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Technical Report

Foresight for New Collaborative Platforms to Support LMIC Science Systems

Anabel Marín and Fiona Marshall

July 2022

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Summary

The wide diffusion of ideas and focus of funders around the 17 Sustainable Development Goals (SDGs) released by the United Nations (UN), suggest that the era of predominance of economic growth as the main driver of welfare is in decline. The notion that development should be focused primarily on economic growth with concerns about poverty reduction, education, health, inequality, and the environment, only to be taken seriously once growth has been achieved, is no longer convincing. All of these goals must be pursued simultaneously and with attention to the synergies between each that can be built in doing so. But to what extent are science systems adapting to this new challenge?

A number of studies, following the release of the SDGs, have started to explore how existing systems are beginning to respond to these shifting demands, as well as to the ways in which they can more rapidly adapt to do so. Many interesting new ideas about how to transform scientific practices, processes and methods are being discussed and promoted in association with these studies. It is now well recognised that if scientific systems are to help to create more just and equal societies, which respect diversity and promote freedom and autonomy, then processes of new knowledge creation and application have to be more open and participatory. Ideas about open science, co-creation and other forms of democratising science seem to be perfect for this job and have started to be supported. Diverse groups of users should be part of processes of knowledge generation, so that their demands are directly addressed, and also used by the system that will itself become enriched. Different forms of knowledge, both formal and informal, have to be respected and incorporated. Evaluation systems must also adapt and value the work done by scientists and practitioners who work with diverse partnerships and transdisciplinary approaches that aim to have a real impact on the life of people and the environment; producing outputs and impacts which are still largely unrecognised in traditional evaluation criteria.

This report discusses the methodology, activity and outcomes of a project funded by IDRC[1]. This Project utilised novel national science system characterisation and participatory foresight approaches based on ‘seeds of change’ (‘weak signals’ or ‘pockets of the future in the present’)

[1] For more background on the project please see the **project webpage**.

to explore some of these issues. Many of the ideas coming to the fore have started to be discussed in other similar studies about what should change in science systems. The desired futures identified centred largely around justice, freedom, democracy, autonomy, and diversity. To move in these directions, funders will need to find innovative ways to support open and distributed science, and inclusive, democratic and participative processes; and to ensure that these are contextually adapted to multiple geographically and socially diverse realities. Critically, the work also highlighted the need to look beyond additions, amendments and extensions to already stretched initiatives. Instead to focus on key leverage points at various scales which can catalyse and nurture more systemic change through disruption and re-orientation. This will of course require attention to evolution of appropriate capabilities, capacities, alliances, governance arrangements and evaluation frameworks.

However, our work in multiple contexts in Africa and Latin America (involving many different kinds of stakeholders) pointed also to a need to focus on critical **tensions** in order to underpin change processes, and of greatest importance the following three tensions:

1. System level tensions: related to negotiations around allocation of funds within countries;
2. Project level tensions: related to negotiations and integration between different forms of knowledge; and
3. Tensions between learning from and supporting transformative initiatives and engaging with their potential to change the dominant science system.

These are each discussed in more detail in the report.

Keywords

Foresight; Low and Middle Income Countries; Science systems; Sustainable Development Goals; Transformations

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Acknowledgements

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Acronyms

CENIT	Centro de Investigaciones Para La Transformación
CST	Centre for Complex Systems in Transition
FCDO	United Kingdom Foreign, Commonwealth and Development Office
IDRC	International Development Research Centre
IDS	Institute of Development Studies
LAC	Latin America and the Caribbean
LMICs	Low and Low Middle Income Countries
SDGs	Sustainable Development Goals
SPRU	Science Policy Research Unit, University of Sussex
STI	Science, technology and innovation
UK	United Kingdom
UN	United Nations
USA	United States of America

1. The research problem

The science systems of Low and Low Middle Income Countries (LMICs) have a need to be transformed to support multiple development objectives in line with the UN's SDGs.

Transformations are difficult due to pressures for change coming from very different directions, with struggles and tensions within systems, and between the national systems and regional and global systems.

During implementation we realised the need to refine our focus. Originally, we defined transformative science systems as those that were able to support the combined ambitions of the SDGs, by recognising and mobilising a broader view of actors, different forms of knowledge and innovation pathways, and being responsive to diverse and evolving societal demands. This focused attention on the role of funders in helping to recognise and create knowledge infrastructures that nurture transformative science, building on transformative alliances, novel governance arrangements, disruptive technologies, and other key enablers. Our growing understanding required an operational redefinition of transformation science systems to 'those systems that can support and allow initiatives that represent "seeds of change" to flourish'.

Our emphasis was first on identifying those features that would enable or hinder the progress of diverse, potentially transformative initiatives, and to consider their cumulative potential to initiate and sustain widespread systemic change. Then, we focused on the role of funding and funders in these processes. 'Seeds of change' were defined as 'innovative initiatives, practices, institutions, and ideas that promise to address some dimensions of sustainability, and that are present in the world in some form but are not currently widespread or dominant'; similarly termed as 'bright spots', 'weak signals' or 'pockets of the future in the present'. They can be small-scale and experimental projects and initiatives that employ new ways of thinking or doing, and exist at the margin of the current world and worldviews. They can also take the form of new social institutions, technologies, or frameworks for understanding the world and are not yet mainstream, but have the potential or have shown at local scale to improve livelihoods, inequalities, and sustainability outcomes.

Our research problem also evolved to become more specifically defined in relation to the regional focus. Our broad aim, as set out in the project proposal, was to develop insights for addressing this problem in LMICs in general, whilst our empirical work has taken place on two specific continents, Latin America and Africa, and focusing on specific countries within each continent. In Latin America the focus countries were as follows: Argentina, Chile, Brazil, Peru, Colombia and Dominican Republic. In Africa the countries of focus were: South Africa, Ethiopia, Kenya, Rwanda and Ghana. This initial focus on selected regions and inputs

about specific problems has been important. On the one hand, problems and challenges are very often local; additionally, stakeholders directly affected by these challenges engage better in future-oriented discussions and proposals for novel ways of supporting knowledge production in relation to issues that are grounded in their own experiences and of others near them. By focusing on specific regions, rather than on LMICs in general, we have gained a better understanding of the specific tensions of each region. In LMICs, global funders have a significant weight and play an important role in helping to diversify research agendas. But domestic actors, who fund important parts of the systems more or less directly, also have a voice, and push agendas in different directions. With systems often performing poorly at delivering - according to the expectations of some powerful domestic actors (for instance in failing to provide relevant knowledge that is then applied by the business sector or national governments) - there remains significant pressure to continue to pursue and reinforce existing science, technology and innovation (STI) pathways that prioritise economic growth. There is a need for funders to collaborate in support of governance arrangements and consultative processes capable of recognising the potential capture by powerful interest groups and safeguarding the alignment of STI trajectories with the aspirations of society as a whole.

In developing the proposal for this project, we acknowledge these tensions. But in doing the research gained a more nuanced understanding of their importance and shape, and have identified important differences between the African countries investigated and those in Latin America and the Caribbean (LAC), particularly in respect to the different weight of national and international sources of funding in the different regions. We investigated the extent to which and how these differences affect possibilities of change. However, future research on transformations should focus on them more centrally.

2. Objectives

The overall aim of the 'Foresight for new collaborative platforms to support LMIC science systems' project was to help to identify how new forms of collaboration between global funders and the science systems of low- and middle-income countries can support the transformative ambitions of the UN's SDGs. Two specific research questions guided our research:

1. What kinds of reforms are underway and which are still needed to enable LMIC science systems (across LMIC, regional and global networks of institutions) to support transformational pathways of development? What would these transformative science systems look like?
2. How are funding flows and other collaborative initiatives - within and across LMICs, regional and global institutions - changing in response to the science system reforms that are underway? How would those flows and initiatives need to change in order to support future transformative science systems?

3. Methodology

The project used two complementary methodological approaches:

1. A novel form of national science system mapping. A process of characterisation of the current national STI trajectories in relation to national stakeholders' sustainable development policy objectives. It is also utilised to begin to identify reforms underway and/or existing elements of a transformative knowledge system, and opportunities and challenges associated with this. This was based on secondary information and interviews undertaken with key informants.
2. Participatory methodologies to identify and understand plural views about desired futures and desired changes for societies and science systems, so that the challenges and opportunities for change identified in the mapping can be addressed and actions that need to be taken to move in these desired futures.

3.1.1 Science system characterisation mapping

An initial mapping of key national science system characteristics was based on available secondary data and the research team's previous direct knowledge and experience. This was then plotted visually and shared with key stakeholders for their development and validation. This method was adapted from Marshall *et al.* (2022), as part of a pilot project funded by the United Kingdom Foreign, Commonwealth and Development Office (FCDO).

Specific funding programmes were examined as the starting point for identifying different types of STI trajectories and aspects of the knowledge system they mobilise and reinforce (or neglect). The information about these programmes was initially organised according to the following categories:

- **Directionality**: The alignment of STI trajectories with development aspirations and priorities. This works on the premise that a transformative science system will build capabilities and capacities to address and link goals associated with economic growth, environmental sustainability, poverty reduction, and social justice.
- **Diversity of knowledge sources**: The comprehensive range of knowledge sources and organisations, formal and informal, public and private, that are included in policy and practice for particular trajectories. This works on the premise that a transformative knowledge system will nurture capacities to link and align formal and informal knowledges and forms of innovation.

- **Focus of innovation**: Prioritised innovation focus between selected firms or networks, or technical or social spheres.
- **Science system infrastructure**: This includes: relationships and networks; institutional, governance, and regulatory frameworks; and capabilities and forms of learning and adaptation that are mobilised and prioritised in supporting particular science and technology trajectories.
- **Policy setting**: The mix of STI and other policies used to enable and direct the use knowledge for innovation and the priorities that inform this.

3.1.2 Foresight for identifying desired futures

We utilised participatory foresight approaches (Hamann *et al.* 2020; Hebinck *et al.* 2018; Pereira *et al.* 2019) guided by and embedded within the characterisation of science systems and associated STI trajectories as described above. For the foresight exercises, we adapted and integrated ideas from the Mānoa method (Schultz 2015) with the Three Horizons framework (Sharpe *et al.* 2016). The Mānoa method identifies desirable future scenarios, based on real world positive weak signals. The Three Horizons approach facilitates discussion about how to move from the present to imagined futures. 'Weak signals' or 'seeds of change' provide the empirical basis for exploring alternative scenarios, and the future knowledge system interactions that would enable them to thrive. This evidence was then used in a process of reflection on the kinds of partnerships, funding mechanisms and other reconfigurations required for transformative science systems.

The identification of 'seeds of change' has been central for our methodology to conduct participatory foresight using the Mānoa Mashup method, which delivers descriptions of preferred futures based on 'seeds of change' (weak signals) found in the present.

These were operationally defined as initiatives that explicitly support and promote ignored or underrepresented aspects of sustainable development trajectories.

The final roadmaps were organised in South Africa and Argentina.

In the next paragraphs we describe different methods we use in the different activities.

- **Future wheels**: Uses a structured brainstorming process to uncover multiple levels of consequences resulting from all types of change. It allows participants to explore and map multiple levels of consequences of trends, events, emerging issues and/or future possible decisions.
- **Three Horizons Framework:** The Three Horizons Framework is a conceptual model to aid peoples' thinking about current assumptions,

emerging changes - the Seeds - and possible, desired futures. It is a graphical approach developed to explore the change in importance of issues over time and connect the future to the present. The Three Horizons Framework is an adaptable tool, and is often used as an intuitive, accessible introduction to futures thinking, as well as to make sense of emerging changes. At its most basic it is a systems model about the way things change over time. It is particularly good for working with complexity, developing future consciousness, and recognising transformative change, whilst exploring how to manage transitions. In this case working with different aspects of desired futures of southern African transformative knowledge systems.

- **Back-casting**: Back-casting works backward from the preferred future to the present. It is a set of participatory steps that allows participants to derive details for how a preferred future can be reached or brought about. These steps can then form the basis of actions to be taken, decisions and policies to be made, and resources needed to create that preferred future. The fundamental question in Back-casting is: “if we want to attain a certain goal, what actions must be taken to get there?” The Back-casting process produces a collaborative analysis of critical key events and interventions that can inform strategies to make a potential scenario or preferred future more or less likely to occur. The results are natural inputs for strategic planning and monitoring.
- **Road-mapping**: Road-mapping is a ‘vision-into-action’ technique which is often used for technology planning to help turn ideas into products or services. It maps potential pathways, with timelines and actions, from the present to the preferred future to help make it possible to reach that future. By drawing on the concept of back-casting, the proposed roadmap design method consists of describing the pathways that are required to realise that vision. Typically, a (good) roadmap is part of a strategic process that helps stakeholders, strategists, and planners to identify, organise and communicate the complex web of decisions, drivers and uncertainties that factor into creating a future scenario or vision.
- **Graphic harvesting**: Graphic harvesting - also known as Graphic Recording, involves a process of careful listening to and synthesising information into an easy to navigate graphic. Graphic harvesting adds engagement and energy into a room, increases group learning, and supports participants memory retention of the content over time.
- **Shell 7 Questions Technique**: This technique was originally developed at Shell to support their strategy development process, and it is used, amongst others, to help identify significant drivers of change. It gathers the strategic insights of a range of external stakeholders about the future and is particularly useful for engaging the opinion of people with a broad view

of the issue(s) at hand, in this case the futures of African science systems and their funding platforms.

- **The Slingshot Method**: A novel method was used by the Latin American team in the final workshop: The Slingshot Method. The objective is to use the metaphor of the slingshot to reflect on the value that present tensions have in imagining desired futures. Uncertainty about the future is often associated with fears, and as a consequence imagination is limited to possible problems. Living with uncertainty, on the other hand, implies embracing the future as a space-time full of possibilities, taking the tensions of the present as an impulse to imagine new worlds.

4. Project activities

4.1.1 Collaborative national science system characterisation process - *March-August 2021*

National science systems were mapped for eleven selected countries in Latin America and Africa. In Latin America these countries were: Argentina, Chile, Brazil, Peru, Colombia, and Dominican Republic, and in Africa they were: South Africa, Ethiopia, Kenya, Rwanda, and Ghana.

The knowledge system mappings were mostly based on existing secondary information and interviews with key informants. Interviews were undertaken with representatives from the government, civil servants in tasks related to the science systems, and researchers. They proved useful in providing an initial picture of the main trajectories or orientation of science systems and the challenges and opportunities for meeting diverse development goals, in each country and region and, on these bases, to identify 'seeds of change'.

4.1.2 Selecting 'seeds of change' – *August/September 2021*

Based up the mapped science systems, 26 'seeds of change' were identified. Reflection on the insights from the initial maps and the opportunities and barriers for transformative science systems was particularly important for linking different backgrounds and perspectives in the team (science technology and innovation studies, foresight studies, action research, and so on) to develop a coherent approach towards linking 'seeds of change' with insights into how funders might support transformative science systems.

4.1.3 First regional foresight workshop - *September/October 2021*

Two foresight workshops were organised, one in Africa led by Centre for Complex Systems in Transition (CST) and the other in Latin America led by Centro de Investigaciones Para La Transformación (CENIT). The objectives of the workshops were to connect the preferred future visions to the present by means of constructing potential pathways using back-casting and road-mapping (see Section 3 for a detailed description of the methodology).

For the Latin American digital workshop, 25 participants from six countries (Argentina, Peru, Colombia, Brazil, Chile, and Dominican Republic) were present, representing six seeds (including the organisations Bioleft, Gorgas Tracker, Chicas Porgramdoras) as well as three wildcards.

For the African workshop, nine participants from seven different countries were involved, including participants from four African countries (Ghana, Kenya, South

Africa, and Rwanda), representing organisations such as Africans Science, Technology and Policy Institute, and Aphrike Research. Participants from Sweden, the Netherlands and the United States of America (USA) with significant experiences of working in the African STI research domain also participated.

4.1.4 Regional interviews - *February/March 2022*

In Latin America, we carried out two in-depth group interviews with two members of CENIT and at least two representatives of different 'seeds of change' (including Bioleft, Gorgas Tracker, Lab techno-social, and Parana River Aquarium). The objective of these interview was to better understand:

1. The ways in which Latin America's existing national science systems have provided opportunities and support for the funding and development of our alternative case studies, 'seeds of change', and in which ways those science systems have acted as barriers to their funding and development.
2. How national science systems might better support the creation and flourishing of these types of initiatives.

In Africa, the second workshop built on the scenarios ('imagined futures') that emerged from the first workshop (which took place in September 2021). It was important to explore strategic pathways that could strengthen decision-making across regional and national science systems through the creation and flourishing of more inclusive and collaborative STI knowledge and funding initiatives.

4.1.5 Final regional workshops - *May/June 2022*

The final global workshop was replaced by two final regional workshops. This decision was taken as we learnt from previous activities that there were regional specificities and language barriers that made a global focus too general and difficult to implement.

In Latin America, the objective of the workshop was to discuss the main conclusions of the foresight workshop with representatives of the Argentine scientific and technological system. The workshop also explored innovative participatory methodologies to imagine what types of scientific systems could give rise to the growth of 'seeds of change', which tensions emerge in the development of these types of scientific systems, and a roadmap for their transformation. The workshop drew upon experimental foresight methods to generate and explore perceptions of alternative futures, and the science systems that could help in bringing those futures into being. Foresight methods are well-suited to uncover assumptions that inform novel practices and ideas and foster a

safe space for reflecting upon cross-linkages and synergies between different causal spheres of innovation.

In Africa, the final workshop brought together a small group of experts (researchers and policymakers) to discuss and share experiences on how funding prioritisations in STI may be needed to be revised to better inform policy recommendations and action plans for realising the strategic direction necessary for attaining transformative knowledge systems in Africa (preferred futures) set out in workshops one and two.

5. Project outputs

With the project recently concluding at the time of writing this report, the main outputs to date have mostly consisted of reports, cross learning, presentations, capability building and networking.

5.1.1 Research outputs

The project produced three main reports: one methodological report, describing the foresight methods used in the project. The other two reports described processes, activities, learning, and intermediate project outputs.

The project also has a webpage, and a blog that will be published by the Institute of Development Studies (IDS).

We aim to develop two additional outputs: a research article to be published in the journal *Research Policy* and a follow-on project, to continue research on some of the key challenges identified (see Section 7 Overall assessment and recommendations for further detail on these).

5.1.2 Milestones achieved in knowledge-building and networking

Through the activities of the research project a network of researchers was developed combining capacities, skills and experience in (i) foresight methods and, (ii) research and action in topics related to science and innovation policy. The network included researchers from a number of different countries in Latin America, Africa, and the United Kingdom (UK).

5.1.3 Capacity

A number of young researchers have been trained in the two main areas of the project: Gabriela Bortz (CENIT, Argentina); Almendra Cremasci (CENIT, Argentina); Rocío Palacin (CENIT, Argentina); and Nora Ndege (Science Policy Research Unit (SPRU), University of Sussex Doctoral candidate from Kenya).

Policymakers and representatives of the ‘seeds of change’ that have been directly involved in the project have also benefited from the project and will continue to be connected to the researchers for follow up activities.

6. Project outcomes

6.1 Different kinds of outcomes

This project was a pilot/exploratory initiative to trial a new package of methodologies and help build networks and communities of practices. It would be positioned in the early stages of a theory of change to catalyse, promote and facilitate changes in funding and funders arrangements (across behaviours, practices, capacities, and relationships) in support of transformative science systems. In this section we discuss first the main learnings from the project in relation to the general questions that guided our work, and second the application of the methodologies for the exploration of these questions.

The main learnings from the project questions posed are organised into two sections:

1. The main characteristics and challenges of current science systems.
2. Shared visions about the future and actions required to move towards this desired direction.

6.1.1 Characteristics and challenges of the current science system

Based on the mapping of science systems we identified three types of challenges preventing movement towards the meeting of multiple development goals:

1. The main underlying rationale of the systems.
2. Regional focus.
3. The connectivity, integration, and linkages within a science system.

Main underlying rationale of the science systems studied

Most of the science systems studies are still ‘curiosity driven’. When parts of them are ‘problem oriented’ they mostly focus on issues related to economic objectives: growth, the competitiveness and technological upgrading of economic sectors or to a much less extent, though present, poverty reduction. Other objectives, though might be present in declarations or reports about the objectives of the system, do not receive substantial funding or support.

As a result, the current systems are mostly not well linked to potential users of newly produced knowledge. In instances when the link to users has been established, it has been achieved mostly with the private sector, companies, or industry associations. The isolated cases of well-functioning systems where

scientists have cooperated with users (e.g., Bioceres in Argentina) were the result of active policies that have been promoting university-industry linkages with the purpose of addressing the inherent isolation of curiosity-driven systems. These policies have not, however, been oriented with the same intensity or funding needed to encourage linkages or associations with other types of users (such as civil society groups seeking to make large corporations accountable for their actions, feminist movements, indigenous peoples, and environmental associations), or to pursue objectives other than growth and competitiveness.

There are exceptions to the above, but this captures the general pattern. Three good examples evidencing this are in Argentina, Chile and Kenya. One exception is Ethiopia, where significant efforts have been devoted to encouraging the science system to directly work with marginalised groups. Some of the differences between systems in Latin American countries and the ones evaluated in Africa reflect the different weight of international and national funding in the systems. In Latin American countries, national funding has greater weight, while in African countries international funders are more dominant. Where domestic funding is more dominant, we observed greater efforts dedicated to support the growth and competitiveness of domestic sectors. In contrast, where the weight is more towards international funding, the agenda moves in the other direction, with more alignment with the priorities emerging in global forums, incorporating multiple development objectives.

There are exceptions also within systems. We found interesting cases from curiosity-driven parts of the system that link well with demands related to development objectives different to growth. In LAC countries, for instance, the most interesting cases of linking with environmental sustainability issues, or with including marginalised groups, have been in the context of curiosity-driven programmes, where researchers have autonomy to shape their own agendas. Since these are not linked to specific programmes, however, the support they receive is limited. For instance, where systems are mostly salary-based but offer a lack of provision for the inputs for doing research such as funding for fieldwork, attending diverse development objectives is more challenging to achieve.

Regional focus

A second important problem identified within both the science system mappings and the engagements with stakeholders in participative foresight workshops, as well as from interviews, was the regional focus. National systems that follow mostly ‘curiosity driven agendas’ or are problem-oriented but connected mostly to national objectives of growth do not connect well with regional or localised demands. Nevertheless, environmental and social problems are very local and require locally adapted solutions. Initiatives like the ones promoting open

science projects or those that aim to bridge disciplinary boundaries incorporating, for instance, non-formal knowledge to be progressive and really address the requirement of attending multiple development objectives need to connect with the needs of communities that are not well represented in the formal systems, and which are often geographically dispersed. Centralised systems that fund only or mostly agendas of curiosity-driven scientists that live and develop frontier research disconnected from local realities encounter problems in moving in the direction of attending demands that come from diverse territories.

Connectivity, integration and linkages within a science system

Transformative change requires attention to patterns of governance, cooperation and participation that encourage a wide set of stakeholders to steer the priorities for STI investment and associated capacity building, and the outcomes that these seek to achieve. Our work is revealing how improved connections between the different parts of the science systems, and with the wider knowledge and innovations system, have the potential to support these processes; and importantly how priority interventions might be identified through attention to emergent initiatives. New, emergent initiatives, with transformative potential are not the norm, by definition. They receive limited support, particularly from formal national science systems. In the short- to medium-term, it is very unlikely that national systems will be significantly redirected to support alternatives. The transformative potential of these alternatives can only be realised and amplified, therefore, if they can connect or link in various ways to other parts of the system that are better supported and funded. For instance, much of the research funding has a disciplinary focus, based exclusively on formal knowledge. Nevertheless, many of the seeds require integration of formal and informal knowledge (e.g., Bioleft), as well as research guided by local problems rather than by disciplinary agendas.

6.2 Shared views about desired futures and actions that need to be taken

The work done in the foresight workshops revealed that aspirations were common across different kinds of stakeholders and regions. They all pointed in the same directions. Central elements to these aspirations were: justice and equity; respect and valuation for diversity; freedom; autonomy; sovereignty; and distributed wealth. Some of these aspirations are aligned with the ideas underlying multiple development goals, which is not entirely surprising given the selection of the ‘seeds of change’. But the work also led to ideas about how to move in the direction of these aspirations. On this, the notions that appeared repeatedly were innovation and adaptation, democratisation,

decentralisation and autonomy, distribution of knowledge, integration and cooperation, respect for the common goods, participation, economic democratisation, locally added value, and the empowerment of minorities, particularly of those that are not well represented in the existing markets and institutions.

In the next sections we describe how the findings from the final two activities of the study oriented a roadmap towards delivering realisable change and action.

First, we describe four areas of change in funding systems that need to be addressed or considered to support progressive transformations in science systems: the general direction of the systems, the approaches to perform research that are prioritised, the areas of intervention, and specific actions.

Second, we discuss some key tensions needing to be manoeuvred in order to move in this direction, and implement effective actions and conclude with some key ideas or actions to consider to promote radical changes.

Table 1. Four areas of change

General directions of change, new approaches to move in these directions, and specific actions to take.

The direction where knowledge systems should move	Areas where focused funding would encourage movements in the desired direction	Areas of intervention	Specific actions
Equality Justice	• Locally or contextually generated and/or adapted knowledge • Problem oriented, transdisciplinary research • Integration of formal and informal, and academic and non-academic knowledge • Participation and collaboration between a diverse set of	Orientation of the systems	• Projects that need extra support: ◦ Projects and support platforms involving multiple stakeholders ◦ Projects that use open science in all the stages - from design to data collection and diffusion ◦ Locally driven projects that respond to local demands ◦ Projects connecting local and national partners ◦ Transdisciplinary projects ◦ Projects that involve knowledge sharing in multiple directions

Freedom Autonomy Sovereignty Human wellbeing	stakeholders (academic and non-academic) • Democratisation of processes of knowledge generation • Distribution of knowledge between larger groups • Applications of knowledge to solve social and environmental problems	Evaluations systems Instruments	◦ Projects that connect with demands from domestic policymaking ◦ Projects that involve knowledge development based on scientific and other kinds of knowledge • New incentives for: ◦ Action-oriented and impactful research ◦ Contextually driven and oriented research ◦ Transdisciplinary research ◦ Multi-stakeholder initiatives, involving non-academics ◦ Outputs other than journal articles e.g., blogs, and artistic pieces ◦ The sharing of results of processes that failed ◦ Platforms for sharing, to reduce knowledge asymmetries ◦ Programmes oriented to support experimentation with novel approaches ◦ Programmes to support research about “deconstruction”

			◦ Programmes to support knowledge creation and sharing by non-academic communities ◦ Programmes to support long-term research ◦ Funding users through user active involvement ◦ Programmes to promote science policy making interactions

Tensions and enablers identified to move in these directions and implement effective actions

Our mapping, scenarios and road mapping exercises helped to identify how existing novel initiatives could inform and influence wider processes of transformative change. The national science system characterisation maps worked as boundary objects to consider the current state of the national science system, and its transformative potential (broadly what needs to be transformed for whom and how) from the perspective of different world views. This included consideration of the structure and function of the national knowledge systems in relation to diverse and shifting sustainable development priorities. This characterisation continued to be an anchor or reference point for the selection of 'seeds of change' through which scenarios for more transformative science systems could be explored. And later as baseline for reflecting on the priorities and possibilities for specific interventions and systemic science system changes.

Underlying the development of the scenarios and road map exercises was a shared understanding that it is not enough to target specific components of a science system, looking for additions, amendments, and extensions to already stretched initiatives. But that the focus should be on key leverage points, such as critical alliances and associated bundles of interventions that will enable them to catalyse and nurture more systemic change. The purpose being to cause a disruption of science systems overall and recognising its central role in re-orientation towards inclusion and sustainability. But also, importantly, paying attention to the properties of a re-oriented science system that will enable it to remain adaptive and responsive to future challenges, both known and unknown.

However, our research also emphasises the need to recognise, accept, understand, and address fundamental but often overlooked tensions in science systems. We maintain that this will underpin the possibilities of establishing realistic intervention pathways - and thus this focus becomes a core enabling process.

Our work made clear that beyond the identification of the main areas of change, and instruments, work on transformations of the science systems should recognise more centrally and identify ways to address imbalances of power and the types of tensions in the system that are limiting and delaying processes of change.

In particular, the study advanced ideas about concrete changes in funding that would involve actors in different positions in the system and through this analysis we identified clear tensions and trade-offs between the following groupings:

1. Global and local agendas and priorities.
2. Formal and informal knowledge.

3. Focus and diversity of knowledge (s) and programmes.
4. Proprietary and open systems.
5. Market-driven and society-driven research.
6. Funding goals and funding people.
7. Theory broad and contextually driven initiatives.
8. Independent research and research connected to specific demands.
9. Funding of infrastructure rather than people.
10. Giving continuity to projects and supporting diversity and experimentation.

With actors in different positions of power representing polar sides in these tensions, an agenda of work that aims to promote progressive changes should consider more centrally ways in which to work with them.

Less powerful actors need to be empowered not only within research projects and programmes, but their views and interests should be represented in discussions both about changes in the systems and about funding programmes.

In other words, the systems might need to move from democratising knowledge generation processes, or research projects (through open science) to democratising funding decisions, funding processes, between countries and within countries. This may be from open science to open funding, or from engaging multiple stakeholders in research programmes to engaging them in funding decisions.

A second important change would be to give more emphasis to understanding processes of negotiation and politics of knowledge. Ideas about knowledge sharing do not capture the complex issues involved in the participatory formula of new knowledge generation and diffusion involving multiple stakeholders, from academia and from outside academia. Often there are hierarchies of knowledges and actors that represent them. When participatory or open processes are implemented, the hierarchies and asymmetries that they involve become very relevant. Without actively addressing these, projects are likely to stay open in the stage of design but not in the results produced.

Finally, ideas and actions to support changes in science systems so that these can address multiple development objectives should recognise more centrally that national and global actors have different interests and that different actors within national systems have different priorities and agendas. With limited funding and resources, different objectives and priorities create a clear tension.

6.3 Cross learning

The project involved significant cross learning between the research teams in IDS, CENIT and CST. The research teams within the IDS and CENIT already

had significant experience work with STI policy in LMICs. CST contributed broad experience in a range of foresight methods. Both groups have worked in research and action projects in different kinds of contexts. The initial stage of the project was dedicated to the exchange of ideas and experience with the aim of developing an appropriate and refined methodological approach. From these interactions and learning processes we identified that for better results we should use at first a combination of novel national science system characterisation and participatory foresight approaches to explore the study questions and surrounding ideas. Following this, the approach was to experiment with novel methods to involve actors in the decision-making process in discussions with actors from the ‘seeds of change’ grouping. A key benefit of ‘mashing up’ a set of ‘seeds of change’ as part of a scenario exercise is that this generated a more creative and comprehensive discussion about how things should and could change. The experimentation of novel methods was necessary to address issues of positionality and power between the different types of actors.

Cross learning was also intensive in working with the ‘seeds of change’ in the different regions and specific countries, since we had to interact with researchers active in different contexts with different views and experiences of what a seed of change represents.

The experience meant that both senior and early career researchers learnt in the process.

Based the work undertaken we were also able to begin to develop a community of reflection and practice to lay the foundations for continued work on the project’s core questions that will be central for an agenda of transformation of science systems. This community involves researchers from different disciplines and policymakers and funders from different regions and positions within existing systems.

7. Overall assessment and recommendations

This project was a pilot exercise that involved significant experimentation and cross learning between and within teams. We consider that our project can be seen as a precursor to more detailed assessment of the key catalysts and mechanisms of change that will support the building of transformative science systems and the role of funders in nurturing them.

As discussed, we learnt within and between the groups both about contents and methods, and we also improved understanding in these two important areas for future research and actions. In terms of methods, we learnt not only how to apply novel approaches to perform participatory foresight to explore questions in the field of science and innovation policy, but also how to adapt and use some of the most recent ideas within science and innovation policy research to enrich foresight exercises in this area. One example is the use of science systems mapping as a starting point for the selection of the 'seeds of change' and to guide participatory foresight workshops.

These novel approaches that emerged from our project work are particularly well adapted for unlocking challenges and therefore have the advantage of offering the possibility to reflect and experiment with both **ideas** and **practices.** This seems crucial in this area where the required changes are urgent and new and very important ideas about the kinds of changes needed have emerged recently, but significant challenges remain for their implementation in some cases.

As argued, this work was experimental but has significant potential to be applied to explore additional questions in future research and action. For instance, our work focused mostly on local context, but there is significant potential to extend it to global settings and actors.

Through expanding to experiment with other contexts and settings. one important learning from the project was that broad characterisations like global north and global south or LMICs hide very important differences across countries, so these must be used with caution. Our work identified indeed very similar desired futures and aspirations between countries and regions, however in advances to try to understand the challenges in moving in these directions, the realities were that there existed substantial differences between countries. Countries with limited resources dedicated to science policy are more dependent on international sources of funding, and there international funders have a significant influence in the research and policy agendas; while those that have more resources and invest more in science policy have less influence from international donors but face significant pressures from domestic actors with power within the national economic system to move scientific research and

impact in their directions. This is validated by the idea that the science system should respond to domestic vested economic interests.

Our work in multiple contexts in Africa and Latin America (involving many different kinds of stakeholders) also pointed to a need to focus on critical tensions. Each of the proposed changes outlined above involve multiple tensions, which need to be revealed, accepted, understood, and addressed if a real and profound transformation is to be pursued.

System level tensions: negotiating allocation of funds within countries

First, development goals cannot be piled up, whereby new practices are simply added to the old to create more options. LMIC economies are still struggling to make their systems respond to demands from the private sector, which was considered crucial until very recently to support economic growth. However, the links are not working effectively, and economic growth is still very unstable in many countries. The need to respond to an increasing set of goals emerges as an additional challenge. In many cases this introduces serious pressures and tensions to their already fragile systems and decision-making processes. Issues of power and vested interests, and in particular the uneven distribution of risks and benefits from changes in the science system adds additional tension. In many Latin American countries, which are mostly nationally funded with local interest groups possessing more power to exercise pressures to shape the system in directions that favour them, it becomes very difficult to attend to the needs of diverse actors and sectors in less powerful positions. In countries which are more dependent on international sources, as a number in Africa are, the pressure to follow a foreign agenda is felt strongly, potentially limiting appropriate contextually relevant changes. If these tensions are not understood and addressed by the science system itself, then any attempts at change will be only too little and too late. This is where the ideas of collectively focusing on key leverage points and alliances which can mobilise the **synergistic delivery** of multiple development goals is so essential.

Project level tensions: empowering different forms of knowledge

Second, power tensions within projects need also to be considered. Ideas about knowledge sharing do not capture the complex issues involved in the participatory or open work of new knowledge generation and diffusion involving multiple stakeholders, from academia and from outside academia. It is not an issue of who is at the table, but on what terms. This includes consideration of who´s knowledge counts, how to support real collaboration and the integration of the different forms of knowledge, and when different forms of knowledge provide different responses to the same problems. These tensions have been identified before, but what our project made clear is that new research needs to be supported to understand how to navigate these with greater precision. If different

forms of knowledge need to be integrated, then we need to understand better how to manage the tensions that this integration will bring.

Between project tensions

Finally, we identified a number of ‘seeds of change’ which are delivering in the regions studied; they are experimenting with new forms of participation, opening processes of knowledge, addressing gender and other kinds of imbalances and inequalities, and tackling serious environmental problems. When we look at these projects individually their results are excellent. However, they are usually isolated within national systems which are still mostly oriented to support growth, and often supported by international funders at small levels, where funding remains competitively sought, and erratically dispersed. Unfortunately, there remains a lack of spaces for experimentation favouring ongoing collaborative reflexive learning with funding organisations – both national and international - about which alliances, processes and forms of support are most effective and about how short-term funded programmes will deliver on more than a sum of their parts in mobilising transformative potential in science systems at various scales. Key decisions about funding are still very concentrated within countries and between countries.

We might have reached the point when funding decision processes, and not only funding mechanisms and instruments might need to change if we are serious about desired transformations and their urgency. These processes need to be democratised. Less powerful actors should be empowered not only within research projects and programmes, but their views and interests should be represented in discussions about changes in the systems and about funding programmes. In other words, we should move from democratising knowledge generation processes, or research projects (through open science) to democratising funding decisions, funding processes, both between countries and within countries. From open science to open funding.

Up to now, attempts to democratise science have tended to put the burden directly onto researchers and their delivery partners, who now face pressures to open up processes, and demonstrate new, extended and deeper impacts. But if democratisation reaches all the areas of the system, including funding decisions, the results might be substantially improved.

Finally, as discussed before, a large part of the resource for this project focused on the foresight exercises. This provided important insights into the possibilities and limitations of these approaches. Our initial attempts to link this with participatory mapping of transformative science systems showed considerable promise. However, it would have been beneficial to have been able to allocate more resource to understanding current funding arrangements (both mainstream and novel and the alliances of actors involved), and to explore with funders their aspirations and actions in terms of ‘seeds of change’, and alongside other

stakeholders, the barriers and opportunities that different configurations of funding present. What is the appetite and opportunity for funders to move forward through the routes identified? Such an approach would have enriched the dialogue on the specific levers and catalysts of transformative science systems that funders might prioritise in particular contexts.

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