealed networking capabilities to influence decision makers to invest complement resources to strengthen the transformative impact of their actions.

The central actor coalitions driving the collective actions in each case, have demonstrated significant capabilities to identify and engage in **interactive learning spaces** with actors from regional, Latin American, centers of excellence in Colombia and Brazil their respective global value chains for panela and cashews. These interactions have not however been sustained and dynamic over time but are rather currently latent in the face of the significant challenges each initiative faces for the strengthening of their transformative innovation potentials. These coalitions have demonstrated, at crucial stage of their development, the necessary specific functional capabilities to facilitate dialogues for the interactive sharing knowledge with key national and international actors to co – create the novel, shared understandings of the localized complexity of their needs for enhanced innovative practices.

This co-created knowledge has been dynamically assimilated and applied as the basis for collective decisions in the actor coalition to prioritize investment of limited resources in activities that demonstrates the greatest innovation potential at the time. As previously stated in both cases there is a lack of systematic critically reflexive evaluative praxis to learn and introduce necessary adjustments to action towards the desired outcomes. Their relationships with intermediary actors with complementary capabilities to facilitate these types of interactive learning spaces, for example for universities, have been significant at times, but sporadic and currently lacking.

Over time, the different types of knowledge dialogues have generated a deeper level of shared understandings as to the alternative nature of their initiatives, as contrasting with those of the dominant territorial socio – technical productive regimes (industrialized sugar, extensive cattle production and maquila type export zones). People from APRAINORES´ membership and leadership demonstrate an especially important identity related to the organic production of their cashews, for example. This reflexive practice has not however evolved into the the co – creation of a theory of change among the people and organizations of these local actor coalitions, and then be able to articulate this to

motive other territorial, development regime and system of innovation actors to enroll themselves in a collective effort to challenge the power of actors more explicitly from the dominant bad development regimes. The functional transformative innovation capabilities for This **"navigating expectations"** are limited in generating more tangible results along an expanding pathway towards transformative inclusive and sustainable territorial development.

In synthesis, the transformative capabilities of coalitions of the coalitions of actors involved in these two emblematic social and solidary economy initiatives is limited and could be characterized as initially emergent in relation to the development of a transformative theory of change, the shared vision, and concrete strategies to continue to consolidate the transformative potential of these two initiatives.

5. Conclusions

In light of the complexity of the process of emergence and dynamic evolution of innovation capabilities over time, I argue that in order to take on the enormous challenges posed by the need to transform the current bad development regime in El Salvador, it is essential to recognize the value and strengthen the capabilities of the coalitions of actors promoting innovative local economic development initiatives that generate livelihood trajectories with decent dignifying work for their human talent, participatory democratic governance dynamics and associational property of the means of production, and also environmental sustainability regenerating territorial ecosystems. This challenge includes those coalitions of actors promoting innovative initiatives that have not yet managed to overcome the significant adverse structural forces limiting their agency to achieve sustainability over time in their initial entrepreneurial attempts but are demonstrating their alternative development potential through resilience and proactive response to the multidimensional COVID19 crisis as well as the emergent effects of climate change and the structural problems of marginalization and socio – territorial inequalities.

The dimension of the challenges implies even greater efforts, going beyond incremental to more radical innovations, scaling up in scope from the micro business level to value chains and localized production systems. There is also a clear need to scale the networking, to build greater horizontal relations between these types of coalitions of localized task networks, to fulfill their potential as collective subjects of transformation (Ellacuría 1990); strengthening in this way their capabilities for transformative innovation to make the structural changes required for the construction of a new alternative reality to the current bad development regime.

Meeting these challenges implies, necessarily, taking on the even more complex challenges of mobilizing wider coalitions of actors to advocate for and

successfully influence strategic decision- making at multiple levels of society to elaborate, implement and learn from a mix of development policy experiments for strengthening the national, sectorial, and especially territorial innovation systems emerging in El Salvador.

Individually and especially considered as a collective of coalitions, they demonstrate an ambition and vision, as well as they potential in their agency capabilities, to generate transformative impacts, over time; not only in the livelihood trajectories of people directly involved in their operations, but also the territorial contexts of their operations, extending their influence to regional, national and in some cases international arenas. However, this potential to become collective subjects of transformation, for the "historical realization of the possible" as Ignacio Ellacuria[8] (1990) put it, in arenas of greater scope, is currently latent and to be realized. Their innovative potential to design and implement transformative alternatives, has been demonstrated, but only in the niches of their territorial localization. These initiatives are however dispersed in all of the country in rural, peri-urban and urban setting, which is positive, but with few meaningful connections between them, and thus there is little evidence of their creating collective agency capabilities, working together in multi – territorial horizontal, and multi scale vertical action networks with other initiatives with similar transformative aspirations. My knowledge of diverse initiatives of this type generates a perspective of cautious optimism as to their achieving this potential for collective transformative action.

To further strengthen their transformative innovation capabilities to fulfill their potentials, an experimental approach in line with the proposal made by Schot and Steinmueller (2018) y Ghosh, Schot, et. al (2021), to promote transformational innovation, is recommended. To meet this challenge, it is also important to recognize the need for what Arocena and Sutz (2004) explain as "gardening policies" to nurture the development of "interactive learning spaces", within and beyond the niches as their horizontal networking gains momentum.

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Notes

[1] The absorptive capacity of the system components can be regarded as the ability to recognize new external information, assimilate it and apply it (Cohen and Levinthal, 1990). This capacity is not only related to the possibility of accessing the existing knowledge in the environment, but also implies the ability to identify useful knowledge and to generate new knowledge (Erbes et al., 2010, p.723).

[2] Arrainjos Productivos Locales (APLs) which are a conceptual and empirical hybrid combination of agglomerated productive arraingements (clusters), with elements of territorial innovation systems.

[3] Bell defines dynamic assimilation as the integration of exogenous technologies into a process of technical change and innovation within the importing firms and economies.

[4] The conclusions presented in this section in relation to the two case studies are derived from a diversity of research efforts over the long term from the early 1990s in the case of cashews in Tecoluca and the 2000s in the case of ACOPANELA in Valle de Jiboa. The systems of innovation approach was introduced through the SUDESCA research project and built into my masters and PhD research at Aalborg, University. This low intensity long term research effort is currently ongoing in both cases in 2021. The methods used have been principally qualitative based on in depth interviews with a diversity of actors over time in each case.

[5] The ACOPADES Cooperative included 18 medium-sized panela producers from diverse municipalities in the San Vicente department. It facilitated access to training, technical assistance and financing for investments through a project funded by USAID, and improved market access for its members. However, when project support was phased out, internal problems arose that led to its disintegration (Cummings, 2007).

[6] This conclusion reaffirms and deepens the more general conclusion of case study analysis from (2007), concerning the nature of innovative capabilities as composed of specific combinations of knowledge and organic organizational structures and resource bases necessary to apply knowledge in practice.

[7] The importance of learning by doing to develop networking capabilities, does not, however, imply that networking capabilities could not be more consciously acquired or taught; just that this would imply additional effort.

[8] Rector of the Central American University José Simeón Cañas, martyred but the Salvadoran armed forces along with other Jesuit priests in 1989 for their advocacy for human rights and a negotiated peaceful end to the civil war.

7

Capabilities for sustainability transitions in the context of trade-for-aid policies in urbanizing Southern Africa

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Abstract

Urbanization generates a considerable opportunity for sustainable socio- economic development in Africa. Simultaneously, there are immense pressures to avoid numerous social and environmental pitfalls related to uncontrolled growth of African cities. Therefore, urbanization-driven development should engage policy design that support the sustainability in its practical implementation. This article focuses on the challenges that business with impact policy (or trade for aid) may encounter when integrating sustainability and inclusion to business concepts, despite the strong macro-level trends putting pressure on demand. A case of a transnational project is used to shed light on the opportunities and obstacles that such an approach may encounter. Our conceptual framework consists of a multi-level perspective on sociotechnical transition as well as transition management. We conclude that sustainable transitions can be pursued together with the goal of economic development in Southern Africa, Namibia, using urbanization as a driver. However, many challenges remain to be solved, institutional structures and undemocratic use of power as well as project management and "niche building". For efficient deployment of business with impact policy measures, it is important to develop relevant project management capabilities in-tandem with local competence building efforts.

Keywords: Southern Africa; Namibia; innovation; urbanization, sustainability; multi-level perspective; socio-technical transition.

1. Introduction

In Africa, accelerating urbanization supports economic development, but the impact has been weaker compared to the experiences from the global North (Gollin et al. 2016). Among other things, the low quality of infrastructure and urban planning hinder the positive socio-economic impacts of the process. The negative externalities of agglomerating population exceed its benefits (African Development Bank 2016). Africa's need to create urban economic agglomerations to support three times the current population in 2050 represents a systemic problem (UN-Habitat 2015) as rapid urban growth will take place in a largely unplanned manner (African Development Bank 2016).

Urbanization generates a considerable opportunity for economic growth and sustainable development in Africa, including construction and civil engineering, architecture and town planning, manufacturing of products related to housing and urban infrastructure, and so forth. However, many countries fail to grab this opportunity because materials, labour and competences are imported and consequently have a limited impact on local industrial capabilities and socially and environmentally sustainable goals add new challenges for business solutions to be profitable.

This article will study sustainable societal transformation and economic development. Through the case of a transnational project that combined goals of sustainable transformation and business, we will shed light on the opportunities and obstacles that such a venture may encounter and focus on the question, what are the key capabilities to possibly avoid the failures in the complex and unpredictable environment.

We finished a 2.5-year project that was aimed at fostering a systemic transformation of African urban development and housing through piloting and implementation of a developed holistic concept. The project was called in short. The project simultaneously contributed to a concrete business process while it studied opportunities for a systemic transformation in a tradition of participatory action research (e.g., Rahman 2008). …….. also aimed at increasing local added value in manufacturing by using Namibian contractors and suppliers.

The article deploys a Multi-Level Perspective (MLP) on socio-technical transition (e.g., Geels & Schot 2007; Geels 2004) as well as the Transition Management (TM) approach (Loorbach & Rotmans 2010; Loorbach 2007). The MLP attempts to analyse socio-technical change in the society by integrating various societal dimensions in the same analytical framework. In the core of the theory is the complex interaction between societal macro-trends, various actors, technologies, and relatively stabilized societal practices. Stabilized practices form a so-called regime that is any identifiable societal system like, for instance,

an industrial branch (e.g., construction industry in this case). A change in the system is seen to be possible only by a complex interaction of various societal actors and dimensions. While the MPL is an analytical framework, the TM is more practically oriented approach, offering a framework for creating and managing systemic change. According to the TM approach (Loorbach & Rotmans 2010; Loorbach 2007), a system level change can be created by using small practical and local initiatives which may over time lead to wider systemic changes. Small changes can be supported, in turn, by using so called "transition arenas". In the arenas, motivated and interested actors and stakeholders are connected to the change creating activity. The authors also wish to contribute to the transition management approach and discussion on sustainability transitions especially in terms of using it as a tool in the context of the global south.

The …… project identified a need for a socio-technical transition in the Namibian case of housing and urban development and developed an integrated concept to try to tackle it by putting into use the key practices of TM. The project also supported the collaboration of …….. and Namibian actors to implement the ……. concept as new kind of urban area that would be economically, environmentally, and socially more sustainable. The long-term socio-economic development impact was planned to emerge through locally rooted but transnational business ecosystem and its extensive business and competence building operations to fuel local development. However, project confronted various delays and was finally ceased mostly due to challenges in decision-making procedures of local authorities who were in position provide serviced land for the development project. Bluntly, these challenges emanated from both, lack of confidence and competence of local authorities on town planning and finally sheer bribery, as well as too high level of immaturity of the concept offered by …….. Namibian consortium for the co-creation and lack of capabilities to engage local level political decision making procedures, to foresee the fraud.

Thus, the article draws lessons from this partial failure to identify and understand some of the key issues that should be considered when attempting to foster sustainable transformations in the global south. At the same time, the article shows how efforts to foster sustainability may provide opportunities for local development and that these two processes are not necessary diametrically opposed as is often considered, or key obstacle for the development. From the viewpoint of industrialists, for example, instead of considering sustainability as a factor limiting many industrial activities by public regulation, it could be a public setting of direction that guides various actors to orient their future actions (c.f. Schott and Steinmueller 2018, 1561-1562). A consensual, well-defined strategy towards sustainability reduces risks that the investors might otherwise encounter and may also contribute to new market formation.

However, also capabilities of consortiums to implement such a strategy are essential, as well as local competences to absorb the new approach.

Key concepts

Our view of systemic change leans on the theories of socio-technical change and transition management. The aim of the business-with-impact project was to foster change in the social practices and institutionalized action patterns related to the construction and housing sectors and to further urban development in Namibia. The aim of the embedded research project (participatory action research) was to learn from the experience and support the project by reflecting the implementation with conceptual and heuristic tools provided by the theory. The construction and housing sectors are understood here as a complex socio-technical system in which technological and social aspects intertwine. By utilizing the theory of Multilevel Perspective (MLP) (e.g., Geels 2002, Geels & Schot 2007; Geels 2011; Geels 2019), social change is seen as necessitating an interaction between three levels of social structure: the socio-technical system level (regime), the landscape level, and the level of niche innovations. The socio-technical system of the construction and housing industry is here conceived as being formed by producers and users, its technologies, regulation, policymaking and practices, et cetera, forming a specific system or a regime in other words (meso-level). The landscape level is a wider social context where the social system is embedded (macro-level). The level of niche innovations represents, in turn, those innovations, technologies and practices that have the potential to change the existing system but are operating outside or in the margins of the established system (micro-level). Many times, niche innovation is protected by specific market conditions or public support, which allows it to develop in a margin of a wider established system and its "mainstream" solutions.

The theory assumes that social systems form "regimes" which define the way of operation and action in a system. The regime is usually a relatively conservative structure resisting wide or radical changes, albeit incremental adjustments to the operational environment are constantly going on. Wider change becomes possible only if the wider socio-economic and political context creates pressure against the existing regime. If the system actors are not able to transform it to become more "fit" with the context by incremental changes, there opens "a window of opportunity" for external actors to change a system – for instance by creating radically new technological and planning solutions in the construction business (cf. Avelino et al. 2017). These niche innovations may, often by their combined impact, lead into changes of the existing regime. The extent of any regime to change also depends on its capabilities. This equals the capabilities of an innovation system where qualities related to research and educational institutions, funding for new initiatives and access to markets, competences of

the business sector, supportive policy design and co-operative practices, among many other matters, define the limits for change (e.g., Cooke et al. 1998).

In the Namibian context, especially increasing urbanization but also rising standards of living have created pressures for the existing system of the construction and housing industry to change. This also opens a window of opportunity for external actors to introduce innovations and ideas into the system. The …….. concept was conceived as one of these potential niche innovations, which taken together with similar kinds of efforts may transform the existing system and its action patterns.

Radical systemic change is, however, a rare incident. According to the theory of transition management (TM; e.g., Loorbach & Rotmans 2010; Loorbach 2010; Loorbach 2007), a system change can be initiated only by small steps, initiatives, and iterative experiments, which then eventually may lead to wider systemic changes as systems tend to "resist" wide changes. These kinds of small changes and experimenting with changes can be supported by niches that provides somewhat protected environments for the innovations to evolve and for the stakeholders to learn and accommodate themselves to the new solutions. In practice, TM aims to foster these niches by creating so called "transition arenas" in which various actors and stakeholders are engaged in the activity by creating common visions and joint actions towards new development paths. According to TM, it is essential to identify change actors, which may lead the change in the system and support the development of various innovative solutions by experimenting with them and iterative learning from the experiments. Accordingly, among the key actors of the …….. project, it was thought that change in the Namibian construction and housing industry would be a long-term process which could be initiated by first creating "transition arenas" by networking essential actors, introducing them to the ……. concept and its underlying ideas, and then by beginning the piloting with the focal actors in the system in the niche building and innovation. The change process is an iterative cycle in which the actors should evaluate their activities and experiments and learn from them. To test the transition management approach in the context of a developing country, the cycle of transition was applied that is frequently used in the European context. The "cycle of transition" fostering the niche building consists of the following phases (Loorbach & Rotmans 2010, 238): 1) problem structuring, establishment of the transition arena and envisioning; 2) developing images, coalitions and transition-agendas; 3) mobilizing actors and executing projects and experiments; and 4) monitoring, evaluating, and learning. These phases were also the base for the …….. project, and we follow them to break down the analysis of structure also in the analysis ed these phases in our ……. project's development efforts.

Perspectives on innovation for sustainability

There is an increasing amount of literature dealing with sustainability related innovations and transitions (e.g., Grin et al. 2010; Geels 2013; Olufolahan et al. 2018; Späth & Rohracher 2012; Kivimaa & Kern 2016; Ehnert et al., 2018;). While the foci of the research have been on more economically developed countries, during the last decade, increasing attention has also been paid to the Asian and African countries (Hansen et al. 2018; Osunmuyiwa et al 2018; Ramos-Mejía et al. 2018; El Bilali 2019; Chang et al. 2017). For instance, the dynamics of innovation processes may differ significantly from those of more developed countries. Such recent concepts like "inclusive innovation" and "frugal innovation", which have been created to better reflect the innovation dynamics and needs of developing countries, reflect well this difference (ibid.).

By inclusive innovation, we mean those innovation processes that intentionally aim at benefiting certain formerly disenfranchised groups of society or enabling them to participate in the processes or ultimately at transforming a whole innovation system to be more inclusive (c.f. George et al. 2012; Heeks et al. 2014). Frugal innovation, in turn, may sometimes work for the same ends, but basically it refers to those goods and processes that are being reduced in their cost and/or complexity, especially to serve those low-income segments of society in developing countries (Prabhu & Radjou 2012). The ……
project essentially embraced these concepts. It intended to contribute to affordable housing with such construction technologies that were easy enough for dwellers themselves to build their houses. It also included the potential dwellers in design processes of the urban zone in question and of the houses.

In a recent extensive review, Wieczorek (2018) systemically analysed the literature on sustainability transitions in developing countries. The analysis was based on 115 documents written between 2005 and 2016 and was structured according to the concepts of the multi-level perspective (MLP, e.g., Geels & Schot 2007). Observations of the review that are relevant for this article include at least the following (Wieczorek 2018):

- Regarding niche formation (protected spaces for innovations, which are not in the mainstream and thus not yet self-sustaining) as an integral part of the MLP conceptualization, there are two opposing views. On the one hand, governments may have decisive role in promoting sustainability transitions and promoting niche formation. On the other hand, centralized state programs do not necessarily provide proper incentives for learning and further development of innovations.
- Experiments on new sustainability solutions and innovations as a source of learning are an important mechanism for creating innovations and capabilities as suggested by TM theory. Especially important seem to be experiments in which developing countries engage with transnational

networks and infrastructures to gain access to various resources and markets in order to develop their own system and support socio-technical innovations.

- In developing countries, informal institutions and cultures may play a more important role than formal institutional structures.
- In the developing countries, regimes (i.e., socio-technical system, e.g., construction industry) and their constituents are more heterogeneous and prone to internal tensions than in developed countries. For instance, old systems may coexist alongside new ones.
- Use of power and power constellations significantly affect sustainability transitions.
- Path dependence ("locking" effect of past decisions, investments and institutional structures) is typical for any regime as a stabilized system, but the way it affects change is different in developing countries. On the one hand, existing poverty and inequalities may hinder the development of new development trajectories. On the other hand, less developed infrastructure and institutions may not put pressure on developing more sustainable systems.
- Related to this, there may be different views on what is sustainable and how to achieve this. Instead of environmental challenges, social inequalities and the lack of access to modern services are more pressing ones.

Some other important findings in the literature emphasize (Hansen et al. 2018) that regimes and niches do not necessarily remain within national boundaries but are tightly connected to regional and global levels through various actor relations and institutions that affect the formation of local transition dynamics. For instance, foreign investors and multinational companies may be such actors that strongly affect the formation of local niches and experimentation (Nygaard & Bolwig 2018). However, the creation of transition processes does not necessarily succeed if, for instance, the inclusion of relevant actors fails (Van Welie & Romijn 2018). Another observation is that regimes in developing countries may be less stable compared to regimes in developed countries.

This may be due to political or economic instability and inefficient administration. This, in turn, may affect the niche formation, which may require a certain minimum level of stability to flourish. (Wieczorek 2018; see also Nygaard & Bolwig 2018). This is connected to the prevailing undemocratic political systems, informal connections, and unjust allocation of benefits. These factors significantly influence the way in which sustainability transitions take place, for instance, by excluding certain stakeholders or groups of citizens from the development processes (Hansen et al. 2018). Also, it has been indicated that small, single projects or experiments have limited ability to induce wider

systemic change if they are not widely connected to the regime (Hansen et al. 2018; van Welie & Romijn 2018).

Thus, the existing literature indicates that the context of developing countries is different from that of developed countries when we approach it from the perspective of sustainability transitions by using concepts and findings of MLP and Transition Management (TM). Typically, less functional and weaker national level institutions and strong role of informal institutions and actors, in tandem with lesser resources and capabilities, makes development country environments more challenging for systemic innovations to occur. While the literature on this area is a constantly expanding, it is also apparent that more studies are needed to shed light on the sustainability transition dynamics in developing countries. Some important aspects that require further analysis are, for example, the role of transnational actors in the formation of local niches, and how such actors can address the local conditions (Hansen et al. 2018). In the following, we aim to address these questions by describing and analysing the success of one internationally initiated development program in Namibia.

Methodology and data

This article is based on data obtained from the research project titled ……. In terms of analysis, the article deploys a case study approach. As the project was a development project, we utilized the participatory action research approach as a general methodological framework (Chambers, 1994), which made it possible to gain deeper insight and understanding of the opportunities and obstacles such undertakings encounter. The participatory approach allowed us to position ourselves in a similar way to the actors responsible for the business part of the project. Approach Into a niche building process, while reflecting the process in abundant interaction with various regime actors, and with landscape level processes that strongly put pressure on new housing solutions of urbanisation.

……. was co-financed by the …….. as well as by the participating …….. companies and the …… participating research institutions. In addition, ……., the University of Namibia (UNAM) and the Namibia University of Science and Technology (NUST) acted as research partners. The ….… research project conducted participatory action research to study the needs, preconditions, and development opportunities related to the implementation of the holistic urban development concept. The ……. concept was a new model for urban development and housing in Namibia and thus a niche innovation (Geels 2004, Geels & Schot 2007) in the Namibian context. In terms of Transition Management, the …… concept was a local experiment, which could be developed into a niche innovation within the local housing and construction industry and eventually create possibilities for a wider change in the existing regime.

In ……., we utilized the co-creation approach to address the challenges of implementing a complex and societally embedded innovation project in which engagement, competence building, and sustainability have significant roles (e.g., see O'Hern & Rindfleisch 2010). In the …….. project, co-creation activities were launched by conducting a focus group study to explore relevant topics with six stakeholder groups of three to nine participants each. A selection criterion was that the participants should represent key groups who had a key role in building and buying the houses. The participants included two groups with potential inhabitants selected from those on the waiting list of the municipality and eligible for a housing loan, two groups of university students as potential future house buyers, town planners of the municipality, as well as those who had a key role in defining the local community actions — especially community leaders of local parishes who had a significant role in all the actions.

Workshops generated a key source of data. Altogether, there were 13 workshops. These workshops resulted in a variety of data as written notes, material produced during the workshops by the invited participants, as well as photos and videos. Another key source of data was individual and focus group interviews conducted especially in the towns of piloting sites with various relevant stakeholders representing public, private, and a third sector. Altogether, the interviews, focus groups, and co- creation workshop data included the following:

- Research interviews. In most of the cases these interviews were recorded, based on the consent of the interviewees, in addition to interview notes that were made. Altogether, 30 interviews were made, until it was agreed within the research group that the research data was saturated (i.e., we did not receive any new relevant piece of data on our key research themes).
- Business meetings together with the representatives of companies. There were some 40-50 business meetings like these.
- Other meetings that often concerned planning of the forthcoming activities such as setting up workshops and how to conduct these successfully. There were some 30 meetings like these.
- Focus groups/workshops that dealt with questions of inclusive urban development and housing (six in Namibia and one in …….).

An additional source of data was the existing literature and documentation related to African (Namibian in particular) urban development, planning and design and its current state of affairs and national and local governments' policy documents, statistics, and other formal documentation. In addition, each member of the research team wrote notes (research diaries) on the functioning of the …… consortium, the development of the concept along the process, and

the dynamics of the housing and urban development regime of Namibia from the perspective of sustainability.

Our data was gathered together and condensed before being sorted into themes and patterns, which were in the core interests of the study (cf. Mckeever et al., 2014). We searched for the emerging patterns and connections in the data to identify themes that could become distinct categories helping to explain developments (Bansal & Corley, 2012). The analysis was facilitated by the synthesis reports and research diaries that the researchers prepared for their own use.

Challenges for and solutions by the ……

The major observation behind the ……. project was that the accelerating urbanization in Africa supports economic development, but the low quality of infrastructure and urban planning hinder the positive socio-economic impacts of the process. Some of the major facts are that Africa's population will continue its shift from rural to urban areas; in 2010 urban dwellers made up nearly 40 per cent of the total population, and an estimation for 2030 is 50 per cent and for 2060, 65 per cent. (African Development Bank 2011). Regarding the urban population of Namibia, it has been increasing from 28 per cent in 1991 to 33 per cent in 2001 and to 48 per cent in 2016 (Remmert & Ndhlovu 2018, 11). Like everywhere in Africa, Namibian cities also act as nodes through which development occurs, and rapid urbanization simultaneously poses risks that affect the sustainable livelihoods of people. (Indongo et al 2013) Furthermore, Africa's need to create urban economic agglomerations to support three times the current population in 2050 is a systemic problem. Industrialization is declining, whilst the service sector is growing fast but is unable to cater to the employment demand.

Africa is urbanizing with a lower GDP per-capita than other regions, with negative basic constraints such as unemployment, social exclusion and poverty (UN-HABITAT 2015). Furthermore, positive development of growing cities would require profound renewal of urban planning practices, including the use of more transparent and inclusive methods locally and co-creation with international planning teams. (African Development Bank 2011; African Research Institute 2013)

The urgent need for housing in Namibia emerges from increasing urbanization and the lack of proper accommodations for these urbanized populations. In Namibia, rural-urban migration accelerated after ten years of independence, and the share of urban population has increased from 28 percent in 1991 to 48 percent in 2016. (NIDS 2016). However, the Namibian cities are mostly small according to the census of 2011. With 325,000 inhabitants, Windhoek is by far the biggest city, and the rest of the twelve cities have populations ranging from

ten to seventy thousand. Even though Namibia is a country where challenges of urbanization are not among the worst, this country was chosen as the first destination because of its relatively stable development and institutional basis, as well as because of many existing networks of the consortium partners, providing a promising starting point for the ……. consortium.

Nevertheless, this rather low urbanization rate does not imply that Namibia would not have its challenges for housing. Since 2000, there has been a rapid increase of shacks and informal settlements in Namibia. According to estimations, between 2012 and 2016, circa 15,000 "shack-like structures" were built close to the capital city of Windhoek alone. According to the Namibia Inter-censual Demographic Survey (NIDS) from 2016 (Remmert & Ndhlovu 2018, 22-23, see Table 1), more than 25 per cent of all houses are shacks. The share of households residing in shacks close to other the towns was even higher, including the town where the …….. project was implemented.

Table 1. Types of dwelling in Namibia

Type of dwelling	**% of households**
Improvised Housing (Shack)	26.6
Traditional Dwelling	32.6
Single Quarter	2.4
Apartment or flat	6.1
Detached or Town houses	30.6
Other	1.4

NIDS 2016;

Source: Remmert & Ndhlovu 2018.

Namibian National Housing Policy was renewed in 2009 ("Vision 2030") with clarified goals to provide access to adequate housing and water and sanitation facilities for all Namibians. Soon after that, the National Development Plan 4 review estimated a backlog of 300 000 housing units (with a population of approximately 2.1 million inhabitants). Several government-led programmes and other initiatives have been launched to respond to the challenge. According to Remmert and Ndhlovu (2018, 39- 42), there have been several official housing programs that have either showed initial success but have run into troubles later or have introduced some successful new elements (e.g., including skills development). Nevertheless, they state that the Namibian housing markets still suffer from a housing shortage due to a mismatch between the price level of the

houses produced and demand in the market as well as rapidly increasing land and housing prices.

According to most experts, the root cause is the low capability of municipalities to produce serviced land to construct the houses (ibid.). As one interviewed expert in the university stated: *"The mass housing programme is a perfect example of a kind of interaction between the national and local authorities in the country. The project was suspended pending revision. I would say one of the biggest problems is that it caters to a small social and economic demographic of housing seekers in the country"*. The consortium had also learned that most of the housing areas consists only of houses without any other amenities.

In order to address these challenges, the …… concept was developed in the planning phase of the project, the idea was to consider holistically the local cultural and social environment and respond to the specific challenges of urbanization in Namibia. The idea of the concept was to encompass urban planning, infrastructure, housing, service structure, and private businesses. Furthermore, the focal idea was to develop housing solutions in a co-creation process with residents, local partners, and other stakeholders — thus diverting from the usual top-down planning model. A ……. company consortium of four companies (an architectural design office, a civil engineering company, a company providing affordable construction solutions, and a health care and social service company) was formed to implement the development project. This initial consortium was later complemented by Namibian companies including both service and manufacturing industries related to construction and housing, as well as by Namibia University of Science and Technology.

At the same time, a separate research and development project was created to study and develop the implementation of the concept. The whole project took place …….. and lasted two and half years. There were only a few previous examples of implementing urban planning projects on the neighbourhood level (e.g., UN-HABITAT's Urban Planning and Design LAB, launched in 2014). Thus, we could not identify any other similar project that would have brought together various aspects of development under a holistic concept connecting it to an international business ecosystem development aiming to boost the local business.

In the following, we describe and analyse the implementation of the project. In the implementation of the project, we utilized the five phases of the cycle of transition presented earlier (e.g., Loorbach & Rotmans 2010). After the planning and composing the project, the ……. process began by structuring the problem in the country context of Namibia. This and other subsequent phases necessitated several trips to meet Namibian actors face-to-face and included various business meetings and formal interviews with numerous representatives of key stakeholder organizations in order to find out more

about the prevailing circumstances of urban development and housing in Namibia. It also included a process to gather information (published and other literate material) on this theme. This phase created a basis for the next phase, creation of the transition agenda and vision building. It was important to introduce and discuss the idea of the …… project with the local actors as early as possible. Discussions on the …….. idea, together with the information gathering on local conditions, drivers and obstacles, then made it possible to reflect and further develop the original plan as well as to form a holistic view on the existing housing and construction regime and the landscape trends as well as on the possibility to develop a niche for the idea in Namibia. Together with the business partners, the building of a business ecosystem[1] also began by extending the local network from the small core network, which was to a great extent based on the initial consortium and firms with existing relations, to the Namibian actors.

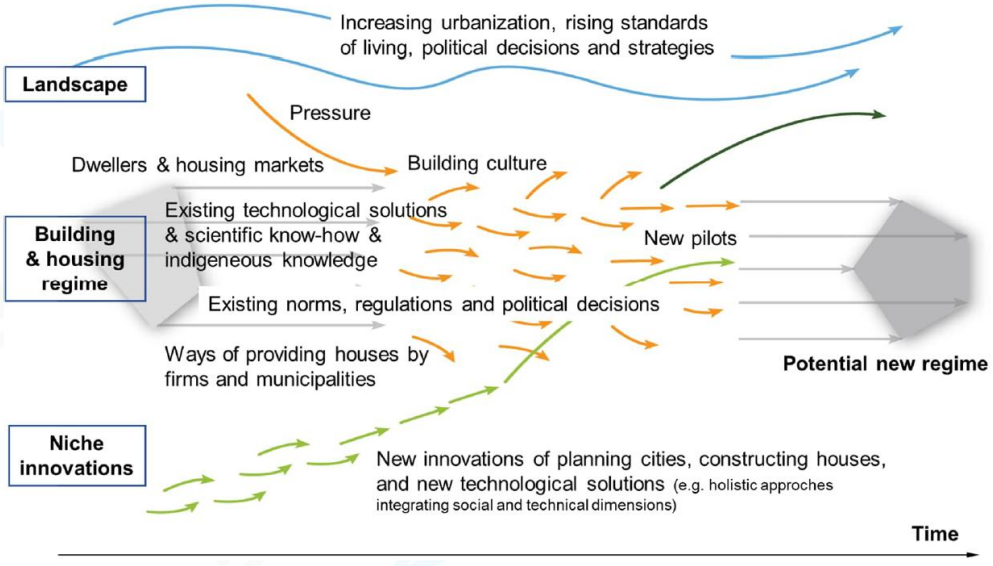
Another important matter of that phase was to select a location for the first pilot urban development and housing area. The consortium sought suitable serviced land from various tows by visiting the local town councils and town planners. Finally consortium decided to build the first pilot houses in a town in southern Namibia. This was due to its active local government and the existing personal relations with the town management. Personal relationships helped to establish the first contacts with the local decision-makers and other relevant actors and supported the development of the project in the region.

A clear challenge at the early phase of planning and ecosystem building were the somewhat distorted expectations based on the history of international projects in the country. Even though was a business-based project (more based on a trade for aid approach than on the more traditional official development aid approach, ODA), especially some government officials anticipated that the project would have been a source of funding for local efforts, as this has been the case in more traditional projects based on direct aid (ODA).

It was also apparent that because of earlier failures in housing projects, some actors shunned engagement with the project to avoid any uncertainties. This may have partly been due to the novel aspects of the project too. The concept itself was conceived to be innovative, but one where there was not enough experience. As a town planning consultant put it in an interview, "*New change brings about threats in government. The decision-making powers sometimes would shut down plans and ideas that are indeed in the best interest of the country*". The project model necessitated interaction of multiple public and private actors across established boundaries, and the funding was largely sought from private sources, which made it challenging for some of the collaborators of the project who were not used to that kind of arrangement.

The following picture depicts the result of our analysis of local circumstances and dynamics of change in terms of MLP. In the picture, the landscape level of wide societal trends especially includes the multifarious challenge of the rapid urbanization of Africa with its all reasons and consequences as well as the actual and expected rise of the standard of living of people. These are megatrends which put pressure on the existing housing and building regime to find new ways to build cities and solve increasing social problems which relate to urbanization. Urbanization is a multi- dimensional systemic challenge in which housing related challenges intertwine with general social development, employment and economic development, and social security and health care related challenges. Furthermore, we interpreted that this pressure was opening a "window of opportunity" for new kinds of socio-technical innovations in the housing and construction sector. Thus, the basic idea of the was to address these questions with a systemic development concept and connect the building of affordable houses to the planning of housing districts where there would be also working places, health care and social services, as well as opportunities for community building.

Figure 1. Housing and construction regime in Namibia in terms of MLP (modified from Geels 2002).



The existing building and housing regime was a progressive business area in Namibia, but there were challenges especially related to the financing and construction of affordable housing. While some support structures had been created, their scope was insufficient. The culture also favoured small houses instead of more efficient blocks of flats and owner-occupied flats instead of renting. Residential areas were built only for dwellings, and other functions like

health services, community building, or business development were not integrated in the planning. As a town planning consultant put it in an interview: "*The local authorities are faced with financial constrains which unable them to properly manage social aspects that are integrated in the layout designs by town planners due to high influx rates of rural-urban migrators*". In addition, the public-private-partnership activity seemed to be relatively limited, and it was administratively steered from the top-down.

To make a systemic socio-technical innovation possible in circumstances where collaboration between construction and heath care sectors was not typical required mobilizing the relevant actors and creating shared visions for the change. However, the building of the wider transition agenda for the change of construction and housing industry in Namibia did not need to start from scratch as there was already the existing *Harambee Prosperity Plan (HPP),* a strategic development program of Namibia from 2016 to 2020. The HPP was based on five main pillars with one being infrastructure development. The plan outlined, among other things, goals for urban development and housing that paralleled many ideas of the concept. It was considered important that such an agenda already existed, as it was assumedly a transition agenda shared by focal actors of housing and construction within the regime. By this agenda, the regime actors were responding to the pressures at the landscape level towards sustainable urbanization and affordable housing in Africa.

By leaning on this general national HPP agenda, the consortium started to create a shared understanding among identified stakeholders and decision-makers. There was an exhaustive number of organizations represented in business meetings, seminars and workshops organized by the consortium and by our supporting R&D project. These included national governmental institutions, higher education and other educational and expert institutions, local and regional authorities, private companies, and non- governmental organizations[2].

However, building a shared understanding and vision by using workshops in which all of the stakeholders would participate to create consensus and openly discuss the challenges turned out to be challenging. For instance, the research team organized two workshops to discuss the viability of the concept in the Namibian context, but the first one largely failed because the participants primarily focused on underlining the position and importance of their own organizations. The second one, in turn, failed to engage representatives of the central government, and thus a wide dialogue and consensus building was not reached across different stakeholder groups.

At the same time, there were no difficulties in engaging these groups in open discussions in meetings where only one group was present; we interpreted this to be due to a top-down political culture, which did not seem to encourage

public–private– partnerships and open dialogue among various societal stakeholder groups. However, quite contrary to this, local city-level workshops with potential dwellers succeeded well; it was easy to engage people in these events, and the workshops generated many insights on housing and broader living preferences. However, also some basic assumptions of international consortium were challenged, including central idea of Smart community to provide shared public spaces for community building purposes. Paying extra from these amenities were challenged, as they were assumed to attract homeless who would occupy those spaces, and make them potentially dangerous rather than inviting for the inhabitants.

The workshops were also used to create a shared understanding of the agenda and targets, but the participating people had also some doubts about it, as they had earlier experiences of other projects where execution after consulting them had not always proceeded without problems. These doubts also had their justification when the project attempted to move towards execution of the experimental phase.

While early engagement and interaction with stakeholders and people are efficient ways to create a shared understanding of a common agenda and the needed changes, the practical implementation should follow the process within an adequate timeframe. In this case, the planned affordable model houses would have been an important concrete step to communicate the process further to various stakeholders. However, due to slow and inconsistent processes among the local authorities, it was not possible to initiate the building process. This, in turn, hindered further discussions on the model. Also, ideal of co-creation starting from fairly open options was a challenge, and source of delay, as there were no sufficiently detailed plans and cost estimations available for the Namibian partners at the early pahse.

At this point, when the urban zone for the pilot housing was already planned and negotiated with the local authorities, there occurred an unexpected turn: the zone was allocated to another constructor with a traditional plan. Later, it turned out to be because of bribery, as our team suspected and later learned from the main national newspaper.

Another urban zone was offered for the pilot instead, but the town plan concerning the zone was unsuitable because of the need for a costly and time-consuming new planning round. The pilot became impossible to implement in business terms, and there were no other choices for the consortium than to withdraw from the execution of the pilot in the locality. Thus, despite the existing long-term relations with well-established Namibian partners and local actors as well as in-depth knowledge about the country and the locality, weak institutional structures provided an unstable base for innovation activities that lead to a failure of the piloting phase.

Monitoring, evaluating and learning — perhaps the most decisive cycle of transition — are in the core of long-term societal development. In the project, this cycle was not executed among an extensive group of stakeholders due to the failure in the piloting, For the learning purposes, a workshop was, however, set up by the researchers to reflect on the different views on the project and to discuss the reasons for the failure of the consortium to proceed into execution of the pilot. In the following, we present some key insights of what was learned.

Discussion and conclusions

We have examined, through one empirical case as a lens, the African urbanization trend, the opportunities it creates for industrialization, and an attempt to foster a sustainability transition in that context. Our focus has been on those challenges that such an ambitious effort of sustainable industrialization may encounter.

Wieczorek (2018) stated that while many systems in developing countries may be absent or dysfunctional, it may also be an opportunity to develop sustainable alternatives. The project had this as a starting point: to not only provide "traditional" affordable housing for shack dwellers, for instance, but to leapfrog by developing whole urban areas to avoid environmental and social problems. The Project aimed at increasing social sustainability and local added value in housing by the developed inclusive concept. The idea was to consider holistically the local cultural and social environment in addressing the challenges of urbanization and to encompass urban planning, infrastructure, housing, service structure, and private businesses.

We claim that in the Namibian context, there was, in terms of the MLP approach we utilized, a window of opportunity open for sustainable niche innovations to emerge in housing and urban development, because of the strong urbanization pressures. There was also a widespread awareness of the nature of problems and of some potential solutions (e.g., social acceptance of solar power, or a need for more inclusive practices in urban planning). However, the existing system (regime in terms of MLP) still seemed to resist the implementation of local level radical changes despite the national level strategic visions and political will (Harambee strategy).

New innovations may be slowed down or stopped by institutional problems and management related challenges. As in earlier studies of sustainability transitions in developing countries have pointed out, (e.g.,Wieczorek 2018; see also Nygaard & Bolwig 2018) this refers to the fact that the existing regime in terms of MLP may have too weak institutional preconditions for the implementation of complex and innovative multi-stakeholder processes, or, international consortium fails to communicate the process and its benefits for all

the key stakeholders clearly enough, to be supported and advanced without serious delays. Therefore, the focus of development should also be placed on the development of institutional practises, and in creation of local level experiments to support wider system level change, it would be important to engage relevant stakeholders to this experience.

We may assume that somewhat random, rather than strategic, choice to locate first pilot house to Southern small town was not likely to be the best choice in term of building of still immature transition arena and related niche development at the national level. While the idea of received very positive feedback from the many key stakeholders in various occasions, it might have been more efficient to develop actual "urban laboratory" to closer to key stakeholders in order to ensure the more efficient interaction and mutual learning process.

Table 2. Summary of housing and construction related sustainability challenges, solutions, and project learnings.

Challenges of African Urbanization	Sustainability Transitions Related Challenges in Developing Countries	Solutions to Address Challenges	Outcomes and Learnings
- Rapid movement of population from rural to urban areas - Africa urbanizing with a lower GDP per-capita than other regions - Growing risks to sustainable livelihood in the cities: growing unemployment, social exclusion and poverty - Out of date urban planning practices.	- Contradictory evidence on niche formation mechanisms: centralized/ government mechanisms vs. less centralized ones - Experiments of new sustainability solutions with developing countries and engagement with transnational networks important - Informal institutions and cultures potentially in an important role - Regimes often heterogeneous and prone to internal tensions - Use of power and power constellations significantly affect sustainability	- Concept as a response to the systemic challenge: Integration of dweller-centred urban planning, affordable construction technology, service and business development - Combination of top-down and bottom-up approaches to address centralization and power constellation challenges: Networking and "green light" from various leading national level policy-makers and at the same time development of local city-level experiment Namibian consortium and business	- The concept considered an innovative and important opening by stakeholders from policy-makers to dwellers - Personal contacts and top-down approach important to gain "good will" and increase acceptability in a formal administrative culture - Contacting informal "community leaders" essential for local level acceptability - Integration of city planners to the discussions (transition arena) important - Challenging to support open stakeholder dialogue across social boundaries - Clear understanding and

	transitions - Poverty and inequalities as well as less developed infrastructure and institutions may hinder sustainability transitions. - Lacking capabilities and systemic management of consortium of niche formation by utilizing abstract tools of TM in a challenging environment – instead of interacting with regime	ecosystem building to foster international linkages and transfer of know- how - Co-creation method to address concurrently housing and social challenges.	constant monitoring on local political atmosphere related to project Development consortium partners' differing interests as a challenge to support holistic approach and consistent vision building - Critical role of local ownership must be understood.

The table above summarizes the challenges of African urbanization, sustainability transition related challenges in developing countries, approach's solutions to these challenges, and the outcomes and learnings of this development process. This aims at contributing to identify some of the challenges and ways forward regarding sustainable industrialization in Southern Africa.

In order to co-create the complex innovative solutions as in the case of the approach, it is essential to foster the development of the ecosystem to proceed locally. However, as our case suggests, some concrete and rapidly implemented limited experiments – as model houses in a real-life environment – would have been beneficial for the project implementation and creating trust for it. But efforts to initiate the niche building for the collective learning experience was lost, not solely due to unstable institutional environment, but possibly also due to incorrect evaluation of the situation by the consortium, where this initiative would have been in a proper place.

One possibility, strongly advancing NUST campus area, with support from its innovative community and leader, could have provided more likely success story for the showcase house – but this was conflicting with business interests, as it might have been difficult to sell the house in the campus area, or this was the assumption – not really elaborated solution. Weak institutional structures, which became visible in terms of unexpected official decisions by the local government, also undermined the importance of trust that was created among the local inhabitants and communities. Lack of trust was visible, for instance, in initial low expectations by dwellers towards constructors' abilities to execute

their plans, as there exist numerous failed or delayed housing programs in Namibia.

Besides institutional preconditions, there are managerial aspects to learn from, too. Based on our analysis of it is important that a core group has a strong commitment to its tasks, a consistent shared vision, and a strong leadership pushing it ahead in lines of the milestones outlined on a roadmap. This may be a challenging task given that, in order to gain notable societal impacts, an ecosystem around the core group quite likely needs to be extended from its initial configuration. Therefore, there is a need to maintain a balance in preserving the coherence of a core group and to simultaneously reach out to find new partners. In retrospect, it can also be seen that the companies' intentions that come with a shared vision were not coherent enough, and their business models were not always solid enough for a different kind of market.

A transnational network needs to be robust. In it seemed that the core group, despite having Namibian partners from the early phases of the business process, nevertheless did not manage to engage enough local partners and consequently lacked local ownership to some extent. Here, again, we have a question of balance. In this case it is a trade-off between, for example, securing intellectual property rights and future business opportunities of a foreign counterpart of a transnational network vis-à- vis crucially important local ownership of a joint process to advance a shared vision was based on the co-creation approach. However, first attempts to engage national key actors (e.g. architecture experts of HEI, national housing programmes, ministries) to actual design process were diluted by lack of clearly designed and communicated co-creation process in addition to prejudices among the some participants, concerning the goals and hidden agendas of the consortium. More concretely co-creation processes only took place when the consortium had begun the design of a first pilot site (Oksman et al 2018). Instead, this should have taken place already from the designing of the whole concept. This was considered in the subsequent activities of with improved results.

In the previous literature it has been seen of crucial importance to develop sustainability experiments in which developing countries engage with transnational networks and infrastructures (e.g.,Wieczorek 2018; Hansen et al. 2018), to gain access to various resources and markets, to develop their own system, and to support socio-technical innovations. This was also the starting point of this project created a possibility for the Namibian actors to reflect Namibian policies and practices with the ones in order to learn and to gain new insights. As one of the challenges of the project and consortium was to engage local private and public actors in the project, it can be claimed, however, that the possibilities of success would have increased if Namibian actors would have been involved in the project already in the planning phase. Perhaps this could have created a closer relationship with the project and supported local

"ownership" of the idea. Now a great effort was needed to create acceptance for the concept, even though it was considered generally as a supportable and innovative one.

While the project also tried to connect itself more widely with the regime actors horizontally and vertically on various social and administrative dimensions to increase its ability to create wider systemic change (Hansen et al. 2018; van Welie & Romijn 2018), this did not support strongly enough the uptake of the idea on the local level and the self-organization of actors after the failed experimentation phase.

Our study suggests, too, that informal institutions play a significant role in the context of developing countries (c.f. Wieczorek (2018). For example, in our case community leaders were important actors in supporting the acceptance in the local community. It was also visible in the administration processes that civil servants as well as politicians may face several contradictory obligations in the crossroads between family, tribe, political party and formal organization. Thus, the regimes are far from being uniform or stabilized by formal institutions, which would support local experiments (cf. Nygaard & Bolwig 2018).

Other challenges for a deployment of the integrative concept in Namibia were the existing poverty and inequalities that are usually more pressing concerns than environmental challenges (aridity may be an exception to this general rule). Path dependence with the colonial past may also hinder efforts to develop infrastructure services and affect the structure of urbanization. An example was the practically missing public transport system as a reminder of transportation during the apartheid era.

In sum, it might be claimed that main failure of consortium, was too eager and time consuming interaction with existing regime and their representatives, while the actual niche building received much lesser effort. As it is known also from advanced economies, exiting regimes and systems are difficult to change, and precisely according to idea of MLP and TM, the niche - protective environment to incubate new innovations and solutions – are the key for the transitions. However, systematic and persistent niche building was not really conducted, although networks and ecosystem building was done, at the level of business and funding partners, as well as customers. The difference between the niche building (for incubating innovations and making experiments) in oder to enhance collective learning and ecosystem building (for creating business consortium and demand) in order to sell and integrate the project to the receiving regime and wider society, is very thin line in terms of practical activities.

Therefore, more advanced abstract level understanding and capability to implement these conceptual tools in practice, could have helped to consortium

to achieve a better result. Bluntly, consortium lacked transition management capabilities in implementation, while in theoretical level it was well understood and described process.

However, despite the failure of implementation in this case, we claim that efforts to foster urban sustainability may provide opportunities for local industrialization−these two processes are not diametrically opposed. This refers to the fact that the objectives of were welcomed in Namibia even though there was a lack of a policy that would have reduced innovative investors' risks to connect sustainability and industrialization.

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Notes

[1] By business ecosystem we mean a network of actors (suppliers, customers, competitors, complementors, regulatory agencies, and other stakeholders) that are interdependent. Together these actors create value that no single firm could create by itself (e.g.,Valkokari 2015).

[2] The total number of these meetings is presented in the preceding methodology chapter.