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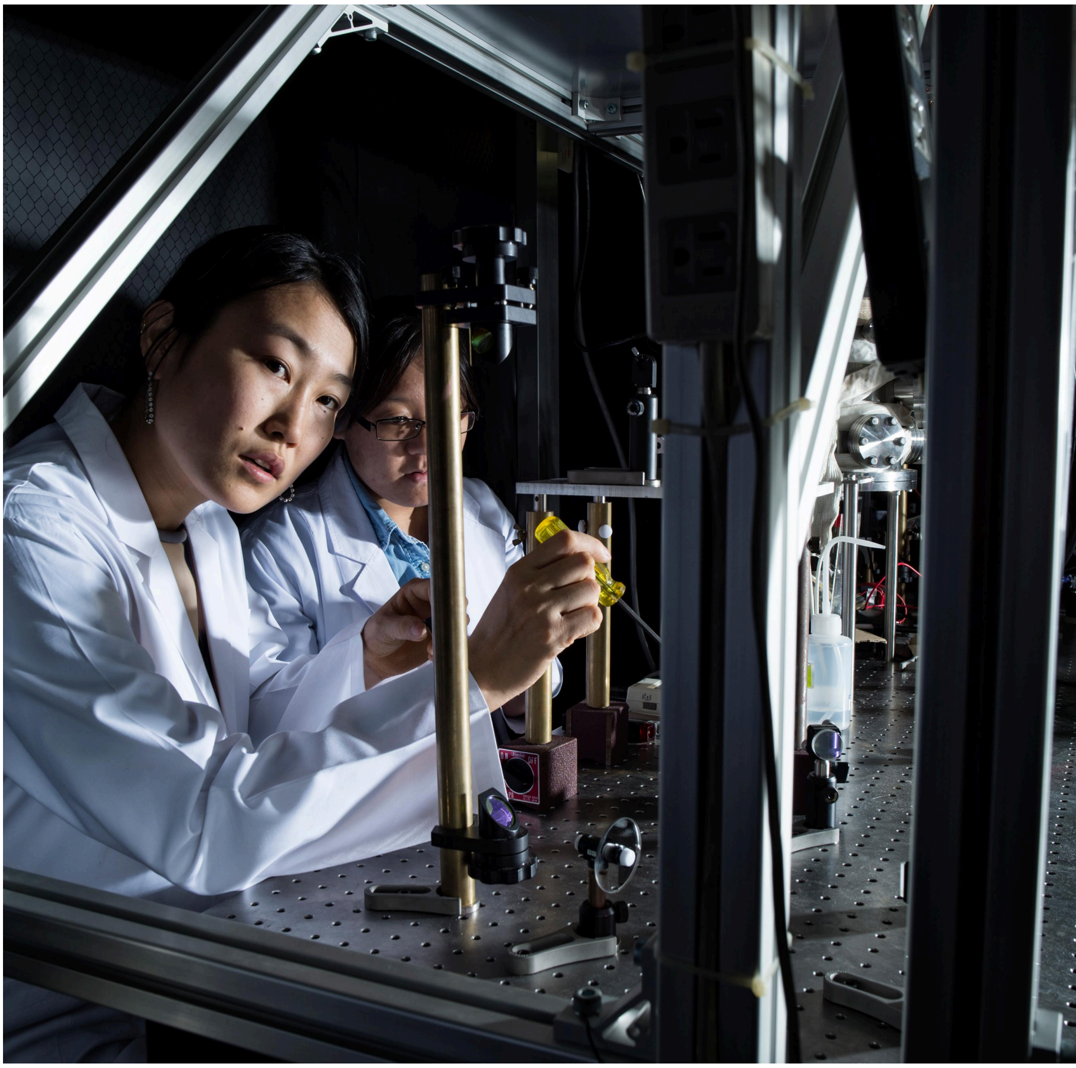


Building Scientific Sovereignty: Data-Driven Strategies for Strengthening Research Capacity in LMICs

TONY BLAIR INSTITUTE FOR GLOBAL CHANGE

Contents

Executive Summary

Scientific research is a powerful engine of national development, driving economic growth and technological progress while building long-term resilience. In an era of weakening multilateralism and reduced global collaboration, scientific sovereignty – a nation's ability to shape and sustain its own research agenda – is becoming a strategic necessity.

Low- and middle-income countries (LMICs), which are home to 85 per cent of the world's population, are disproportionately exposed to global challenges – from climate shocks and health crises to energy insecurity and food-system disruption. Yet they represent less than 10 per cent of R&D investment and produce just 14 per cent of annual scientific publications.[1,2] This imbalance leaves them increasingly exposed. In the face of worsening geopolitical fragmentation, tightening aid budgets, rapid technological advances in areas such as artificial intelligence, and systemic shocks including Covid-19 and the Ukraine war, multilateral science networks are crumbling and development-focused research funding has diminished. As traditional donors scale back, many LMICs are left vulnerable.

For decades, a prevailing assumption in development policy has been that LMICs should focus on technology adoption and diffusion as a shortcut to growth. In this view, scientific research and long-term capacity-building – including labs, national facilities, human capital and funding bodies, along with scientific governance – are a luxury: expensive, slow-moving and removed from pressing development goals. This mindset has shaped not only donor agendas but also domestic policy across LMICs.

Yet this trade-off is increasingly being challenged. A growing chorus of scholars, policymakers and international bodies argue that scientific research is not a competing priority but a foundational one. Technology transfer can deliver huge gains, but it cannot act as a substitute for domestic capacity-building as the basis of durable national transformation.

A new chapter in scientific self-determination is taking shape; governments across Africa, Asia, Latin America and the Middle East are reviving post-independence ambitions to harness research for national development. Yet many LMICs struggle to turn ambition into impact. Too often, strategies rely on one-size-fits-all models that overlook local context, assume uniform goals and fail to consider differing institutional starting points. Meanwhile, policy-relevant data remain fragmented, incomplete and misaligned with decision-makers' needs. Attention skews towards outputs – publication counts and global rankings – while the systems and institutions that enable scientific progress are overlooked. The result is piecemeal, under-powered efforts that fall short of the scale, coordination and long-term vision needed to build dynamic, resilient research ecosystems.

In response, the Tony Blair Institute for Global Change has generated and collected a set of more than 80 R&D-relevant indicators covering 129 countries, compiling them into a global data explorer that forms the basis of this paper. The indicators bring visibility to the core levers of scientific capacity, enabling policymakers to benchmark progress, identify structural gaps and design more context-specific, strategic interventions.

Drawing on this assembled data set, we have conducted statistical analysis to map global patterns in how basic-science ecosystems function, highlighting how progress is most often made and where systems tend to stall. We have grouped countries into ten clusters based on shared characteristics, constraints and institutional maturity. In this development-focused paper we have examined five of these ten clusters, at the lower end of scientific maturity: nascent, seeding, emerging, establishing and rising.

For each cluster we have analysed common bottlenecks and enablers, offering tailored policy options grounded in quantitative insights and practical experience. These insights underpin the recommendations that follow, introduced at a high level here, then explored in depth through the analysis and policy toolkits presented in the chapters that follow.

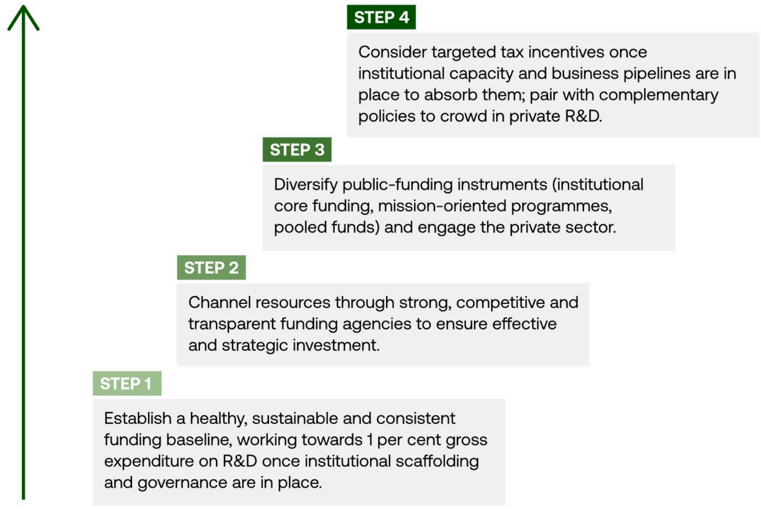
Key Recommendations and Findings

Our insights are organised around four core themes: funding, talent, institutions and strategy. For each we have highlighted key patterns in the data and offer broad, actionable recommendations.

1. **Funding:** R&D spending correlates with greater research output, but returns per dollar vary widely across and within clusters. In low-maturity clusters, the link between spend and impact weakens, and factors such as governance and institutional quality become decisive. Here, capacity-building efforts can be aided by concentration: focused, multi-year core funding for national flagships or mission-led programmes to provide stability, retain talent and plan strategically. As systems mature, it is necessary to broaden the toolkit of public instruments and enable private-sector plug-in to enhance dynamism and resilience. The path to stronger science systems lies not just in bigger budgets, but in sustained and better-sequenced investment.

FIGURE 1

R&D spending targets are only a first step



Source: TBI analysis

2. **Talent:** Talent mobility, more than education spending, predicts research strength – especially in lower-maturity ecosystems. Governments in LMICs should pursue three main strategies to create an enabling environment for research talent and combat the effects of brain drain: boost the attraction and circulation of talent (including core-funded research chairs and re-entry fellowships, as well as shorter-term schemes); invest in domestic training (high-prestige PhD tracks, international co-supervision and accelerator schools); and track and engage the non-resident diaspora, leveraging connections abroad while building capacity at home.

FIGURE 2

Top talent drives research strength

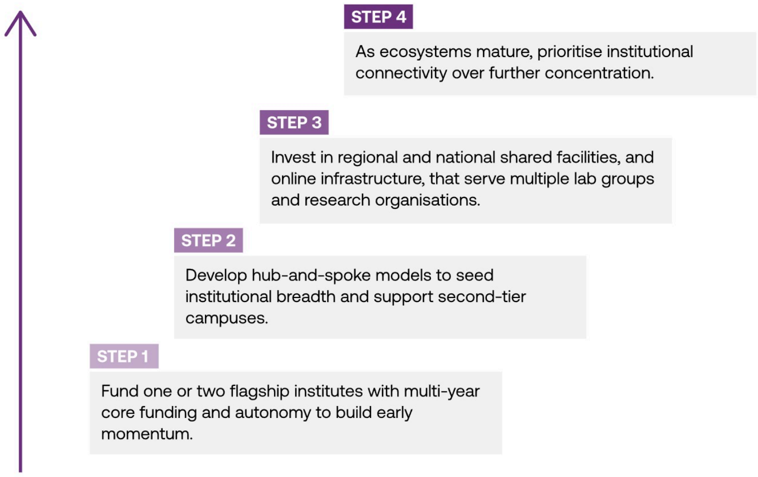
1. **Turn brain drain into brain "circulation"**
   Governments should fast-track visas, offer stable, core-funded chairs and re-entry fellowships, and enable short "tours of duty".
2. **Deepen training at home, leveraging networks abroad**
   They should also launch high-prestige PhD tracks, international co-supervision and accelerator schools with clear career pathways.
3. **Activate the diaspora**
   It is also important to keep live registries, foster scientific diplomacy, run co-Principal-Investigator calls and exchanges, and build regional supervision pools that link labs across borders.

Source: TBI analysis

3. **Institutions:** Concentrating resources on one or two flagships can drive early scientific gains and seed research communities, but as ecosystems mature they require a broader base. Progress depends on diversification, strengthening regional and sectoral infrastructure, and fostering coordination. Institutional governance, culture and incentives can be binding constraints, and explain why a few centres excel on modest budgets while many do not.

FIGURE 3

Centralisation vs diversification is a balancing act for institutions



Source: TBI analysis

4. **Strategy and delivery:** Strategy and the ability to deliver on policies turn isolated capabilities into a dynamic system. It's important to start with a short, costed science, technology and innovation (STI) plan led by a single accountable owner and including a few national bets; co-create policy with researchers and fix operational chokepoints (procurement, visas, facility access and intellectual property); and build analytic capacity to track, evaluate and adapt instruments. Countries should run annual reviews with open dashboards to reallocate resources towards what works. In LMICs, sequencing and feedback are crucial: own the plan, unblock delivery and learn fast.

FIGURE 4

Strategy and delivery capacity underpin an effective science ecosystem

PILLAR 1	PILLAR 2	PILLAR 3
Own a short, costed national STI strategy aligned with long-term goals. Select one accountable lead, take few national bets, use budgeted instruments and include annual reviews.	**Co-create policy and unblock operations** to embed researchers and identify bottlenecks, as well as piloting and then scaling what works.	**Build a learning system** in order to track institutional capacity and outputs, question metrics, evaluate instruments and then iterate.

Source: TBI analysis

This paper is both a call to action and a practical resource. It invites governments, funders and scientific partners to shift towards the long-term, system-level investments that unlock sovereign science capacity. By leveraging better data to drive context-specific strategies, LMICs can turn today's uncertainty into a launchpad for a more equitable and resilient global scientific system.

01

Introduction

In an era of growing geopolitical fragmentation and reduced focus on international capacity-building, many countries face a stark new imperative: constructing scientific ecosystems that are less dependent on international cooperation and more rooted in sovereign capability. The weakening of multilateralism has frayed many of the global science linkages that low- and middle-income countries (LMICs) once relied upon, while dramatically reducing the availability of development-focused research funding.

Traditional scientific powerhouses such as the United States and United Kingdom have significantly rolled back support for development-oriented scientific programmes. The cancellation of the Global Challenges Research Fund and Newton Fund[3] (key enablers of LMIC research partnerships in the UK) has left a void in support for international research[4] – and it is a gap set to widen with the planned reduction of aid to 0.3 per cent of gross national income from 2027.[5] In the US, threats to withdraw from the WHO[6,7] and UNESCO,[8] the gutting of USAID [9,10,11] and slashed budgets across domestic agencies such as the National Science Foundation and the National Institute of Health[12] signal not just a departure from international science networks but also a deeper retreat from the scientific frontier. This retreat – spanning everything from global health initiatives such as the President's Emergency Plan for AIDS Relief to fundamental science partnerships with the European Organization for Nuclear Research – has dramatically reshaped the architecture of international science.

For many countries this shifting terrain exposes a vulnerability: limited domestic capacity to steer and sustain their own scientific agendas. Without indigenous research capacity – including labs, universities, infrastructure and a critical mass of trained scientists – countries lack the ability to frame their own problems and priorities, adapt global knowledge to local contexts, and build long-term resilience to health, climate and economic shocks. Scientific sovereignty is not just a developmental aspiration, but a strategic necessity.

The question is no longer whether national science matters for development, but how countries can build systems that reflect their own contexts, goals and agency.

Scientific Sovereignty in LMICs

In recent years the idea of scientific sovereignty has gained prominence in global policy, increasingly finding its way into formal agendas, strategies and national debates. In high-income countries it is often framed through the lens of strategic competition and resilience against geopolitical threats. However, in LMICs it is often tied to development and self-determination, relating to capacity-building and reducing reliance on former colonial powers or international donors. It signals a shift towards domestic control – structurally, financially and strategically – and reflects a broader ambition to shape science systems that are locally grounded but globally connected.

This ambition builds on deep historical roots. During post-independence periods, many leaders across Africa, Asia and Latin America viewed science as a vital lever for self-determination and structural transformation. Kwame Nkrumah, Ghana's first president, formalised the Ghana Academy of Sciences in 1963 to drive scientific research and technological advancement as a means of breaking dependency and accelerating industrialisation. India's first prime minister, Jawaharlal Nehru, was a vocal advocate for "scientific temper" in public life – a free, critical habit of mind and ethos of enquiry. Under his leadership, India strengthened the role of the Council of Scientific and Industrial Research to coordinate research efforts across sectors, as well as creating the Indian Institutes of Technology to train world-class engineers and scientists.

However, come the 1980s, this momentum was interrupted by a development paradigm that favoured market reforms and near-term stabilisation, emphasising short-term results. Building domestic science capacity was increasingly viewed as a process that was too slow, costly and abstract for urgent development goals. However, recent shifts in geopolitical dynamics have prompted a renewed emphasis on scientific self-determination. At the African Academy of Sciences 15th General Assembly in 2024, the call for African scientific sovereignty and renewed investment in scientific infrastructure were defining themes.[13,14] Quoting Vannevar Bush's *Science: The Endless Frontier*, Kevin Chika Urama – vice-president of the African Development Bank Group – noted that "a nation which depends on others for its new basic scientific knowledge will be slow in its industrial progress and weak in its competitive position regardless of its mechanical skill".[15] Rather than a push for isolation, or for national research ecosystems that are entirely self-sufficient or insular, such calls are a demand for *agency*.

The Economic and Social Dividends of Scientific Research

Today's development challenges demand both the ability to absorb external technologies and the capacity to generate knowledge at home. This is not a binary choice: adopting innovations from abroad and investing in domestic ecosystems are not competing strategies, but deeply complementary ones. While imported solutions can help address immediate needs, it is scientific research that equips countries to adapt, improve and innovate on their own terms. Meanwhile, access to technologies and platforms – particularly general-purpose tools such as artificial intelligence or satellite imaging – can catalyse new lines of enquiry, inform domestic research agendas and even lower the entry costs for building local capability.

There are many compelling reasons to invest in research capacity.

- **Economic and industrial impact.** Basic science is an engine of economic growth. Countries with well-developed science ecosystems consistently generate higher-impact innovations than peers at similar income levels. Moreover, publications in core disciplines such as physics, chemistry and biology reliably predict patent activity and industrial diversification.[16]
- **Resilience.** Scientific capacity underpins a country's agility in emergencies. During the Covid-19 pandemic, strong local research capabilities in countries such as Senegal, South Africa and Uganda enabled rapid diagnostics, sequencing of viral variants and mobile

Epi-Tent field hospitals.[17] These homegrown solutions not only saved lives but demonstrated that local science infrastructure directly strengthens public-service delivery and health sovereignty.[18]

- **Education and human capital.** Investment in research builds talent pipelines. Countries with stronger research universities and publicly funded science institutions tend to retain more skilled professionals, reduce brain drain and foster innovation ecosystems that empower young researchers and entrepreneurs. Over time this human capital becomes a cornerstone of new industries and governance.

Beyond Spending: Both Strategy and Capacity Matter for Development

Too often, scientific development goals are framed in terms of scale: how much is being spent and how fast investment is growing. In LMICs, where resources are limited and trade-offs are sharp, scale of investment alone is not enough; what matters is whether limited resources are used in ways that maximise their impact and can be justified against competing priorities. The case is not simply for more investment in research, but for better sequenced, more strategic investment.

That means adopting context-sensitive approaches: strategies that align with national goals, reflect local constraints and are designed to deliver long-term value. Our findings show that the effectiveness of a research system depends not just on how much is spent, but on how those resources are channelled: through which institutions, with what level of coordination and according to what vision of national development. It is not a case of money in, impact out. A strong strategy is shaped by – and must respond to – national context: a country's scientific traditions, industrial base, natural advantages, institutional architecture, political economy and developmental aims.

Equally important is recognising that the objectives of scientific investment will differ between countries. Some will prioritise academic-research excellence, while others might focus on industrial development, job creation or the delivery of essential public services. There is no single model of success. But whatever the end goal, effective and sustained scientific capacity building is foundational. Strategies need to be internally coherent, outward-looking and rooted in the realities of a country's institutional starting point and development trajectory.

In the context of limited resources and urgent development demands, governments need better tools, stronger evidence and effective frameworks to guide investment in R&D. Data is essential. In recent years a great deal of effort has gone into mapping innovation systems: tracking patents, startups, venture-capital flows and other hallmarks of applied technological development. But comparatively little data is available on the state of scientific research: the strength of national institutions, the depth of training pipelines, the structure of scientific governance and the health of domestic publication ecosystems. Without these insights, governments and funders struggle to benchmark progress, learn from peers and chart viable trajectories for national research ecosystems.

Where data exist they are often fragmented, incomplete or insufficient to answer the questions that policymakers need answered. There is too much emphasis on outputs such as the number of published papers and global rankings, and too little on the underlying architecture of capability: the systems, cultures and infrastructure that make research productive, resilient and developmentally relevant.

This report and the accompanying data explorer aim to fill this gap. By creating a way to visualise and compare fundamental science ecosystems between countries, we aim to provide decision-makers with a clearer picture of where they stand, peers they could learn from and potentially strategic opportunities. The goal is not to measure but to empower: to enable more context-sensitive choices about where to invest, how to grow and what kind of scientific future to build.

Data Explorer: Global Science Capacity

This report is released alongside a new data explorer. A full methodology and description of the tool's structure and functionality can be found on the website, but here we outline the most salient points.

The data explorer brings together more than 100 indicators spanning three broad domains.

1. **Science:** Metrics that reflect a country's core research infrastructure and capacity.
2. **Tech:** Indicators of downstream technology development and innovation ecosystems.
3. **Enablers:** Broader contextual factors that underpin science and technology systems, such as governance quality, logistical infrastructure and digital access.

Together these metrics offer a multi-dimensional picture of how countries build, sustain and leverage scientific capability. Only countries with sufficient data coverage across these domains were included in the final explorer; in total, 129 countries met the inclusion threshold.

The science indicators span four subdomains.

1. **Institutional infrastructure:** This includes the number of research institutions producing peer-reviewed publications, types of institutions and the spread of scientific output across organisations.
2. **Funding:** Includes gross domestic expenditure on R&D, and private-sector research and investment.
3. **Talent:** Measures of human capital such as tertiary-science enrolment, researcher density and talent mobility.
4. **Outputs and collaboration:** Includes publication volume, citation impact (such as h-index) and international co-authorship rates.

These metrics are drawn from trusted international sources, including the Global Innovation Index, the Nature Index, the UNESCO Institute for Statistics and Elsevier's Scopus-based Research Intelligence.[19,20,21,22] All metrics are normalised to a 0-100 scale and do not represent raw values. A higher score does not necessarily mean it is qualitatively better for all metrics.

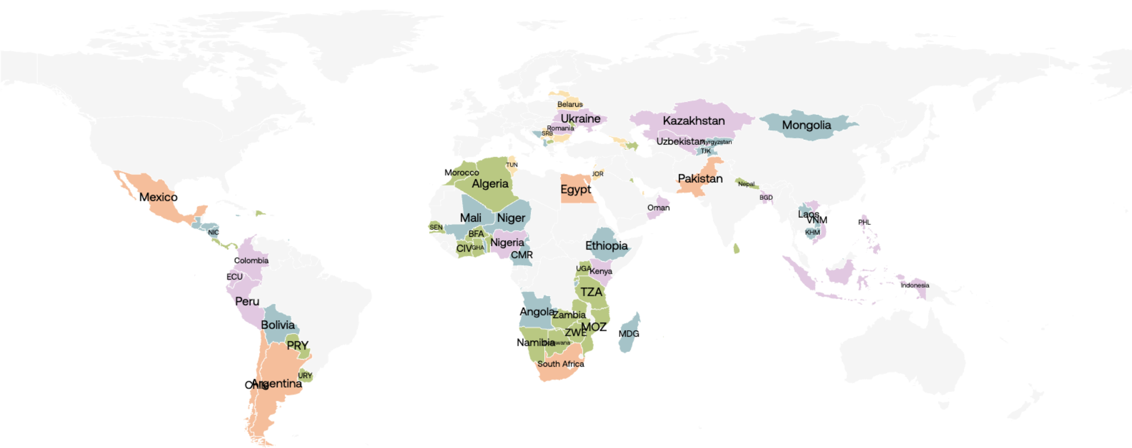
Using this data set we have identified key patterns and relationships that shed light on the dynamics of research ecosystems, clarifying which levers matter most at different stages of development. To translate these insights into actionable guidance, we applied a statistical clustering method (known as k-means clustering) to group countries with similar characteristics in terms of scientific capacity and ecosystem maturity.

This approach produced ten distinct clusters. The five least scientifically mature of these are the most relevant to development-focused contexts; as such, these are the five clusters that are explored in detail in the sections that follow. Each cluster profile highlights common opportunities, structural constraints and policy levers, drawing not only on quantitative analysis but also on insights from case studies, expert interviews and broader literature. These clusters are not rigid stages of progress but starting points for strategic reflection; they are tools to help countries identify peers, benchmark ambition and chart context-specific pathways forward.

FIGURE 5

Global map with countries grouped into clusters based upon science metrics

Cluster (science R&D) Nascent Seeding Establishing Emerging Rising



Source: TBI analysis

It should be noted that our analysis and explorer are not exhaustive. They partially rely on widely used indicators such as citation counts, the h-index and global university rankings, which can skew perceptions of scientific value by favouring visibility, incumbency and dominant epistemic norms over accurate scholarship, local relevance and real-world impact. These limitations (discussed in more detail later in the paper) are particularly acute in LMICs, where regional research is often underrepresented in global databases, and where the goals of scientific projects may not be publications or patents.

Accordingly, the findings presented here should be understood as a baseline for comparison, not a definitive ranking. They are intended to prompt more context-sensitive approaches to strengthening national science systems. Moreover, the policy toolkits are not prescriptive and will not apply universally: national priorities, wealth, institutional maturity and political context vary widely even within clusters.

Instead, the toolkits are intended as broad starting points, illustrating how different mixes of tools might align with a country's current capabilities and constraints. As always, design details matter. The most effective policies will be those that respond to local bottlenecks, are monitored for real impact and evolve over time.

02

Cluster Analysis

Each cluster in the data explorer represents a distinctive set of system dynamics. Countries within the same cluster differ in size, region and income level, but are often comparable in terms of strengths and structural challenges, meaning they have opportunities to learn from one another. In the sections that follow we characterise each group in turn, offering a synthesis of their core attributes and constraints, along with tailored policy suggestions grounded in the data.

Here we broadly define each cluster, with characterisations drawn from both quantitative data and qualitative research. More granular analysis – of metrics, enablers and trajectories – is developed throughout the paper.

The Nascent Cluster: Laying the Groundwork for a Science Ecosystem

The countries in the “nascent” cluster – ranging from Niger to Guatemala, Kyrgyzstan to Laos – represent the earliest stage of science-ecosystem development. They span multiple continents and political contexts, from small island states with limited administrative capacity to sub-Saharan Africa and Central America. Despite their diversity in wealth, governance models and historical relationships to research policy, these countries share a common challenge: limited institutional scaffolding for scientific advancement.

Many in this group face acute governance and development hurdles, including fragile institutions, political volatility and under-resourced higher-education systems. Most operate with bare-minimum research infrastructure, lacking national science councils, active grant-giving bodies and up-to-date science strategies. Without the core complementarities between institutions, regulatory systems and innovation policy, scientific investment is often ineffective or difficult to absorb. In short, most do not yet have the institutional machinery required to implement many of the recommendations in this report, and as such we address them only sparingly.

Opportunity: This is not yet the stage for scaling outputs, but rather for building enablers. Compared to "seeding" countries (see below), the nascent cluster scores significantly lower on numerous enabling indicators such as gross-capital formation, regulatory capacity, government effectiveness, corruption perception, logistics, education expenditure and rule of law – preconditions for a functioning science system.

For countries in this cluster with more developed enabling infrastructure, targeted early investments can accelerate progress. Priorities might include establishing science-governance structures such as national councils, building research infrastructure and piloting institutions such as competitive grant agencies and early-career fellowship schemes.

The defining feature of the nascent cluster is not a lack of scientific ambition, but a lack of foundations: the institutional, financial and human layers upon which an ecosystem can grow. Creating these layers must be the priority if these countries are to progress and become part of more mature clusters in the decade ahead.

The Seeding Cluster: Strengthening Foundations for Scientific Growth

The seeding cluster comprises countries where research ecosystems are starting to emerge and bear fruit. Scientific institutions are sprouting, funding is sparse and capacity is often concentrated in a few areas of activity. Spanning sub-Saharan Africa, South and South-East Asia, Latin America and parts of the Middle East, they include politically and economically diverse states, though many are grappling with a degree of political instability or fragile governance.

This cluster is large, with considerable internal variation. Most seeding countries benefit from formal science-policy infrastructure, including a national science council or coordinating body, a grant-giving research fund and a science, technology and innovation (STI) strategy. But the effectiveness of these structures, along with breadth and depth of institutional capacity, varies. In some countries the first research institutes are just taking root, dependent on donor support and producing little internationally recognised science. At the upper end, several countries have moved beyond basic policy commitments to implement robust, strategically aligned national science systems, including targeted innovation programmes, novel talent initiatives and regional coordination. Governance, investment and logistics indicators map strongly onto science capacity within the cluster: better-equipped nations tend to exhibit stronger capital formation, more effective governance, sound regulatory environments and better business conditions.

What defines this cluster is a lack of institutional depth. Talent pipelines are thin and vulnerable: inbound-researcher mobility is low and few countries offer viable long-term career paths in science or engineering, thus most experience persistent brain drain. Science spending remains low and funding systems are underdeveloped.

Opportunity: Despite these limitations, much potential exists. The seeding cluster represents not a blank slate but a shallow and uneven foundation. These countries need not replicate high-income models to make progress, but they require deliberate, strategic investment in talent and infrastructure. The cost per unit of progress is relatively low and the potential for compounding returns is high – especially if interventions are calibrated to the specific conditions and starting points within this diverse group.

The Emerging Cluster: Scaling Momentum

The countries in this cluster – spanning multiple continents and including Nigeria, Vietnam, Peru and Ukraine – occupy a crucial transitional space in the global science landscape. They range from South-East Asia's manufacturing hubs to the dynamic, resource-rich economies of sub-Saharan Africa and Latin America. Many are middle-income economies undergoing rapid demographic and urban transitions.

What unites them is a shared stage of scientific development: a visible research base, maturing institutions and mounting ambition, tempered by constraints in funding, talent retention and institutional reach. At the core of these systems is a small but active network of research institutes, though most lack internationally recognised flagships and almost none have universities ranked in the global top 1,000. Outbound talent flows generally exceed inbound ones, resulting in a familiar brain-drain pattern that further constrains domestic capacity.

Opportunity: Despite these constraints, the countries in the emerging cluster achieve respectable scientific impact. Compared to the establishing cluster (see below), on average, they are much larger economies, but invest a smaller share of GDP into R&D. They post a slightly higher h-index, but their spend efficiency is lower. Emerging countries display the highest proportion of research financed by business among the five clusters, paired with relatively strong collaboration between universities and industry but low inbound-talent mobility and few internationally prestigious universities. What emerges is a portrait of research systems with real momentum but fragile foundations. The challenge for this cluster is to scale and stabilise.

The Establishing Cluster: Unlocking the Potential of Institutional Maturity

This cluster includes 12 countries across Eastern Europe and the Caucasus, the Middle East and North Africa (MENA), and southern Europe. Several are EU member states or candidates (Bulgaria, Latvia, Montenegro and Serbia), while some – such as Armenia and Belarus – retain elements of centrally planned research systems. The MENA members in this group reflect a mix of middle- and high-income economies pursuing research investment as part of broader efforts to build knowledge-based sectors.

Establishing countries, on average, have the highest GDP per capita of the clusters included in this report and spend the highest proportion of GDP on R&D. Their science systems are comparatively mature, with more stable institutions and formal science bureaucracies. They host the most researchers, have the highest tertiary enrolment rates and produce the highest number of papers for their GDP. Institutional scaffolding – the likes of ministries, science councils and grant bodies – is in place, and more established than in earlier-stage clusters.

However, this institutional maturity does not always translate to proportional impact. Countries in this cluster might be held back not by lack of funding, but by structural inertia; many exhibit highly centralised, legacy research cultures with limited talent inflow and relatively static ecosystems.

Opportunity: Together, the features outlined above signal both friction and opportunity. With stable institutions already in place, these countries are well positioned for strategic reform such as redirecting funding towards peer-reviewed competitive grants, and cultivating a new generation of leading institutes. To avoid stagnation they must shift focus from preserving legacy structures to renewing them, interrogating research culture and norms, empowering talent and using existing capacity more effectively.

The Rising Cluster: Converting Momentum into Global Competitiveness

The six countries in this cluster – Argentina, Chile, Mexico, Egypt, Pakistan and South Africa – have moved beyond emergence and now sit between regional leadership and true global reach. Each demonstrates a growing capacity for scientific coordination and influence, while almost all host at least one scientific institution ranked in the global top 1,000, display sustained if uneven R&D investment and conduct research that circulates well beyond national borders.

These are mid- to upper-middle-income economies with larger populations and long-standing academic traditions. Several — such as Pakistan and Egypt — built national science councils or flagship academies in the post-independence period, often tied to broader visions of industrial modernisation or developmental sovereignty. Others, like Chile and Mexico, have more recently anchored science policy in productivity, competitiveness and export-oriented growth.

What binds them is not just legacy but momentum: a step-change in quality signals (including scientific outputs and elite-researcher cohorts) relative to earlier clusters, despite all six remaining below the 1 per cent gross expenditure on R&D (GERD) threshold in our data. Institutional capacity is present but uneven: business financing of R&D is moderate, collaboration between universities and industry is solid but not frontier level and global impact metrics do not match up to top-tier systems.

Opportunity: These systems have the scale, visibility and institutional base to make a decisive step up. The next leap will depend on pairing that scale with greater efficiency: improving quality and transparency, strengthening the interface between science and industry, crowding in private R&D and building national research agendas capable of driving both domestic development and international recognition.

Cluster Profiles

To better understand the strengths and limitations of each cluster, we grouped individual indicators into five composite pillars: research institutions, funding, education, researchers and scientific outputs. By averaging across these pillars we can visualise each cluster's scientific profile using the radar plots below. The shape and size of each polygon reflects the relative capacity of that cluster across the five pillars, offering a quick visual summary of where systems are strongest and where gaps remain.

FIGURE 6

Each cluster reveals the shape of a country's scientific ecosystem

Source: TBI analysis

While the clusters provide a structural map of science-system development, they do not by themselves explain how countries progress nor why some systems extract more value from inputs than others. To move from description to diagnosis, we analyse the relationships between metrics: which inputs appear most tightly linked to performance, where bottlenecks persist and which commonly assumed drivers show little explanatory power. This helps surface a set of core insights about how countries build scientific capacity, what distinguishes more efficient systems and where targeted investment could deliver the greatest returns.

We group these insights into four foundational themes – funding, talent, institutions, and strategy and delivery – that provide the structure for the findings that follow. Through the remainder of the report we return to the five clusters to apply these findings, offering high-level, cluster-specific policy suggestions informed by the patterns identified.

03

Funding

Investment underpins any scientific ecosystem. While it is widely accepted that a solid funding baseline is necessary to build capable institutions and support high-impact research, capital is not enough: strategic disbursement through the right institutions, conditions and frameworks is equally critical. Effective policy demands not just more funding, but smarter funding too. This chapter examines effective funding strategies for LMICs and how governments can stretch limited resources for maximum impact.

Finding 1: R&D Spend Drives Outputs, but Institutions Matter

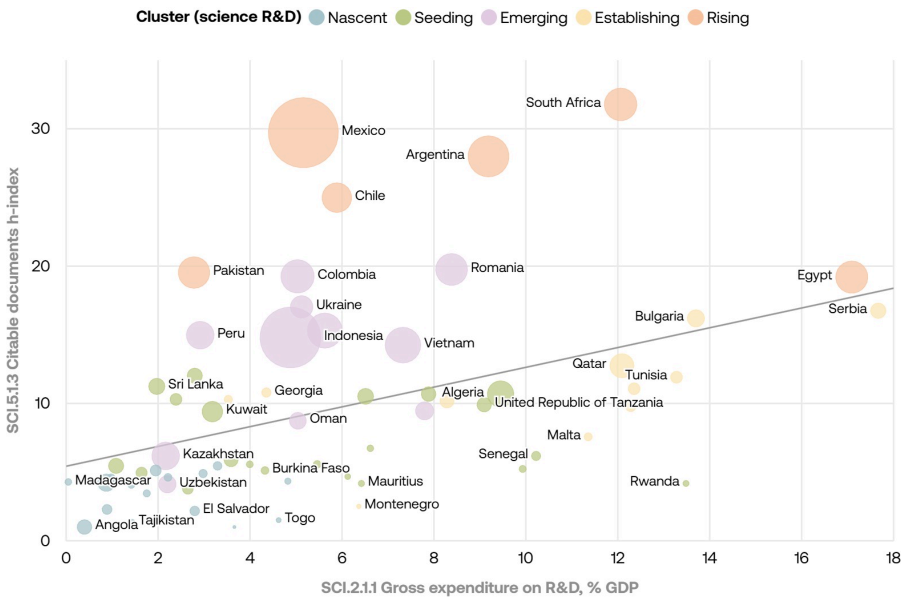
Money matters, but how you spend it matters more: the same GERD dollar buys very different scientific returns across ecosystems.

Countries need a healthy funding baseline to sustain a strong research ecosystem, and our explorer illustrates that higher R&D spending drives scientific output and quality. Across the data set there is a strong correlation between national R&D intensity (measured as GERD as a percentage of GDP) and research performance. In line with previous analysis, countries that devote a larger slice of their economy to research tend to publish more papers, attract more citations and sit higher in global science rankings. While this insight is high-level, it is important for governments to internalise amid current global fiscal constraints and to commit to funding research.

However, this strong relationship conceals enormous variation. Countries with similar budgets often achieve vastly different levels of impact: some achieve several times the global median impact per dollar, while others fall short – a phenomenon also noted in prior studies.[23] Comparing Pakistan to Egypt in the figure below (where bubble size indicates GDP), we see that Pakistan spends significantly less on R&D, but achieves similar outputs – indicating greater efficiency.

FIGURE 7

Similar expenditure on R&D can buy very different scientific returns across systems



Bubble size denotes the size of the country's GDP ($ current)

Source: TBI analysis

Note: Figures use titles for our science-indicator metrics that mirror the data-explorer schema: DOMAIN.PILLAR.INDICATOR (e.g., SCI.2.3). SCI, TEC and ENA denote the three domains – Science, Technology and Enablers. Within Science, the pillars are numbered: 1 = Institutional infrastructure; 2 = Funding; 3 = Talent; 4 = Outputs & collaboration; the final digit identifies the specific indicator within that pillar. A full list of indicators appears in the data explorer.

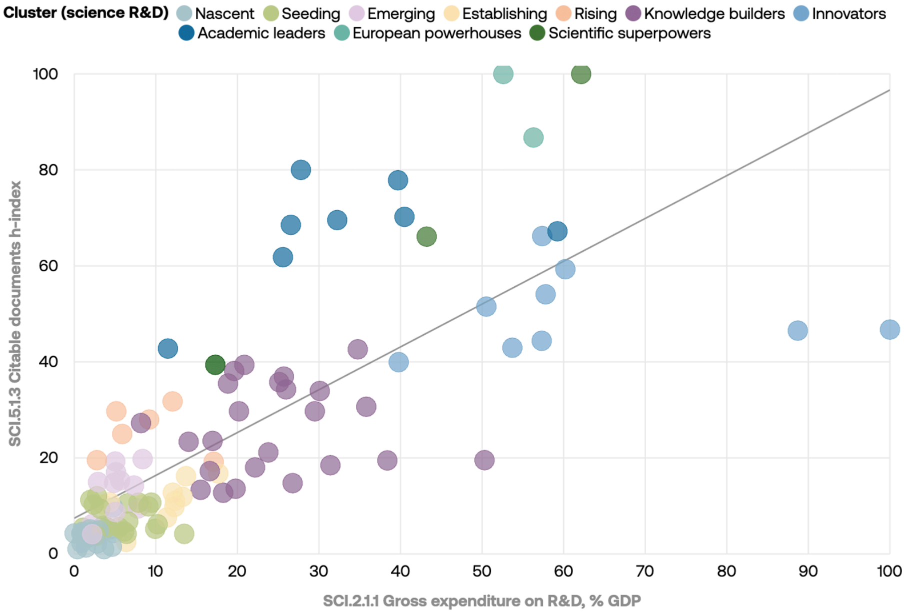
What explains the difference? The answer is institutions: not just how much is spent, but how strategically, transparently and effectively it is deployed. The presence of strong public research institutions, competitive grant funding, regulatory capacity and a healthy research culture often matter more than the headline cheque size. Money opens the door, but institutions determine how far a country can walk through it.

For LMICs, this finding is especially salient. In an era of constrained budgets and rising pressure to deliver results, governments cannot afford to waste money on poorly aligned systems. As ecosystems mature, variation in spending narrows: in more advanced clusters, funding levels converge and systems stabilise. But in less developed clusters, the relationship between spend and impact breaks down, and spend intensity and efficiency fluctuate greatly; this is a sign that institutions and ecosystem conditions, more than budgets, are crucial determinants of outputs.

Performance is chaotic and unpredictable: some systems deliver outsized returns, while others convert large budgets into limited outputs. In the seeding cluster there is essentially no correlation between GERD and h-index, and return on investment ranges widely. From the emerging cluster onwards, the GERD-to-output link strengthens, becoming statistically solid in the establishing cluster.

FIGURE 8

The relationship between R&D expenditure and outputs becomes weaker among countries with less developed science ecosystems



Source: TBI analysis

Note: Figures use titles for our science-indicator metrics that mirror the data-explorer schema: DOMAIN.PILLAR.INDICATOR (e.g., SCI.2.3). SCI, TEC and ENA denote the three domains – Science, Technology and Enablers. Within Science, the pillars are numbered: 1 = Institutional infrastructure; 2 = Funding; 3 = Talent; 4 = Outputs & collaboration; the final digit identifies the specific indicator within that pillar. A full list of indicators appears in the data explorer.

Across the sample, money buys entry to the big leagues – but it is wiring, as much as wattage, that matters. A constellation of institutional and structural factors shape how effectively resources are deployed:

- Countries with stronger elite universities, corporate R&D presence and talent mobility achieve greater research quality and reach per dollar.
- Translating research into intellectual property (IP) depends more on regulatory quality, rule of law, collaboration between universities and industry and the presence of corporate R&D investors. Countries with stronger governance see higher patenting efficiency: firms are more willing to invest in domestic innovation.

In both domains, institutions amplify or dilute the value of R&D spending. For many countries, focusing on those levers offers far greater marginal gains than nudging GERD a few tenths of a point.

Finding 2: Tax Incentives Don't Predict Impact – Business R&D Does

Across the data set, the share of business-financed R&D is a powerful predictor of research performance and national R&D spending. Countries with strong business involvement in research outperform their peers on both academic and innovation metrics. In fact, corporate presence is one of the most discriminating metrics between the clusters, and countries typically reach the 1 per cent of GDP benchmark for GERD only when business R&D surpasses government spending.[24]

Tax incentives are among the most widely trialled policy tools to boost business R&D, promising to stimulate private-sector investment without upfront public expenditure. But while the appeal is clear, impact is less so. Despite the salience of tax incentives in policy discussions, our analysis indicates that they have, at best, a weak relationship with both R&D intensity and research performance.

Unfortunately data coverage is thin for early-stage systems, but among countries with available data we find no meaningful correlation between the generosity of tax subsidies and R&D intensity. There are no detectable links to the share of business-financed GERD or to corporate R&D lab presence.

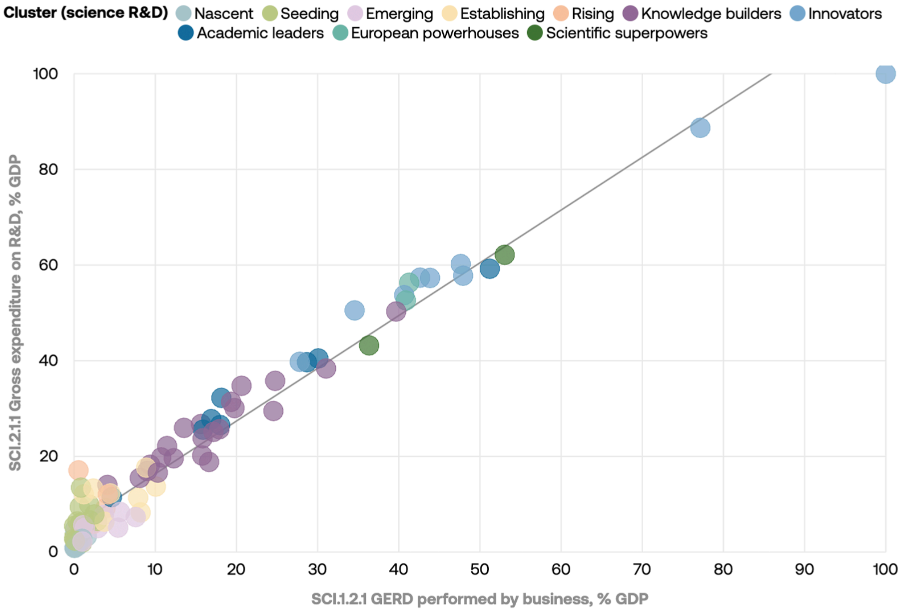
In other words, generous tax breaks do not, on their own, correlate with greater research effort, scientific impact or a stronger private-sector research footprint.

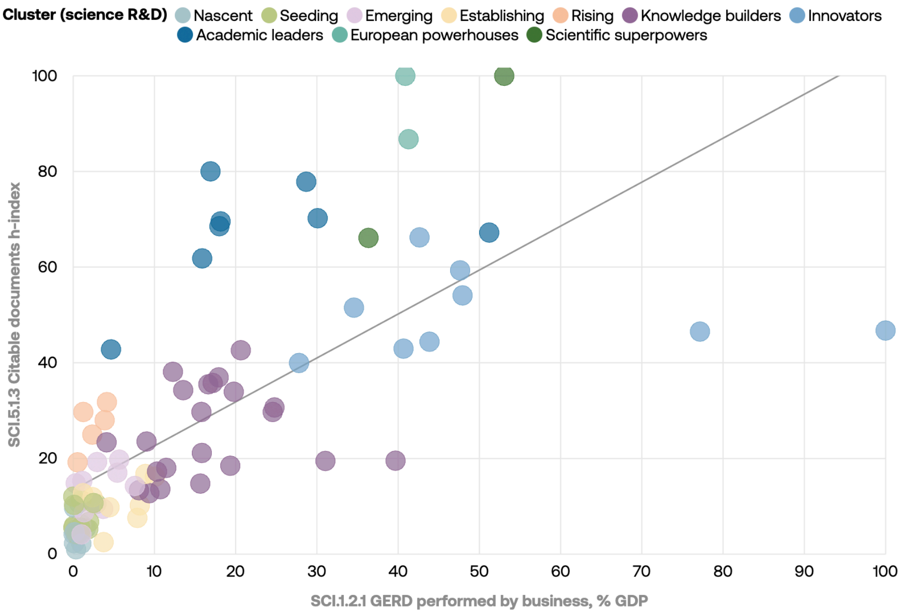
In the case of LMICs, the limited impact of R&D tax incentives is not merely a question of poor policy design: it also results from structural constraints. Firm-level R&D activity is limited to begin with, so tax incentives have little to latch on to. Where there is minimal absorptive capacity, weak innovation ecosystems and/or already low corporate tax, firms lack the incentive or ability to make use of credits. Complex, retrospective schemes favour large incumbents and deter the participation of small and medium-sized enterprises (SMEs), limiting early-stage impact.

The central question, then, is how developing countries can effectively engage the private sector, both as a co-funder of science and as an active participant in research. Strategic financial architecture is essential to stretch limited funds and unlock new pools of capital.

FIGURE 9

Share of business-performed R&D is a powerful predictor of both national science spend and research outputs (h-index)





Source: TBI analysis

Note: Figures use titles for our science-indicator metrics that mirror the data-explorer schema: DOMAIN.PILLAR.INDICATOR (e.g., SCI.2.3). SCI, TEC and ENA denote the three domains – Science, Technology and Enablers. Within Science, the pillars are numbered: 1 = Institutional infrastructure; 2 = Funding; 3 = Talent; 4 = Outputs & collaboration; the final digit identifies the specific indicator within that pillar. A full list of indicators appears in the data explorer.

Policy Toolkit

If headline spend and tax incentives are not sufficient for LMICs, while strategic government funding and corporate R&D are drivers of scientific strength, then the task for policymakers becomes clearer: create financial instruments to deploy public money effectively and draw private finance into national research ecosystems.

1. GRADUALLY RAISE GERD TO 1 PER CENT OF GDP

To build resilient science systems, countries need a stable, sustained funding baseline. As a minimum benchmark, countries should aim to gradually raise GERD to about 1 per cent of GDP. Science funding currently falls short of this goal in 65 per cent of the countries in our analysis, including all the countries in the five lower-maturity clusters.[25] This is a longstanding goal – first discussed by the African Union in 1979[26] – yet progress remains limited, and in today's constrained fiscal environment it is becoming more difficult to reach it.

2. CHANNEL FUNDS SMARTLY THROUGH A COMPETITIVE FUNDING AGENCY

Institutional competence is critical, especially where budgets are tight. Research funding agencies are not just channels for money: they are the architects of scientific capacity. They turn budgets into labs, fellowships and patentable inventions; coordinate the delivery of national strategies; and monitor outcomes. From this central position they can identify bottlenecks and steer resources towards high-impact tools. When they demonstrate results, manage funds transparently and build trust with ministries, they can reframe science as national investment, not cost.

Our data reinforce this: several countries in the rising cluster deliver three to four times the global median research impact per dollar, often thanks to long-standing, well-run agencies that allocate funding competitively and track performance.

Key features of effective funding agencies include:

- **Stable financing.** Predictable, long-term funding creates the foundation for researchers and institutions to plan strategically, support multi-year projects and build partnerships, instilling confidence within the scientific community. This has knock-on effects for talent acquisition and retention: uncertainty regarding career prospects and research support drives brain drain.
- **Competitive, merit-based calls.** Transparent, peer-reviewed and competitive funding processes improve the quality and legitimacy of research funding.
- **Leadership with scientific credibility.** Agencies benefit when scientists are involved in leadership and decision-making. Those with first-hand "coal-face" knowledge of research ecosystems can identify bottlenecks, understand research dynamics and anticipate opportunities, as well as instilling trust.
- **Autonomy with accountability.** Agencies require independence to make decisions free from political cycles, short-term pressures and bureaucratic interference. Autonomy must be grounded in transparent governance, clear mandates and mechanisms for public accountability.
- **Mission clarity and institutional culture.** High-performing agencies have a clear sense of mission and a culture that prizes excellence, openness and integrity. These attributes are harder to legislate, but no less important. An agency that builds social capital and is responsive, transparent and driven by values can set the tone for an entire research system.

CASE STUDY

São Paulo Research Foundation, Brazil

The São Paulo Research Foundation (FAPESP) is one of Latin America's most effective public-research funders, with a constitutionally protected budget: 1 per cent of São Paulo tax revenue must go towards it. In 2024 it invested more than $1.15 billion in more than 28,000 peer-reviewed projects. Around half of the funding disbursed was used for "research to advance knowledge" and about 10 per cent was for industry-linked R&D, with an impressive average time from proposal submission to initial funding decision of just 65 days.

Formally established in 1962, FAPESP emerged from an unusual political coalition between communist academics and São Paulo's industrial elite, united by a shared conviction that science and technology were central to national and state-level development. Both parties supported ring-fenced science funding, resulting in the constitutional mandate for a portion of tax revenue to be allocated directly to the agency. This protective shield insulated research funds from short-term political cycles, enabling long-term planning – and has played a central role in making São Paulo the most scientifically productive region in Latin America. Its funding model combines competitive peer-reviewed grants and fellowships with strict overhead caps (for example, management is capped at 5 per cent of budget) and high transparency, earning trust from researchers.

Key Lessons

- Build coalitions by aligning science with development goals that resonate across ideological lines.

- Entrench this principle by legally protecting funding commitments with earmarks or constitutional provisions.
- Pair these with institutional autonomy and credible governance to earn public trust.

3. DIVERSIFY PUBLIC-FUNDING INSTRUMENTS AND CREATE MECHANISMS FOR PRIVATE-SECTOR PLUG-IN

Even the best-run agencies are constrained by narrow toolkits. To unlock different types of research and respond to evolving system needs, countries with strong funding agencies should move to deploy a broader mix of funding instruments that are tailored to context, aligned to mission and structured for impact.

Mechanism 1: Mission-Oriented Funding

Mission-oriented funding aligns science with national goals, mobilising research, industry and government around shared priorities. This type of funding is especially vital when domestic resources blend with donor or multilateral finance: missions can ensure that public investment is steered towards societal goals, not just external interests.

Unlocking multiple functions, well-designed missions:

- concentrate resources to nucleate ecosystems and attract talent
- drive socially valuable research that markets or academia in isolation might overlook
- coordinate partnerships across sectors

- de-risk early-stage innovation to crowd-in private capital
- signal long-term government commitment to new industries

In this way, especially as part of under-developed systems, missions can act not just as funding tools but as catalytic coordination devices, shaping the institutional environment for innovation. But without focus and disciplined execution, they risk becoming vague slogans or bureaucratic checklists. Clarity in strategic intent, not rhetoric, drives results.

CASE STUDY

National Biopharma Mission, India

Launched in 2017, the National Biopharma Mission (NBM) is a mission-driven initiative to accelerate biopharmaceutical innovation and reduce import dependence. Funded by India's Department of Biotechnology and the World Bank, it is implemented by the Biotechnology Industry Research Assistance Council (BIRAC), a public-innovation agency.[27]

The mission targets four pillars – vaccines, clinical trials, bioinformatics, and biotherapeutics and medical devices – with clear, time-bound deliverables such as regulatory filings and manufacturing capacity. Funding is milestone-based, aligned with national health priorities and coordinated through BIRAC's dedicated Program Management Unit. To drive coordination and uptake, BIRAC has leveraged mechanism such as Grand Challenges India, open calls and consortia-based funding with private partners.

By 2023, NBM had supported more than 100 institutions and companies, contributing to homegrown vaccines, diagnostics and a stronger clinical-trials ecosystem (including a critical role during India's Covid-19 response).

The mission's success offers lessons:

- Use stage-gated, milestone-based grants to drive results without heavy bureaucracy, linking disbursements to concrete deliverables.
- Empower capable agencies such as BIRAC to act as strategic coordinators, not just grant distributors.
- Anchor missions in long-term national priorities to ensure coherence and resilience beyond political cycles.

Mechanism 2: Grand Challenge Funds and Advanced Market Commitments

Governments can establish targeted challenge funds tied to national priorities (which may or may not align with broader missions) such as water security, maternal health or digital services, stimulating innovation and drawing international partners without compromising strategic control. Such instruments support systems-level coordination and investment while remaining lean and focused.[28]

Governments and public agencies can also commit to buying novel local solutions – such as off-grid energy or local diagnostics – to nudge firms into research. Prizes such as Grand Challenges Africa[29] reward breakthroughs on local problems and often combine funding with follow-on support, encouraging R&D by offering recognition and market pathways.[30]

A larger-scale variant is the advanced market commitment (AMC): "pull" financing tools with which governments (often with donors) guarantee future purchases of a prospective product if it meets agreed criteria. By creating credible demand up front, AMCs incentivise private firms to invest in the R&D required to deliver the solution.[31] AMCs have primarily been deployed by international coalitions, the landmark example being the 2009 $1.5 billion commitment that accelerated pneumococcal-vaccine development by five years and brought multiple producers to market.[32] Building on this success, AMCs are being explored in domains such as climate tech,[33] agriculture and edtech.[34]

For AMCs to serve LMICs, three conditions are essential:

1. **Credibility.** Firms must trust that commitments will be honoured, via binding contracts or escrowed funds.
2. **Sufficient pull.** The guaranteed price and volume must offset the R&D risk, even if they are much smaller than pharma-scale AMCs.
3. **Complementary policies.** The pneumococcal AMC was accompanied by guaranteed regulatory support and upfront grants from organisations such as global vaccine alliance Gavi. In climate tech, AMCs could go hand in hand with carbon pricing.

Given budget constraints, regional blocs or blended finance structures might be needed to share costs. Still, even modest national AMCs could send powerful signals to local innovators, especially when paired with technical assistance.

Mechanism 3: Core-Funded Research Institutes
Core funding gives publicly backed research institutions the stability to plan ambitiously, invest in infrastructure and attract talent. Unlike fragmented grants, multi-year institutional support enables autonomy, lowers administrative burden and allows researchers to focus on strategic priorities rather than survival.

Strong core funding for national flagship institutes is especially valuable in underdeveloped research ecosystems. It can serve as a foundation for system-building, concentrating top talent and helping selected national or regional institutes become focal points. It supports the creation of durable research environments and communities, with the space and security to train graduate students, maintain shared facilities and develop specialist capabilities. It also helps institutions build a reputation, making them more competitive for future international or mission-aligned funding.

Such institutes can serve as magnets for new researchers, hubs for collaboration and engines of capability spillover – visible symbols of national scientific ambition. We return to this mechanism in later sections.

Mechanism 4: Campus-Industry Anchors and Ecosystems
Attracting firms to establish “anchor” labs near top scientific centres (and building mini-ecosystems or innovation zones around them) creates hands-on training opportunities; this also seeds knowledge spillovers and enhances collaboration. Firms gain access to talent and ideas; countries gain industry-linked research capacity and expertise. Governments can support co-location through co-investment packages and fast-tracked approvals, which ease operational friction and facilitate joint programmes aligned with national priorities.[35] The goal is not a single lab but a durable campus-industry platform where ideas, people and capital can circulate.

How it works in practice:

- The selection of one or two universities with strong departments in priority fields.
- The offer of an anchor-lab package (including a facilities fit-out, matching grants, visas for staff, streamlined IP and procurement).
- Collaboration through joint seminars, shared PhD supervision and access to core facilities for both sides.
- Added “ecosystem” elements around the anchor: incubators, on-site tech transfer offices, legal clinics and shared prototyping spaces.[36]
- A light-touch legal sandbox for the innovation zone: simplified IP/licensing templates, flexible contracting and procurement, and fast-track regulatory approvals.
- Outcomes measured via research jobs created, joint outputs (papers, patents) and downstream innovation activity within the local economy.

A leading example is IBM Research Africa. Launched in 2013 with facilities in Nairobi and Johannesburg, IBM’s labs are embedded on or near major campuses and work with local universities and governments on priority domains.[37] The labs train graduate students, co-author research and run joint projects, helping seed data-science capabilities.

Examples from other countries demonstrate the different ways that governments can incentivise and capitalise on co-location:

- **China’s Zhongguancun Science Park** in Beijing combined tax incentives and patent fast-tracking to become a hub of research-intensive firms and university linkages, spurring high-tech growth.[38]
- For **Technology Park Malaysia** and **Brazil’s Campinas Technopole,** land and grants were provided by the government to co-locate firms with research institutes, resulting in stronger industry funding for university research and more joint publications.

- **Masdar City (United Arab Emirates)** is a government-backed science and technology district that provides lab facilities, a free-zone business environment and streamlined regulation. It has become Abu Dhabi's premier R&D cluster,[39] creating fertile ground for new academic institutions – notably the Mohamed bin Zayed University of Artificial Intelligence, the world's first AI-focused research university, which trains local PhD talent and elevates the hub's profile.

Mechanism 5: Fund Industrial PhDs and Fellowships
Proximity is enhanced by permeability. Industrial PhD programmes (and industry-academia fellowships) fund graduate students and researchers to split their time between a university and a company's R&D team, working on projects under joint supervision. Widely used in high-income countries, these schemes are gaining traction in LMICs as a way to build capacity while deepening private-sector linkages. Benefits include:

- **Knowledge transfer:** Embedded researchers help transfer ideas between academia and industry, fostering collaborative innovation.
- **Human-capital development:** Graduates gain "T-shaped" skillsets – deep research expertise plus broad business acumen – making them valuable in both sectors and creating a cohort of "boundary spanners" who can navigate both environments.[40]
- **Innovation output:** Firms benefit from new ideas and often retain PhD talent, while industry-academia links deepen through increased patenting and faster commercialisation of academic discoveries.[41]

Programmes require clear IP and publication rules to balance academic and commercial needs;[42] most also use matching grants to ensure that companies have skin in the game. South Africa, for example, has launched an Industrial Innovation Fellowship to embed PhDs in tech startups, while Malaysia is exploring co-funded doctoral placements tied to industry clusters. Joint appointments aim to build a new generation of scientists fluent in both discovery and its translation into local industry.

Mechanism 6: Matching Grants to Catalyse Investment
Matching grant programmes share the cost of R&D between government and the private sector. Unlike tax incentives, they provide upfront, flexible funding, making them accessible to firms with limited capital and no prior research history. They lower the financial barriers that prevent firms – especially in LMICs – from conducting research. These grants typically cover 50 per cent or more of project costs and can target individual firms (including "first-time R&D" entrants) or consortia of companies and universities.

Effective design matters.[43,44] Evaluations highlight features that boost impact:

- **Flexible match ratios** relevant to context (1:1 or 2:1, for example).
- **Upfront disbursement** to ease participation by capital-constrained firms.
- **Simplified processes** to avoid deterring SMEs.
- **Targeting consortia** to foster partnerships and knowledge spillovers.

Evidence from Chile and other middle-income countries shows that firms receiving matching grants tend to increase not just spending but also innovation outputs such as patenting, productivity and new collaborations.[45]

4. CONSIDER TAX LEVERS, BUT ONLY ONCE CAPACITY EXISTS

Tax incentives are not a starting point but a second-order tool, effective only once the foundations of scientific capacity, institutional strength and business appetite exist. Where they do, tax incentives can be amplifiers if they are designed to overcome local bottlenecks. These principles improve effectiveness for LMICs:

- **Front-load and simplify.** Successful incentives are upfront and predictable. Refundable credits and super-deductions at the time of investment help cash-strapped firms to participate. Retrospective schemes with complex paperwork favour only incumbents.

- **Incentivise new R&D, not existing spend.** Targeting firms with little prior R&D maximises impact. Malaysia's "double-deduction" for maiden R&D, targeted at electronics SMEs, spurred first-time participation. South Africa's 2016 reforms introduced a refundable credit and simplified process focused on emerging sectors, enabling a 24 per cent rise in applications and improved outputs in targeted clusters.
- **Reward outcomes, not just input.** Link incentives to innovation milestones such as patent filings, prototypes or industry-academia collaborations to align support with meaningful progress.
- **Measure impact, not just uptake.** Track additional R&D activity and innovation outputs per tax dollar – disaggregated by firm size and sector – to evaluate behaviour change, not participation rates.

FIGURE 10

Different scientific ecosystems require tailored funding trajectories and policy mixes

Cluster	Indicative near-term GERD target (approximately 5 years)	Potential policy instruments
Seeding	Step up to approximately 0.2 to 0.4% GDP, earmarked, multi-year	• Commit to foundational public investment: gradually raise GERD once infrastructure and governance are in place. • Where not present, establish a public research funding agency: light peer review with 2 to 3 calls a year. • Lay the policy and legal groundwork: IP protections, regulation and contract enforcement. • Provide multi-year core grants to 1 to 2 national flagships (labs or academies) to create early centres of gravity (shared facilities, graduate training). • Mission-aligned grants for basic capabilities: tight, near-term missions (for example, public health and agri-tech) to stand up basic capabilities and crowd coordination without overstretching. • LMIC-led pooled funds with donors.
Emerging	Step up to approximately 0.3 to 0.6% GDP with a 5 year path to more than or equal to 0.5%; pair with more than or equal to 40% business share target	• Scale agency into full competitive funder (more than or equal to 40 % budget via open calls) • Core funding for small set of flagships: Back 3 to 5 institutes/university departments where performance is already visible to create recognisable anchors. • Time-bound missions that pull industry in: specify deliverables and use stage-gated funding. • Matching-grant schemes: larger, competitive co-funding rounds (including first-time R&D) that require firm–university teams and include milestone payments. • Campus-industry zones: co-location of priority departments with R&D-active firms, shared prototyping labs and simplified IP. • Industrial PhDs and joint fellowships: scale permeability to turn existing private interest into pipelines and IP. • Selective AMCs: modest, sector-specific pull contracts where domestic firms already operate.
Establishing	Sustain more than or equal to 0.5 % GDP but re-balance toward competitive streams	• Agency reform: block-to-competitive reallocation. Shift from infrastructure megaprojects to competitive, peer-reviewed portfolios. • Second-generation missions: upgrade mature fields with stage-gated, outcome-linked tranches to refocus large but static budgets; consider small bets on emerging areas. • Large matching grants for scale-ups: multi-year co-funding to pull new firms deeper into R&D; reward prototypes/patents, not inputs. • Innovation-zone pilots to modernise tech-transfer. • Outcome-linked tax credits: simple, front-loaded incentives (refundables/super-deductions) aimed at new R&D and SMEs; pair with advisory support to nudge incumbents.
Rising	Step up to more than or equal to 0.5% GDP with predictable 10 year horizon; alongside business share path towards more than or equal to 50%	• Performance-based core funding: continue to champion high-performing labs and tie renewals to external reviews and international hiring. • Translation missions: missions that bridge lab-to-market with regulatory support. • Full suite of private-sector mechanisms: anchor labs, innovation zones, matching grants, industrial PhDs, curiosity-driven grants, large-scale mission funds and centre-of-excellence renewals. • Industrial PhDs and senior industry fellows: grow the cadre converting research into IP. • Blended finance co-investment for national and regional research infrastructure. • Outcome-based tax incentives to amplify existing pipelines. • Selective AMCs: use credible pull contracts in a few domains to raise private R&D and domestic manufacturing.

Source: TBI analysis

04

Talent

Scientific progress is made by people. It is researchers – their ideas, relationships and trajectories – that turn inputs into impact. Yet in many LMICs, nurturing and retaining research talent remains a major, perhaps *the* major, bottleneck. This section sets out how scientific talent shapes national research performance, and outlines options for countries to attract, retain and circulate scientists more effectively.

Finding 1: Education Spend Alone Doesn't Build Research Strength

Primary, secondary and tertiary education are essential to creating future scientists and facilitating wider engagement with research. In this sense, the conventional wisdom that funding education creates stronger science systems is correct. But in our data set, education outlays are only weakly associated with near-term research performance – especially in lower-capacity clusters – and show little predictive power for the number of elite researchers, research-staff density, h-index, citations or top-ranked institutions. For R&D capacity-building, education spend alone is a poor predictor of system strength,[46] which indicates that once a functioning education pipeline exists, additional spending does not drive proportional scientific gains. This is partly due to lag effects: dollars channelled into primary and secondary education take a decade or more to reach the research workforce, and the effect dilutes across the whole economy.

But crucially, in many countries across the seeding, emerging and establishing clusters, brain drain remains a defining challenge: students and early-career researchers often pursue training or employment abroad but lack incentives to return. In such contexts, education investment ultimately subsidises the scientific labour forces of wealthier nations. Without complementary systems for retention and support, education outlays do not translate into domestic research strength.

FIGURE 11

Education spending correlates weakly with scientific output and activity

To view this interactive graphic showing how education spending predicts research output and activity, please go to: https://institute.global/insights/tech-and-digitalisation/building-scientific-sovereignty-data-driven-strategies-for-strengthening-research-capacity-in-lmics

Source: TBI analysis

Note: Figures use titles for our science-indicator metrics that mirror the data-explorer schema: DOMAIN.PILLAR.INDICATOR (e.g., SCI.2.3). SCI, TEC and ENA denote the three domains – Science, Technology and Enablers. Within Science, the pillars are numbered: 1 = Institutional infrastructure; 2 = Funding; 3 = Talent; 4 = Outputs & collaboration; the final digit identifies the specific indicator within that pillar. A full list of indicators appears in the data explorer.

Finding 2: Talent Mobility Is Predictive of Research Strength

If education lays the foundation, mobility builds the house. Countries that attract, retain and circulate researchers outperform peers with comparable education systems and budgets. Unlike education spending, mobility reflects current research-system design: how easily scientists can enter, how rewarding it is to stay and how connected R&D systems are to global networks. As such, mobility metrics show around an order of magnitude more predictive power than education outlay in terms of research outputs.

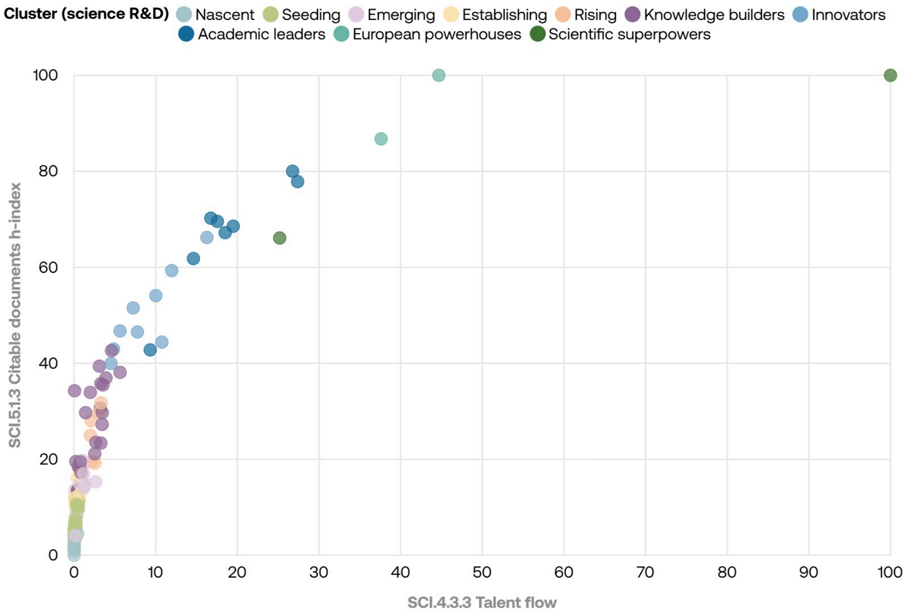
Less obviously, this effect is even more pronounced in low- and mid-tier clusters, where gains from increased talent flow are largest and mobility can partly compensate for weaker institutions. In these clusters:

- talent flow remains a powerful predictor of outcomes after controlling for GERD and researcher headcount[47] – it is not merely a proxy for "more spend" or "bigger workforce"
- higher talent flow is linked to faster gains in top-tranche researchers
- seeding countries with above-median flow have about 40 to 50 per cent higher median h-index and citation levels than below-median peers

Globally, talent flow tracks business-financed R&D; within developing clusters the association is not significant. In mature systems, private R&D and mobility reinforce each other; in earlier stages, public labs and targeted programmes must play the catalytic role.

FIGURE 12

Talent mobility is strongly associated with better research outputs



Source: TBI analysis

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The core insight is simple: the circulation of talent precedes excellence and lets less-mature systems punch above their weight. By contrast, large domestic training systems with high brain drain and weak reintegration rarely convert education spend into scientific performance. For these countries, the bottleneck is not more degrees but better mechanisms to attract, anchor and circulate talent. Ultimately, the shift from “brain drain” to “brain circulation”, or even “brain regain”, is one of the most powerful levers available to LMICs seeking scientific gains.

Policy Toolkit

1. TURN BRAIN DRAIN INTO CIRCULATION

Combating brain drain need not always mean permanent repatriation, but it does require incentives to return, contribute and lead. Overseas training and networks can be an asset as long as there are mechanisms to recapture that value through return pathways or sustained diaspora engagement. Governments can tap into this potential by easing re-entry, offering prestigious and stable roles, and building institutions that make the prospect of coming back both viable and meaningful.

Mechanism 1: Easing Visa and Repatriation Barriers
Simplifying immigration and re-entry for skilled researchers is a minimum first step when encouraging diaspora scientists to return or collaborate. For example, Malaysia's Returning Expert Programme has brought back more than 4,600 Malaysian professionals since 2011 by offering fast-track residency for families, as well as financial perks (a flat 15 per cent tax rate for five years, duty exemptions and so on) for all.[48] These visa and tax incentives lower the cost (bureaucratic and financial) of returning, making it more attractive for expatriate talent to resettle and contribute locally.

Mechanism 2: Core-Funded Research Chairs and Fellowships
Many countries bring talented researchers home by guaranteeing well-funded, multi-year positions with security for salaries, research funding and teams. Endowed chairs and re-entry fellowships are attractive to researchers who otherwise rely on short grant cycles, reducing the career risk for those contemplating a return and ensuring that they have the resources to continue high-level work at home. For instance, India's Ramanujan Fellowship to repatriate outstanding Indian-origin scientists offers a five-year research position with competitive funding for those with proven track records abroad.[49]

Prestigious chairs offer returning scientists more than funding: they provide recognition, autonomy and meaningful influence within the system. In less mature ecosystems, a single acclaimed scientist can significantly shape a region's research agenda, nucleating scientific communities. Anchored by returning principal investigator Gordon Awandare, the West African Centre for Cell Biology of Infectious Pathogens has grown into a regional hub, supporting more than 200 fellows from 14 African countries while running internationally connected labs.[50]

There are lessons to be taken from similar schemes:

- Where possible, host chairs inside recognised (or new) centres of excellence with strong facilities.
- Prioritise (and invest in) recruiting the very best talent (including diaspora), then leverage their reputation and give them freedom to hire, partner internationally and carry flexible budgets.
- Pair generous start-up packages with clear five- to seven-year external reviews to keep standards high.

CASE STUDY

South African Research Chairs Initiative

Launched in 2006 by the Department of Science and Technology and the National Research Foundation, the South African Research Chairs Initiative (SARChI) is a flagship programme to attract and retain world-class research talent in South African universities. With up to 15 years of support per chair, the initiative aims to build institutional depth by anchoring top-tier research leadership within universities, while nucleating research clusters and postgraduate training hubs.

Chairs are structured: Tier 1 for internationally recognised leaders with strong supervision records and Tier 2 for promising mid-career researchers expected to reach global standing within five to ten years. Candidates from abroad for Tier 1 must spend at least 50 per cent of their time at a South African institution; Tier 2 candidates must reside full time for the duration of the award. A 60/40 target for external vs internal hires encourages recruitment from industry, the diaspora and abroad.

An international five-year review found SARChI to be highly effective in attracting and retaining top-tier researchers and boosting South Africa's global research competitiveness. Chairholders consistently outperform national benchmarks on key metrics, and the programme has significantly expanded the pipeline of master's and doctoral graduates.

A key feature underpinning this success is SARChI's tiered model, which combines the recruitment of internationally recognised leaders with support for emerging national talent. This structure builds multi-generational capacity by linking each chairholder to clear supervision and mentoring responsibilities, making excellence sustainable across institutions.

Mechanism 3: Prestigious Domestic Doctoral Programmes
Elite, home-based PhD programmes can keep top students onshore and tempt diaspora and foreign candidates to enrol. This requires generous, reliable stipends for students, the ability to provide quality mentorship (which often means bringing in international faculty) and modern shared facilities. Examples include new institutions such as the Mohamed bin Zayed University of Artificial Intelligence in the UAE (offering fully funded AI PhDs with international hiring, modern compute and strong branding) and the African University of Science and Technology in Nigeria, which provides world-class doctoral training at home.

When domestic PhD systems are politicised or fragmented, top students often leave or disengage. Effective doctoral pathways need transparent hiring, strong supervisory networks and research cultures that reward originality over seniority. Institutional trust is a prerequisite for the success of doctoral programmes.

2. BUILD DEEP, CONNECTED TRAINING PATHWAYS

Investing in training means more than expanding enrollment. In many LMICs, the bottleneck is not student numbers but the quality of scientific training. Thin supervision, weak institutional support and limited exposure to frontier methods can stall promising researchers before they reach full potential. Here is how targeted programmes – from co-supervision schemes to novel training institutes – can build depth, accelerate skills and connect early-career scientists to global research networks.

Mechanism 1: International Co-Supervision and Flagship Mobility Fellowships

A highly effective approach is structured international co-supervision and mobility fellowships: pairing local PhD candidates with experienced supervisors abroad while keeping a strong home-institution anchor. Candidates are sent to train with world-class groups (or co-supervised by diaspora academics) and often guaranteed research funding or academic posts upon return, so that skills and networks flow back into the domestic system. Examples include Kazakhstan's Bolashak programme and the China Scholarship Council schemes, which have sponsored thousands of young scientists for training abroad with return obligations – effectively converting brain drain into "brain circulation".

In contexts where experienced supervisors are scarce, co-supervision models help build capacity without needing to train a full domestic professoriate first. Serbia's Diaspora 2023 programme illustrates this, funding research teams made up of Serbian-based scientists and diaspora researchers abroad (with support from the Serbian government, World Bank and EU), co-producing research while building domestic capability.[51]

Parallel efforts are in train elsewhere:

- **Indonesia's PMDSU scheme** fast tracks high-performing undergraduates into PhD programmes under elite domestic mentors (but often involving training abroad), adding more than 1026 doctoral researchers since 2014.[52]
- **Nigeria's TETFund AST&D programme** funds full PhD training for university staff – either domestically or abroad with a return requirement – and has increased the number of doctorate-holding faculties in federal universities by more than 30 per cent.[53]

Successful schemes bond early-career researchers to local labs while embedding them in global networks, creating a mobile but rooted scientific workforce that brings knowledge and skills home.

Mechanism 2: Novel Educational Institutions and Accelerator Schools
While universities are central to building talent, academia faces structural limitations in many LMICs. In early-stage ecosystems, formal master's and doctoral programmes are often thin, faculty numbers are low, supervisory capacity is stretched and academic incentives remain weak. Much of the responsibility for talent development falls to a few overburdened academic leaders who simultaneously mentor students, build labs and raise external funding – a heroic but ultimately unsustainable effort. In these contexts, novel training institutions and accelerator schools offer a powerful supplement that can rapidly train and deploy scientific talent.

By operating outside traditional academic structures, these institutions and schools can deliver intensive, mission-driven training, decoupled from academia's administrative burden, and can attract international faculty. They also help overcome the reputational and procedural barriers that often discourage global partnerships, making them especially valuable in cases where traditional institutions lack visibility or agility. Similar regional doctoral schools, sandwich programmes or short-term research residencies can expand high-quality training at relatively low cost by leveraging networks rather than infrastructure.

CASE STUDY

African Institute for Mathematical Sciences

The African Institute for Mathematical Sciences (AIMS) is Africa's first network of Centres of Excellence in mathematics. It delivers rigorous, ten-month, fully funded master's programmes hosted across several African countries, designed to rapidly move talented graduates to research readiness.

Students are immersed in a rich research environment and taught by rotating global faculty – including Nobel laureates and Fields Medalists – with a curriculum built around independent research, problem-solving and real-world applications.[54] Alumni routinely progress to PhD programmes worldwide or into high-impact roles across Africa.

Building on this model, AIMS has launched a data-science track – piloted in Rwanda and now expanding – focused on big-data analytics for development, led by the AIMS Next Einstein Initiative, with support from the International Development Research Centre.[55] By operating outside the constraints of traditional university structures, AIMS functions like an accelerator for scientific talent: modular, fast and mission driven. It concentrates expertise, shortens time-to-competence and creates clear pathways for research careers, showing how high-agency training can meet emerging scientific needs in low-resource settings.

3. STRENGTHEN TALENT NETWORKS AT HOME AND ABROAD

Mobility is not just about immigration: sabbaticals, joint appointments and short-term exchanges can yield powerful results, particularly in low- or mid-tier systems where full repatriation is politically or financially unfeasible. Developing this kind of scientific capacity hinges on networks, connecting local scientists to each other, diaspora professionals and the global scientific community.

Mechanism 1: Diaspora Registries and Science Diplomacy
Diaspora scientists often remain informally involved in their countries of origin, offering mentorship, sharing data and co-authoring papers. But without systematic coordination, much of this engagement is ad hoc. Tapping into the expatriate scientific community in a structured way can counteract brain drain without requiring permanent return. Maintaining a formal, updated registry of diaspora researchers is hugely valuable in turning this latent network into a strategic asset. Greece's Knowledge and Partnership Bridges Initiative maps skilled Greek scientists abroad and connects them to joint funding opportunities, mentorship requests and domestic partnerships.[56]

Diaspora scientists can also play a critical role as advocates, not just collaborators, by helping their countries access funding, equipment and visibility on the global stage. In Latin America and the Caribbean, research shows that diaspora scientists already contribute significantly to science diplomacy: lobbying for international resources, brokering collaborations and mentoring young researchers, often without government coordination.[57] Formal registries and engagement platforms can channel this goodwill more effectively, especially for countries with large, well-trained expatriate communities.

CASE STUDY

Pinoy Scientists and the Balik Scientist Program, Philippines

Founded as a community-led platform driven by social media, Pinoy Scientists spotlights the work of Filipino researchers worldwide, building community pride and peer networks, and facilitating informal mentorship among early-career and diaspora scientists.[58] While not state-led, it offers a promising model of how grassroots, low-cost, narrative-driven efforts can strengthen scientific identity, surface role models, spur international collaboration and keep scientists connected to home – laying the groundwork for deeper reintegration strategies.

The Balik Scientist Program, run by the Department of Science and Technology and institutionalised in law in 2018, provides formal placements, funding and incentives for overseas Filipino scientists and technologists to return or collaborate. Since 2022 it has attracted 120 scientists, including one who helped develop a vaccine for African Swine Fever.

Together they form a complimentary playbook: community visibility and belonging expands the pipeline and keeps ties warm; structured incentives and programmes convert that interest into impact.

Governments can empower these actors through small grants, advisory roles or public recognition. Involving diaspora scientists in national science strategy or diplomacy efforts can help align their work with domestic priorities, turning voluntary engagement into a powerful extension of national capacity.

Mechanism 2: Short-Term Exchanges and Sabbatical Tours
Not all expatriate scientists are ready to return full time, but many are willing to contribute on a temporary basis. Programmes that support "tours of duty" allow researchers to spend sabbaticals or short visits at home institutions, offering hands-on mentorship, joint research or advisory support. Many countries enable diaspora scientists to return periodically to teach intensive courses or consult on national research agendas, facilitated by travel grants or sabbatical funding tied to teaching, training or lab-building goals. Short-term exchanges can be low-cost, high-impact ways to infuse domestic systems with frontier skills and keep expatriates connected to national development.

Mechanism 3: Regional Supervision Pools
Regional co-supervision networks can dramatically expand doctoral-training capacity in low-resource settings. By pooling advisors across neighboring countries and diaspora communities, "supervision clouds" ease supervisor bottlenecks and enable students to rotate between labs. They can access joint training, equipment and expertise beyond their home institution without the high cost of building new infrastructure.

This approach is especially well suited to countries with shared languages, cultural ties or regional scientific priorities. Qatar's QRDI Fellowship for Displaced Arab Researchers hosts Arab PhD holders from conflict-affected countries such as Yemen, Sudan, Palestine and Syria in Qatari research labs for three years, pairing them with local mentors. Research topics are aligned with Qatar's national R&D priorities, linking personal reintegration with national goals.[59] These fellowships not only build capacity but create durable transnational research linkages that persist well beyond the programme.

FIGURE 13

Strengthening science systems requires stage-appropriate talent policies for each cluster

Cluster	What the numbers say	Stage-appropriate policy
Seeding	First need critical mass. Researcher density and talent flows very low, heavy brain drain.	• Visa and re-entry: one-stop fast track for returning scientists and family, fee waivers and flexible grants to make short return stints feasible. • Flagships to concentrate top talent: create a visible home base that can absorb the first generation of returnees and anchor training. • Core-funded research chairs: a handful of "national return chairs" with lab space, start-up packages and freedom to hire, explicitly tasked with building graduate pipelines. • Novel schools/accelerators: short, intensive-methods schools hosted by new chairs to quickly raise supervision capacity. • Seed domestic PhD programmes: keep cohorts small and guarantee full stipends. • Diaspora registry and short tours: name known senior diaspora as visiting field leads with funded multi-week blocks tied to lab setup and thesis exams.
Emerging	Elite scarcity – modest headcount but rising output. h-index improves sharply where talent flow is above the median.	• Visa and repatriation incentives: cut friction for high-skill inflow, fee waivers and flexible grants. • Core-funded research chairs at scale: 20 to 50 competitive return chairs across 3 to 5 priority fields, with technician lines and lab-starter grants. • Establish prestigious domestic PhDs that are selective, globally visible with OECD-parity stipends, quality facilities, external examiners, and international and industrial co-supervision. • Scholarships and return obligations: seed a cohort of PhDs with guaranteed future reintegration. • Short exchanges and sabbaticals: tours of duty to seed methods, transfer skills and nucleate projects. • Regional supervision pools: pool scarce advisors across neighbourhoods.
Establishing	Larger researcher base, but talent flow remains low.	• Reform-linked research chairs: renew/expand chairs conditional on open recruitment and external reviews. • Consolidate prestigious PhDs: fold fragmented doctorates into few elite tracks with international examiners, clear career progression and meritocratic culture. • Short sabbatical inflows to refresh curricula and methods with visiting professorship rosters aligned to gaps. • Diaspora governance roles: seat senior diaspora on doctoral/tenure committees to raise trust and standards.
Rising	Moderate researcher density, talent flow highest outside mature tiers.	• Competitive centres of excellence: scale existing success and provide reasons to stay. • Tiered research chairs: mix star returnees with rising domestic PIs; link renewals to doctoral placements, spin-out creation and internationally-recognised outputs. • Prestigious PhDs as national brands that include global-parity stipends, competitive admissions, methods schools and embedded industry stints. • Short exchanges and sabbaticals to bring frontier techniques. • Outcome-linked tenure and grant pipelines (less than 7 years) to convert mobile researchers into long-term leaders. • Selective regional supervision pools for niche fields to widen topic coverage without thinly spreading staff. Leverage stature to orchestrate inter-LMIC talent exchange.

Source: TBI analysis

05

Research Institutions

Behind every thriving science system is a web of capable research institutions – not only buildings but the organisations that train researchers, host discovery and coordinate national effort. In many LMICs, that web is thin and uneven. For leaders, constrained by finite budgets and complex politics, the question is often sequencing: when to concentrate resources on a flagship and when second-tier campuses move to the front of the queue to broaden the base. This section examines how institutional landscapes shape national research performance and offers a simple framework to build deep, resilient ecosystems.

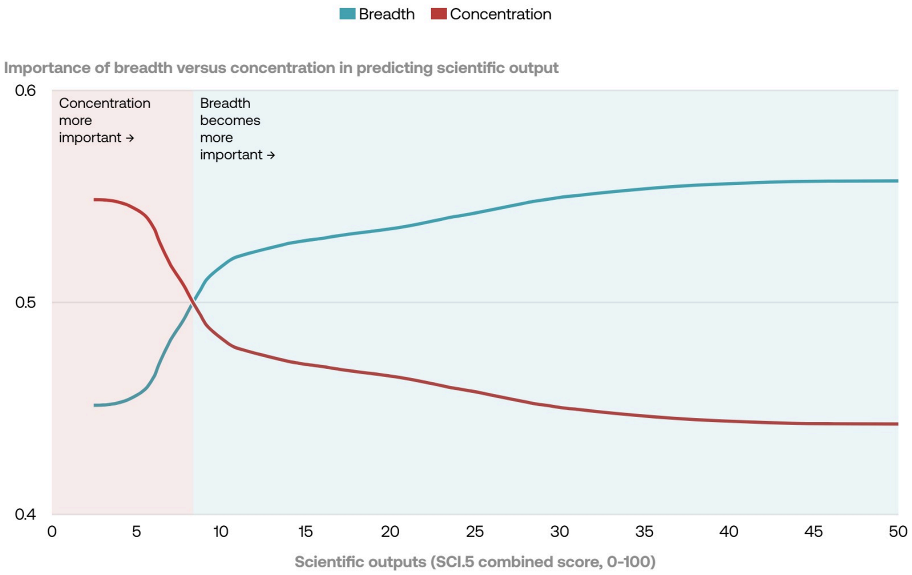
We focus on the trade-off between centralisation and breadth because they are the strongest measurable levers in our data set. But interviews conducted by the authors of this paper repeatedly surfaced other, harder-to-quantify drivers: culture and governance. Systems that reward merit, protect research time and grant trusted leaders autonomy often outperform better-funded peers. If every procurement decision, hire or research direction requires multi-layered sign-off, scientists drown in bureaucracy and trust erodes in both directions. Culture cannot be legislated into being: it is built by appointing capable institutional leaders, ring-fencing their autonomy with clear accountability, simplifying rules that impede research and listening to scientists about what is broken.

Finding 1: Centralisation Pays Early but Limits Long-Term System Growth

Two metrics in our data support this finding: publication centralisation tells us whether a few dominant institutes produce most of a country's papers, while breadth counts how many institutes are publishing at all. As systems mature and outputs rise, concentration tends to increase – but expanding breadth explains more of the performance gap once systems get going. In plain terms, flagships get you off the ground while sustained progress comes from widening the circle.

FIGURE 14

Concentration is correlated with better outputs in the least mature systems, but breadth overtakes concentration after a tipping point



Source: TBI analysis

As shown in the figure above, there is a pivot point. Left of the pivot, concentration is the more important lever; right of the pivot, breadth becomes more strongly correlated with national research outputs.

FIGURE 15

Across the full data set, both publication centralisation and the average number of institutes tend to increase as systems mature

Cluster	Average publication centralisation	Average institutes
Seeding	53	0.26
Emerging	76	1.31
Establishing	71	0.33
Rising	81	2.45

Source: TBI analysis

In low-capacity systems, increased centralisation is strongly associated with improved national impact – crucially, more than breadth. Within the seeding cluster, countries with higher centralisation (such as Uganda, Tanzania, Morocco and Ghana) post national h-index levels about 50 per cent above the cluster median. The signal is clear: when the base is thin, focus pays. For these countries, pooling funds and talent in one or two flagships can boost visibility and performance.

For emerging and establishing systems, the picture is more complex: they occupy a transitional zone around the pivot point and the right strategy varies by country. Many establishing systems already have one or two strong academies and a high concentration of output, which coincides with above-median performance (such as Bulgaria and Serbia). But across the cluster, breadth is now the stronger predictor of quality: countries that get more institutes publishing regularly tend to outperform similarly concentrated peers. A minority of establishing systems remain dispersed and below the pivot; for them, additional focus can still help. For the rest, flagships are doing their jobs and they should plan to pivot; the next gains come from expanding the league of capable institutes.

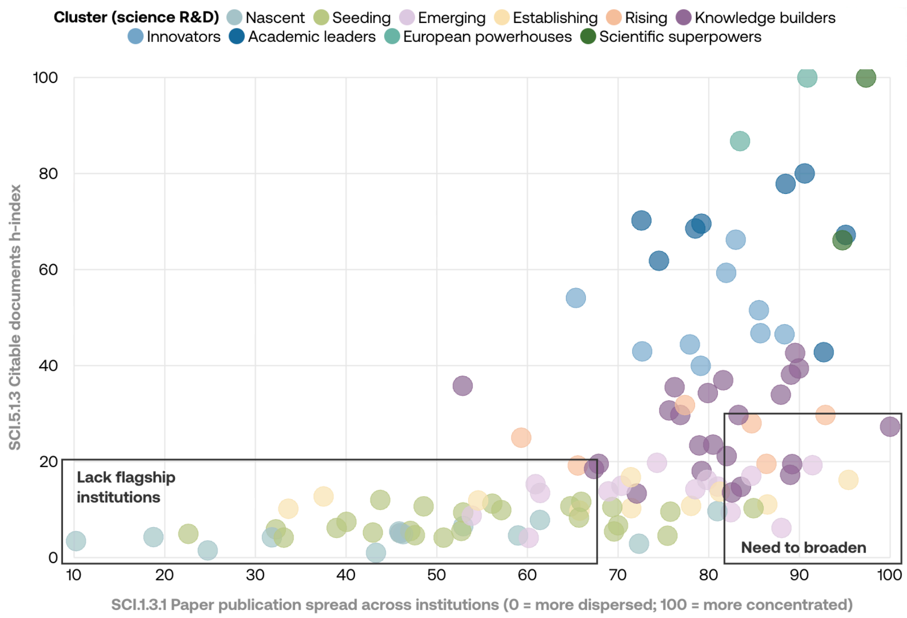
Finding 2: Institutional Breadth Becomes Critical as Systems Mature

Many emerging countries also sit in the transitional zone. Within this cluster, the systems that pull ahead are those already broadening participation – supporting more reliable publishing institutes and wiring them into the flagship's networks – though for some more dispersed ecosystems, concentration can still pay.

Beyond the pivot, feeding top campuses yields diminishing returns; what strongly moves the needle is expansion and scale, along with the system-wide infrastructure that connects them. From the rising cluster upwards, breadth and connectivity decisively dominate: scaling second-tier institutes, building cross-institution centres, deepening industry partnerships and investing in national platforms that keep people and projects moving.

FIGURE 16

Research systems first need strong flagships, but must broaden later to keep developing



Source: TBI analysis

Note: Figures use titles for our science-indicator metrics that mirror the data-explorer schema: DOMAIN.PILLAR.INDICATOR (e.g., SCI.2.3). SCI, TEC and ENA denote the three domains – Science, Technology and Enablers. Within Science, the pillars are numbered: 1 = Institutional infrastructure; 2 = Funding; 3 = Talent; 4 = Outputs & collaboration; the final digit identifies the specific indicator within that pillar. A full list of indicators appears in the data explorer.

Here we consider three countries that sit in the higher-concentration/lower-impact bucket (“Need to broaden”), each for different reasons.

Legacy Centralisation: Bulgaria

Several establishing countries fall into this bucket, consistent with a cluster profile of relatively mature but less dynamic ecosystems dominated by a few legacy institutions. Bulgaria has a historically centralised model, with its research landscape developing around the Bulgarian Academy of Sciences

(BAS), a network that has long acted as the country's principal research performer. Even after the post-1990 transition, BAS remained the largest public research organisation, concentrating prestige, people and resources.

Policy Funnel: Saudi Arabia

Saudi Arabia's policy model channels funds (in line with national strategies) through central agencies and a small set of well-resourced national actors. The King Abdulaziz City for Science and Technology (the national science and technology agency) issues large, centrally aligned grants, while the King Abdullah University of Science and Technology – a graduate, research-only institution founded in 2009 – anchors a significant portion of capacity and aligns research with Vision 2030 via centres of excellence and an "accelerating impact" strategy.[60] The result is world-class nodes within a relatively narrow institutional base – a pattern shaped more by design and resource choices than by bottom-up competition.

Flagship Focus for Development: Uganda

With tighter budgets and a younger ecosystem, Uganda (the only seeding country in the bucket) followed a deliberate flagship-first path. The Ugandan government created targeted funding streams for Makerere University to build labs, modernise facilities and finance applied projects: first the Presidential Innovations Fund (25 billion Ugandan shillings, or $7 million, over five years from 2010) and, since 2019, the Research and Innovations Fund (about 30 billion Ugandan shillings, or $8.4 million, per year). Makerere now anchors national quality and reputation; it was ranked eighth in the Times Higher Education 2024 Sub-Saharan Africa rankings and has been commended for its central role in the attainment of Uganda's strategic vision.[61]

Policy Toolkit

1. FUND FLAGSHIP INSTITUTES WITH MULTI-YEAR CORE FUNDING AND AUTONOMY

Early-stage ecosystems with limited R&D capacity often spread resources too thinly across many nascent institutions. Countries with stretched resources benefit from deliberate focus: choose two or three national flagships, fund them well and let spillovers seed the next tier. By providing multi-year core funding and ensuring that top labs have the autonomy to drive their own research agendas, governments can create centres of excellence that lift the entire system. Well-funded flagships can become nuclei that attract talent, produce quality research and demonstrate the value of science to national development, spurring spillover benefits to the next tier.

There are key steps involved in implementing this strategy.

- **Selectivity:** Identify two to three institutions with the greatest potential (such as those with strong leadership, a focus on national priority areas or a bank of existing talent)[62] to serve as national flagships.
- **Transparent criteria for flagship choice:** Consider track record and mission fit, and conduct time-bound reviews to avoid permanent lock-in.
- **Secure core funding:** Provide each with stable, predictable funding over a multi-year horizon (five to ten years or more), insulated from political turbulence. Financial security allows long-term planning, hiring and infrastructure development. For instance, Egypt's government-backed National Research Centre, founded in 1956, grew into the largest R&D institute in the Middle East with about 4,500 scientists thanks to sustained public funding.[63]
- **Autonomy and excellence:** Grant flagships managerial and academic autonomy (within accountability bounds) to recruit top researchers, set research priorities and manage budgets.

2. DEVELOP HUB-AND-SPOKE MODELS, WHERE THE FLAGSHIP SUPPORTS REGIONAL OR SECTORAL SATELLITES

As the research ecosystem matures, countries should adopt a hub-and-spoke model whereby leading institutions support a broader network of emerging centres. With this approach, a top-tier institute serves as the hub, mentoring and partnering "spoke" institutions: smaller or newer universities, regional campuses and specialised centres. The goal is to seed vibrant research communities throughout the country by transferring the flagship's expertise outward.

As these centres mature they should be required (or incentivised) to share expertise, by training PhD students who can populate new labs, for example, or twinning programmes with developing colleges. Flagships can act as "anchor tenants" in the research ecosystem, spawning spin-off labs and mentoring emerging groups.

To design an effective hub-and-spoke system, countries should consider the following.

- **Mentorship programmes:** Formally link flagship hubs with second-tier institutions, requiring joint research programmes, staff exchanges or training workshops with provincial universities or technical institutes. Leading institutes' senior researchers can mentor faculty in the "spokes" on proposal writing, lab management and techniques.
- **Collaborative micro-grants:** Within the hub, set aside a micro-grant fund to finance small joint projects with emerging institutions. These grants enable mixed teams from the hub and spokes to work together on research or technology development. Over time this builds trust and a culture of collaboration.
- **Regional specialisation (avoiding redundancy):** Institutes should strategically specialise by region or sector. Rather than each institution duplicating efforts in every field, policymakers and funders can designate centres of excellence in different domains aligned with local strengths. By leveraging geographical, demographic and/or comparative advantages, each hub or spoke can develop a niche that serves national needs.

3. CREATE SHARED NATIONAL CORE FACILITIES

World-class science often requires expensive equipment and facilities, from gene sequencers and supercomputers to telescopes and clean rooms. For LMICs, equipping every university with such high-end infrastructure is neither feasible nor wise. The smarter play is investment in shared national or regional core facilities that are open to researchers across institutions, be that on site or remotely. Concentrating capital in a few well-chosen centres maximises the impact of every dollar spent on infrastructure, catalysing breakthroughs by enabling local researchers to tackle questions that they otherwise would not be able to.[64]

To implement shared facilities effectively, the following actions are important.

- **A national needs assessment:** First, perform a strategic analysis of what equipment and facilities will have the highest impact on national research priorities. Avoid ad-hoc purchases; create a coordinated plan identifying a few key investments. Planners should locate facilities to leverage existing strengths but also ensure geographic access.
- **Open access and remote connectivity:** Make facilities as broadly accessible as possible by, for example, establishing clear protocols for any qualified researcher to request time or services at the facility. Leverage technology to allow remote access where feasible; for instance, high-speed networks can let a scientist in a distant city run an analysis on a supercomputer or microscope located at the core facility, with data beamed back electronically.
- **Sustainable operations:** Provide funding not just to buy equipment but to maintain and staff these facilities. A core facility is only as good as its expert operators and its uptime. This means budgeting for dedicated technicians, engineers and managers who keep the instruments running and train users. Shared facilities should operate on cost-recovery or subsidised models.

FIGURE 17

Early systems need concentrated flagships, but sustained growth depends on widening the field through more institutes, shared facilities and collaboration

Cluster	What the numbers say	Stage-appropriate moves
Seeding	Results improve when effort is concentrated.	• Core-fund 1 to 2 flagships with multi-year grants and autonomy to serve as visible national hubs that concentrate talent and resources and anchor training. • Stand up shared national core facilities (for example, sequencing/HPC), national booking platform with remote access where feasible. • Hub-and-spoke mentoring in 1 to 2 priority fields. Consider requiring flagships to support a small number of regional/sectoral satellites (joint labs, staff exchanges, co-PIs). • Micro-collab vouchers (small, fast grants) to pull emerging labs into the flagship's projects.
Emerging	High concentration with rising breadth; returns to extra focus fade.	• Support superstars by keeping top 2 to 3 institutions well funded. • Formalise hub-and-spoke around the flagship in 3 to 4 fields (compacts on training, shared cores, supervisory committees). • Flagship-led micro-grant pools for partner universities. • Core-seed 2 to 3 second-tier institutes (lab-starter packages, technicians). • Create regional centres of excellence with multi-campus boards. • National shared facilities and data platforms such as open-access instrumentation and common data repositories to knit campuses together.
Establishing	Some highly concentrated systems do well, but across the cluster breadth is now better than concentration in predicting quality.	• Track breadth and concentration: prepare to broaden. • Targeted "second-tier lift": upgrade 3 to 6 tier-2 institutions/labs to bring a small cohort into the top tier; hub-and-spoke obligations included. • Consider co-PI rules in some national grants: at least one partner from a different domestic institute on centre/priority calls. • Shift a larger share of funds to competitive, multi-institution calls with clear performance metrics. • Expand national shared facilities with guaranteed access quotas for non-flagships.
Rising	High centralisation and solid breadth; expansion and connectivity dominate marginal gains.	• Build cross-institution centres in priority domains with industry co-labs and shared IP/playbooks. • Competitive centres of excellence/multi-campus institutes – scale existing strengths while hardwiring collaboration across universities. • Cross-disciplinary challenge programmes. • Regional nodes to extend access (satellite cores, mobile labs). • National platforms (HPC, biobanks and so on) with professional operators and service models. • Co-funded facilities with industry and international partners – upgrade capability and utilisation.

Source: TBI analysis

06

Strategy, Policy and Delivery

Funding, talent and infrastructure are vital, but not self-implementing. Strategy and delivery capacity are what turn scattered capabilities into a coherent system. Without them, systems drift: budgets fragment, equipment sits idle and policy misses the bottlenecks that researchers actually face. In LMICs, where fiscal space is tight and trade-offs are sharp, sequencing, coordination and adaptation are critical to success. This chapter distils three practical pillars that were repeatedly emphasised in interviews conducted by the authors of this paper.

1. **Put the basics in place:** A short, costed STI plan with a clear owner, a few national bets and instruments to fund them.
2. **Build delivery capacity:** Empower capable agencies, co-create policy with researchers and unblock bottlenecks via advisory panels, secondments and policy sprints.
3. **Build policy capacity in government:** Install a feedback engine made up of a small analytics unit, external evaluations and clear metrics.

These pillars are cross-cutting, in that they are relevant to all clusters but the emphasis shifts with maturity. We note where the weight should fall at each stage.

Policy Toolkit: Recommendations and Application by Cluster

1. PUT THE BASICS IN PLACE: A NATIONAL STRATEGY

A national STI strategy provides a focused roadmap for research and innovation aligned with a country's development agenda. This should not be a long wish list but a digestible, costed and actionable strategy with a clear owner. Key elements of a good STI strategy include the following.

- **Time-bound:** Five to ten years, but revised annually.

- **Governance and ownership:** One lead agency to coordinate implementation (a science ministry or council, for example), with a mandate and clear budget. Such high-level ownership ensures cross-ministerial coordination and political support.
- **Priority-setting:** Countries identify a few priority sectors or fields to focus investment and reforms that play into their strengths – a number of national bets. India's principal science advisory council identified nine national missions (including AI, quantum science, electric vehicles, biodiversity and deep-ocean exploration) as flagship research programmes to tackle key development challenges. Each mission is led by a relevant ministry and backed by dedicated resources, ensuring focus on areas of strategic importance.[65]
- **Costed plans and funding:** Actionable strategies link plans and bets to instruments (grants, core funding and fellowships, for example) and are backed by realistic financing plans.
- **Implementation and review mechanisms:** The includes defined timelines and setting out which institutions are responsible for each initiative, specifying how progress will be assessed (annual reports, evaluation metrics, council oversight meetings) and incorporating regular reviews. Such mechanisms help adjust strategies in response to challenges and keep them on track. International partners and think-tanks can assist with independent evaluations to measure impact.

The above approach prevents scattergun spending, lets governments make portfolio choices (flagships versus networks; curiosity-driven versus mission programmes); and gives funders and universities a predictable roadmap.

CASE STUDY

Rwanda's National Science Strategy

Rwanda's concise and actionable STI agenda, created in 2020, enumerates six priority sectors and puts governance, financing and human capital at the core, tied directly to national development goals and Vision 2050's shift to a knowledge-based economy.[66] Integration with these aspirations helped secure buy-in across ministries.

Policy and delivery are anchored in the National Council for Science and Technology (NCST), established by law and housed under the office of the president, giving it the mandate to coordinate across government.

It runs effectively thanks to the following elements.

- Progress is reviewed through Science and Innovation Days and progress reports, linked to national planning cycles.
- A National Research and Innovation Fund has disbursed about $4 million to 91 priority-aligned research projects.
- Budgeted annual grant calls (for the likes of agriculture and energy) create predictable instruments.
- A Research Coordination Committee convenes major institutions for joint planning, monitoring and evaluation of programmes under the strategy.

Delivery is adaptive: when the NCST's researcher forums flagged excessive paperwork and duplicated reporting across agencies, the government introduced a single integrated reporting portal for research projects in 2022.

Clear ownership, limited and defined priorities, funded instruments and routine feedback loops turn strategy from a wish list into a working delivery system.

2. CO-CREATE POLICY WITH RESEARCHERS AND UNBLOCK OPERATIONAL BOTTLENECKS

Science strategies benefit from the close involvement of front-line researchers in policy design and implementation. Co-creation of policy means tapping researchers' coal-face expertise to shape relevant programmes, while also addressing practical bottlenecks that hinder research on the ground. Strategies often fail at the point of execution due to ignored front-line constraints such as stipends not being paid on time (which can lead to researcher loss), broken procurement or lack of access to facilities. The highest-return reforms are often operational; involving scientists surfaces these quickly and builds legitimacy.

Potential mechanisms for integration include the following.

- **Standing channels for front-line input:** One example would be research advisory panels giving scientists a voice in setting priorities and crafting policy. Such councils typically include top academics, industry R&D leaders and diaspora experts, creating a formal bridge between the scientific community and the highest levels of government. Success factors include a clear mandate and regular meetings integrated with policy cycles.
- **Embedded researchers and secondments:** Embedding researchers within ministries on temporary assignments can rapidly build capacity and inject on-the-ground insights. Several LMICs have piloted such

programmes, while on a smaller scale some governments run scholar-in-residence or secondment programmes to place PhD researchers into ministry policy units for six to 12 months. In Malawi and Kenya's health ministries, embedded researchers have mapped process delays and proposed administrative fixes.[67]

- **Policy sprints and hackathons:** Some governments organise short-term, focused collaborations with researchers to brainstorm and solve specific problems. These "policy sprints" bring together policymakers, scientists and stakeholders for intensive workshops (lasting days or weeks) to develop actionable proposals.
- **Science-policy think-tanks and networks:** Independent policy-research institutes can help generate ideas and scrutinise implementation, acting as both partners and constructive critics of the government.

3. BUILD SCIENCE POLICY AND METASCIENCE CAPACITY WITHIN GOVERNMENT

LMICs are recognising the importance of high-quality science policy and metascience capacity within government. Even well-funded science strategies falter without feedback. The ability to measure, learn and adapt is essential to steer the system effectively – and these steps can further that cause.

- **Embedded metascience units:** A small unit inside a ministry or council that tracks how the system works: where money flows, what outcomes are achieved and which instruments need fixing. This could be staffed by a mix of scientists, social scientists, economists and data scientists.
- **External evaluation partnerships:** Partnerships with universities or regional think-tanks to evaluate grant instruments, talent schemes and other parts of the research ecosystem. These partnerships provide independent insight and help build national learning capacity.
- **Strategic metrics and learning loops:** A clear mandate to interrogate the metrics used to track success, enabling governments to understand what's working, what isn't and how to adapt in real time.

- **Research-information systems and data platforms:** A foundational step is to maintain robust data on the national research ecosystem – funding flows, outputs, human resources and innovation indicators – to inform decision-making. Brazil's Lattes Platform is a standout example: a national CV and research tracking system covering more than five million researchers. It enables real-time analytics on productivity, collaboration and funding gaps, powering better grant decisions and talent planning.

A modest investment in metascience – even a small dashboard team or annual strategy review cycle – creates a learning system that gets better over time.

07

Discussion and Limitations

While the metrics used in this report provide valuable insights into national science ecosystems, they also suffer from several well-documented limitations. Chief among these is a reliance on global academic-performance indicators – such as papers published, the h-index, citation counts and international university rankings – as proxies for scientific quality and institutional excellence.

These metrics, though widely used, have long been criticised within the scholarly community for offering a narrow and often misleading picture of research importance. The h-index, for instance, rewards cumulative volume and citation frequency, systematically disadvantaging early-career researchers and institutions working in niche or locally focused fields. Citation counts more broadly tend to reflect visibility, prestige and network effects rather than the intrinsic quality and relevance of scientific work. Even in the world's most advanced research systems, these indicators can distort incentives, entrench hierarchies and discourage risk-taking. As the Leiden Manifesto[68] and the San Francisco Declaration on Research Assessment[69] have argued, over-reliance on these quantitative measures can undermine more meaningful forms of evaluation.

These shortcomings are even more pronounced in the context of LMICs. Global indexing platforms such as Scopus and Web of Science systematically underrepresent journals and scholarly output from institutions based in LMICs – especially those published by regional or non-English outlets.[70] Research that is deeply relevant to local contexts but appears in unindexed formats often goes uncounted, reinforcing global disparities in scientific visibility and influence. Institutions that prioritise work in more locally relevant fields, applied research, policy engagement, and education and training – such as the African Institute for Mathematical Sciences – may have significant societal and/or capacity-building impact that is not adequately captured.

Moreover, these metrics are closely tied to access to international networks and high-profile collaborators – advantages disproportionately concentrated in high-income settings. Patterns of citation density and research impact often mirror the epistemic priorities of scientifically dominant nations, which can obscure the context-specific contributions made by researchers elsewhere.

Beyond these conceptual issues there are also significant empirical constraints. Research data infrastructure across LMICs remains highly fragmented and uneven, with many countries lacking reliable, centralised systems to track R&D activity, funding flows and publication output.[71] Where data exists, it is often incomplete or inconsistently reported. These gaps limit the comparability, resolution and reliability of even the best-available indicators, pointing to a larger need: strengthening the global infrastructure for measuring and understanding science.

We have sought to address these limitations by diversifying our metrics to reflect a broad set of scientific indicators, thereby generating a meaningful lens through which to understand patterns of visibility, academic influence and institutional positioning across LMICs. Still, we recognise that this is only a partial view. Ultimately, our aim is not to present a hierarchical ranking or reduce scientific systems to simplistic metrics. Rather, it is to offer a structured starting point: a tool for exploration, comparison and strategy design that reflects insights from and the limitations of the available data. Our goal is to contribute to a broader conversation about the need for better, more context-sensitive ways to understand and support science systems in development contexts.

Conclusion

There is no single pathway to scientific advancement. Each country must navigate its own historical and institutional terrain – and in doing so, shape a research system that reflects local strengths, constraints and ambitions. While our cluster typology offers broad policy recommendations, the accompanying data explorer enables countries to benchmark themselves, identify structural gaps and chart their own course.

This is a call for ambition and action. Scientific agency requires homegrown knowledge infrastructure – not as a luxury, but as a necessity for tackling urgent development challenges. It allows LMICs to move beyond dependency or a catch-up model of science, building research systems that serve national priorities. In doing so, LMICs can help shape a more equitable, resilient and dynamic global scientific future.

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