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POLICY BRIEF

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Framing science, technology and innovation measurement:
20 years of evolution towards a future agenda and participatory process

Introduction

The Decadal Plan (DSI 2022a) aims to propose ways to pivot the national system of innovation to impact on South Africa's persistent socio-economic and environmental development challenges. It implements the White Paper 2019 vision for Science, Technology and Innovation (STI) "enabling inclusive and sustainable South African development in a changing world". This vision is aligned with the National Development Plan, and the global commitment to STI-oriented systemic transformation to achieve the Sustainable Development Goals (SDGs) (Box1).

There is growing recognition of the need for evidence-informed policy making that can provide a foundation for democratic debate, and that provides useful knowledge for policy actors. For the Department of Science and Innovation (DSI) to assess the transition requires two new kinds of policy evidence. First, in line with the national practice led by the Department of Planning, Monitoring and Evaluation (DPME), DSI has designed a framework and process for monitoring and evaluation of its own policy programmes, investments and activities (DSI 2022b). Second, the larger challenge is to conceptualise and design a new framework of STI indicators that can evaluate progress towards achieving the desired inclusive and sustainable policy outcomes, reflected in changes in the national system of innovation, in positive socio-economic change and reversals of environmental degradation.

This policy brief aims to contribute to the second task. How can we build on current capabilities to align indicators and measures more strongly with policy efforts to address our persistent socio-economic challenges?

Indicators are not neutral, and have many applications, not least that they reflect and shape policy and public narratives of what goals and types of STI are considered to be important. Whereas in the past decades, the same innovation policy and measurement models were applied in any context, now, there is a growing emphasis on how to design an innovation policy mix to address the ways in which global challenges play out in each country.

Dominant indicator models and normative assumptions may be limited, or not suitable, for assessing the impact of the Decadal Plan, which is based on alternative development models and capabilities.

To inform and catalyse such a conversation, this policy brief first traces the evolution of STI measurement over the past twenty years, demonstrating a shift in framings, from simple indicators primarily focused on the goal of economic growth, towards more comprehensive and multi-dimensional indicators adapted to context. Second, it describes an ongoing process of experimentation by the Centre for Science, Technology and Innovation Indicators at the Human Sciences Research Council (CeSTII-HSRC). Finally, a participatory process is proposed that can be replicated to conceptualise, design and populate new STI indicators.

Three framings for policy and measurement: how have indicators evolved over time in South Africa?

STI measurement in South Africa has a long history, dating back to the 1960s, through adoption of the global standard of OECD models. To trace the evolution of STI measurement and indicators, it is useful to draw on insights from the Transformative Innovation Policy space. Schot and Steinmueller (2018) mapped out three "framings" that underpin the logical design of STI policy. These have emerged sequentially over time, in response to specific growth and development challenges, as in Figure 1 below. All three framings continue to operate in parallel, and to shape our policy thinking and practice in South Africa.

Box 1: Key activities required for the transition to pivot the national system of innovation towards the Decadal Plan's STI priorities.

- Using STI to modernise key sectors of the economy – modernising manufacturing, mining and agriculture – to drive competitiveness and productivity improvements and, ultimately, higher GDP contributions
- Exploring opportunities presented by the emerging circular and digital economies as new sources of growth
- Harnessing the capabilities built by the NSI to drive innovation across key sectors – health and energy
- Using STI in support of an STI-enabled, capable state, enabling improved service delivery and decision making
- Using STI to support social progress – eradicating poverty, inequality and unemployment
- Using STI to address the three societal grand challenges (SGCs) in relation to: climate change and environmental sustainability, future-proof education and skills and the future of society

Source: DSI (2022a), p. 37.

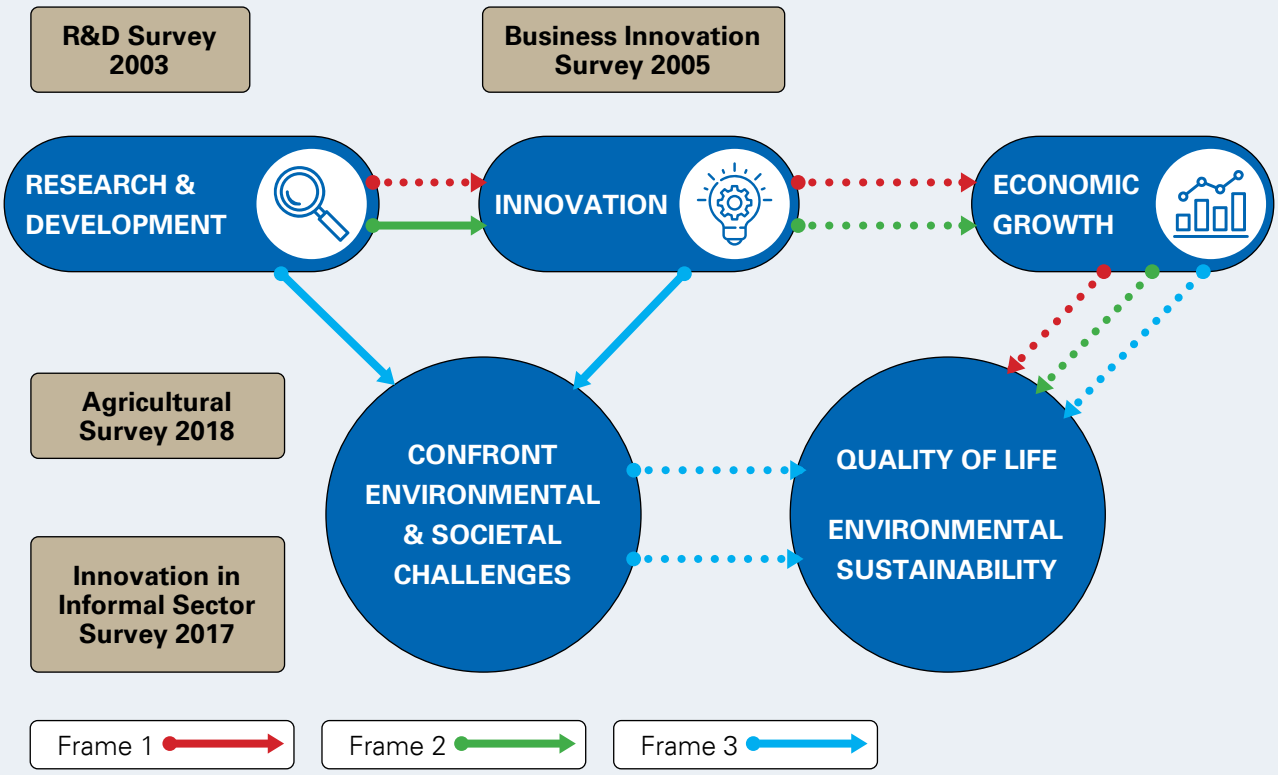
Framing 1: a linear science push for growth underpinning measurement

From the outset, the DSI mandated CeSTII-HSRC to conduct national research and development (R&D) surveys, to provide indicators of the scale of knowledge creation. Over time, the data was recognised as national statistics by Statistics South Africa, and used by the OECD and the UNESCO Institute for Statistics for global benchmarking.

In this period, indicator research was informed entirely by the first framing, which valorises R&D as essential to economic growth, and tends to adopt a linear, science push, causal model. The argument is essentially that the more governments invest in R&D and scientists, the more science can address market failures in private provision of new knowledge. This knowledge can then be commercialised through innovation, to contribute to economic growth.

In this model, the STI measurement challenge is simple: calculate the total amount of domestic funds invested in science and research, to reflect research intensity. The way in which R&D would enable innovation or impact on economic growth is not specified, nor measured, and consideration of the impact on quality of life or sustainability is absent in this model, reflected in the dotted lines in Figure 1.

Figure 1. Mapping the evolution of three framings of STI measurement in South Africa 2003 to 2023



Source: Adapted from Transformative Innovation Policy Consortium https://www.tipconsortium.net/

Framing 2: innovation systems and flows of knowledge informing measurement

From the 1980s, globally, it was recognised that science does not work in such a linear way. Competitiveness is shaped by dynamic national systems of innovation that enable creation and flows of knowledge, technology and resources. The second framing logic is informed by the innovation studies paradigm, which holds that the better the enabling conditions, learning and flows between networks of actors and supporting institutions in an innovation system are aligned, the better an economy will grow. To assess the impact of R&D directly, measures and indicators of business innovation, technology transfer and commercialisation are designed and used.

This framing also assumes that economic growth will result from innovation, and recognises that it will impact on societal development needs, but how this is done is not measured, nor explored, which is depicted in the dotted lines in Figure 1.

Framing 3: transformation and societal grand challenges for measurement

In our contemporary world, the emphasis shifted dramatically to a third framing model, recognising that value can be realised only if all citizens are included and have access to new advances in science and technology. The role of the scientist changes to tackle pressing societal and environmental challenges, through driving socio-technical systems change in desired directions. This is evident in the changing nature of performance indicators for researchers, beyond publication counts to a notion of impact on the SDGs, for example.

The third framing involves deliberating and exploring goals and underlying values, and embedding them in participatory processes oriented to systemic change to achieve the SDGs. The focus shifts to directionality, participation, anticipation and policy experimentation.

This creates a need to measure and understand how R&D and innovation are directly oriented to confront challenges to improve the quality of life, and how, in the process, they will intentionally drive economic growth and transformation.

Building on existing indicators to reflect new policy directions

How should STI measurement in South Africa change to reflect new Decadal Plan commitments and shape policy evolution?

The logic of the Decadal Plan is informed by framing 3 assumptions to pivot the national system of innovation. In reality, policy actors will not, and do not need to, abandon the first two framings completely. Schot and Steinmueller (2018) propose "layering" policy evolution from the lens of third framing, so that new goals and new instruments are added intentionally. The challenge is to assess how STI plays a role in driving changes towards the desired social, economic and environmental future envisioned.

This is the task with which the CeSTII-HSRC team has been grappling since 2018 – an experimental process of "layering" to devise new kinds of measures and indicators of societal impact of STI, to enable shifts towards a new national indicator conversation.

We recognised the need for new kinds of evidence to build on and complement existing measures, informed by new policy goals, directionality and participation. At the same time, we continued with the core mandate underpinned by framing 1 and 2 thinking.

The team has worked progressively, and in an incremental manner, to experiment in a range of intersecting ways with framing 3 thinking:

1. Challenge-led analysis of existing R&D and innovation data
2. Challenge-led stretching and extending analysis of R&D and innovation data
3. Challenge-led creation of new datasets
4. Designing and adopting new frameworks that encompass measures of outcomes and impact.

To realise the full potential of this approach requires a conversation to coordinate national effort across DSI and its entities. In the next sections, we provide examples of our experimentation thus far, illustrating but four of many possible kinds of new measures and indicators.

Challenge-led analysis of existing R&D and innovation data

A simple and very easy change was to analyse existing datasets in new ways, in terms of wider policy priorities and directions. For example, we typically use R&D data to create evidence of the

potential of the science system as an aggregated whole to support economic growth, but the kinds of policy insights possible from such indicators are limited.

CeSTII-HSRC added disaggregated analysis of the potential of R&D investment to address national development priorities, in relation to SDG priorities, spatial and sectoral distributions of expenditures and human resources.

Challenge-led stretching and extending of existing data

Framing 3 thinking foregrounds inclusive transformation. To shift thinking and to alert policy actors to the importance of science for societal impact, we designed a model to complement the headline indicator of Gross Expenditure on R&D as a proportion of Gross Domestic Product. The model proposed a measure of how much R&D is oriented to human development, changing the ways in which we think about R&D intensity.

Another example is disaggregation of national business innovation statistics to identify the modes of innovation capabilities in a sector, or region, or nationally, and then, profiling the firms that use each mode. This has the advantage of providing more granular and contextualised empirical evidence of firms' technological and innovation capabilities, as the foundation for policy intervention and implementation. Policy actors can use this to determine how the STI policy mix can be targeted to grow from what exists, in relation to what is desired, rather than in relation to the precepts of generic policy models.

Context-specific and challenge-led creation of new data

Adding modules to customise innovation and R&D surveys, informed by South African innovation policy and development priorities, can also begin to create measures more suitable for evidence to inform policy.

To facilitate the creation of more in-depth data in contextually significant spaces, CeSTII-HSRC used the Oslo 2018 innovation survey as a core instrument. The new, broader definition of innovation adopted allows for the design of surveys in new priority sectors. To adapt the surveys, and to analyse the data effectively, required the use of qualitative methods, typically case studies based in a sub-sector, or region, or institutional sector.

In 2018, CeSTII-HSRC piloted an agricultural business innovation survey that creates new data on innovation in commercial agriculture, providing evidence essential to monitor how STI addresses food security in a context of climate challenges.

From 2017, CeSTII-HSRC designed and implemented an adapted business innovation survey in informal enterprises in a peri-rural area, which required much more methodological experimentation and learning. This research yielded insights into the specific modes of innovation capabilities in a sector that provides livelihoods for millions of marginalised South Africans.

In the mining sector, new surveys aim to measure how R&D and innovation are oriented towards the policy goal of modernisation. In the state-owned enterprises (SOEs) sector, a measurement framework was designed to shape and monitor how SOEs can gear up to strengthen R&D and innovation systems in ways that enable them to manage complex technological and environmental challenges.

This approach shifts the available evidence from a bias on R&D and innovation measurement of formal firms in manufacturing and services in urban areas to include firms in primary sectors, and in township economies and rural areas. Such new customised data allow for a more holistic assessment of the rates and modes of enterprise innovation that are currently found in our country.

Designing new indicator frameworks to measure change and impact

To deepen the layering of framing 3 thinking, the current challenge is to experiment with ways to measure the changes and benefits that may result from policy interventions, and whether they are having the desired impacts.

CeSTII-HSRC has experimented with the design of customised complementary frameworks of STI outcomes and impact, drawing on multiple sources of available data, to create more empirically comprehensive and rigorous evidence.

Table 1 illustrates one such framework, oriented to SDG 2, eradicating hunger and ensuring food security, to layer onto standard measures of agricultural R&D expenditure. It assesses the innovation activity of key actors – small, medium and large commercial enterprises – in the agricultural production component of the food system. The framework and selection of measures is informed by the Decadal Plan policy goal to expand industrial inclusion (as distinct from social or spatial inclusion) and to enhance modernisation and sustainability in agriculture.

Table 1. Indicator scheme for policy intent: technological upgrading to modernise and strengthen agricultural production for export, to grow jobs and to build a sustainable, resilient food system

Indicator	Measure	Items used to construct measure	Data source
Modernisation of agricultural production	Increased science and technological intensity of ALL agri-production enterprises	Create measure of modes of innovation, using dimensions of novelty, role, activity	AgriBIS series
	Increased technological capabilities in medium and small agri-production enterprises	Mode of innovation disaggregated for SMEs only	AgriBIS series
	Use of advanced/digital technologies by commercial enterprises	Use of at least one of a set of advanced technologies by innovative enterprises increases or decreases	AgriBIS series
	Intent to use advanced technologies by commercial enterprises	Intended use of at least one of the sets of advanced technologies by innovative enterprises increases or decreases	AgriBIS series
Sustainability of agricultural production	Effect of innovation on exports	Increase or decrease of exports over time, and relative to balance of imports	AgriBIS series
Growth in agricultural exports	Negative climate effects improved as outcome of innovation	Outcomes of innovation tackled: biodiversity, water preservation, soil fertility, reduced greenhouse gas	Stats SA/DTIC
Growth in agricultural jobs	Effect of innovation on employment creation	Increase or decrease of jobs over time for innovative enterprises	AgriBIS series
		Increase or decrease of jobs over time for all agricultural enterprises and all enterprises nationally	StatsSA/QLFS

A participatory process of co-design for the future

Large scale and coordinated conceptual and technical work is required to design such frameworks and measures of outcomes and impact, and it requires the contribution of multiple expertises. A participatory process was extrapolated from our experimentation, which can be replicated to conceptualise, design and populate new STI indicators in a range of focus areas and priorities.

Figure 2. A participatory process of co-design of new indicators

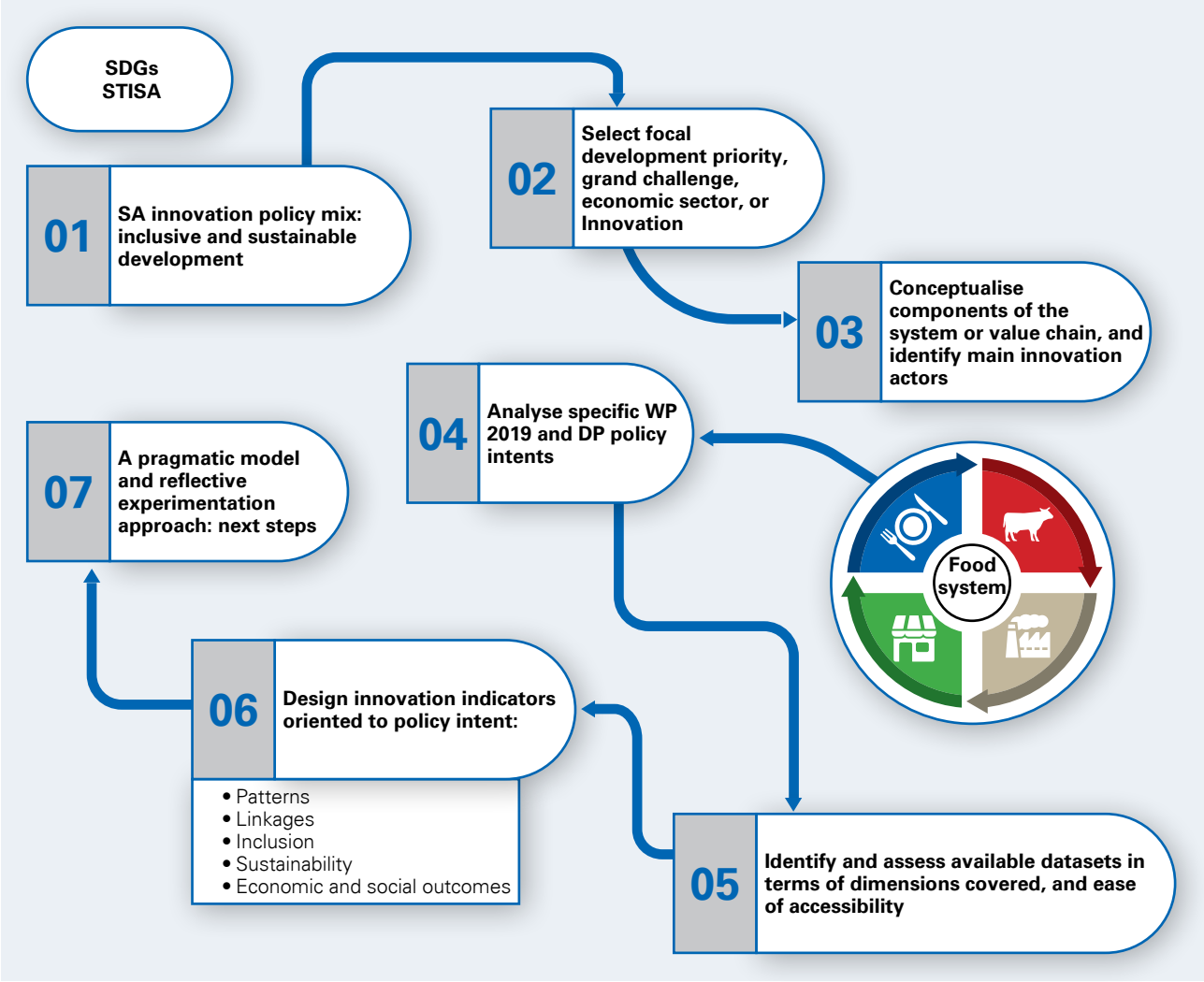


Figure 2 depicts a model for how we can layer by building on, extending and complementing standard indicators in our own context, in a feasible manner. The process requires accessing multiple datasets, from innovation and firm surveys, from administrative data and from national statistics, as well as the creation of new datasets. Such a design process itself strengthens the kinds of knowledge flows and networks required for societal impact. It requires expertise from STI policy analysts, from a range of sectoral experts from public and private sectors, from measurement experts, from government users and from practitioners.

The process highlights that it is not enough to have good data. It also requires new policies, structures, resources and instruments to build stronger eco-systems, with new kinds of competences, and different kinds of governance. And, it requires deliberate action to take into account social biases, values and cultures that may affect knowledge production and the use of science and evidence.

Through such a process of co-creation, we can begin to build the kinds of eco-system required to conceptualise and design STI indicators that more effectively provide evidence to inform progress towards the goals of the Decadal Plan. This is the task that will guide the work of CeSTII-HSRC over the coming decade, in partnership with DSI, StatsSA and NACI.

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