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# From project portfolios to institutional strategy: mainstreaming climate resilience in agricultural research at CGIAR

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Agricultural research institutions face mounting pressure to demonstrate climate impact, yet lack systematic approaches to assess and strategically reorient their portfolios. This perspective presents a four-method portfolio analysis framework—combining discourse analysis, publication review, key informant interviews, and stakeholder mapping. The framework was used to assess the International Institute of Tropical Agriculture's (IITA) 2013–2025 climate portfolio considering new strategic planning. The results of the review revealed five transferable lessons for research organizations: first, reduce the focus on adaptation alone to also include mitigation; second, close gaps between what is documented versus what is undertaken in practice to strengthen policy relevance; third, address the lack of deeper integration of gender and youth; fourth, strengthen institutional capacities to affect policy change; and fifth, advance collaborations across institutes to better address the multidimensionality of climate change impacts and opportunities. Beyond IITA, applying such a portfolio analysis framework is expected to significantly strengthen the ability of institutions to navigate the evolving climate finance landscape and support strategic reorientations in a coherent and impactful way. The approach offers other research institutions a replicable method to move from climate-relevant projects toward comprehensive institutional climate strategies.

## KEYWORDS

climate resilience, agricultural research, portfolio analysis, strategic planning, CGIAR, institutional transformation, climate adaptation, Africa

## 1 Introduction

Agricultural research institutions need to play a key role in addressing the climate crisis facing farmers across the globe (UN FAO, 2024). With climate shocks increasing in frequency, programming within these institutions contends with the twin pressures from farmers and donors alike of increasing climate-relevant research and demonstrating improved impacts. In the Global South, the CGIAR research centers are prominently positioned to make a difference in the hotspots most impacted by climate change (CGIAR, 2025a). Out of the 14 centers within the CGIAR system, four are headquartered in sub-Saharan Africa, where climate vulnerability is especially high (WMO, 2024): AfricaRice, International Livestock Research Institute (ILRI), World Agroforestry (ICRAF), and the International Institute of Tropical Agriculture (IITA). With its long-term mission “to offer leading research partnership that facilitates agricultural solutions to hunger, poverty, and natural resource degradation throughout sub-Saharan Africa” (IITA, 2025), IITA made a concerted effort for its 2024–2030 strategy toward

“reorienting our strategic focus to include climate-resilient agriculture” (IITA, 2024). Such a reorientation involves moving from undertaking climate-relevant, project-based research toward embedding climate change strategically across the organizational make-up for generating meaningful short-term results and long-term impact.

This perspective article presents a strategic review of the existing climate research portfolio of IITA, headquartered in Nigeria and its 24 research stations across sub-Saharan Africa. The article makes three main contributions: First, it details the mixed methods used for an internal review process of research outputs and projects. Given the omnipresent challenges of climate change and urgency in taking climate action, the resultant multi-method framework enables other national and international agricultural research institutions to assess and reorient their own climate portfolios to be more coherent and impactful. Second, it presents five transferable lessons learned from the review. Third, it translates the findings into practical actions to take to achieve the shared goal of addressing the climate crisis. Climate impacts demand more than institutional commitments: they require transitioning from strategy to adaptive and iterative implementation. This perspective article supports that critical transition by moving beyond individual projects toward mainstreaming climate resilience in agricultural research.

A systems perspective is essential for this shift. Fragmentation in agricultural research portfolios is rarely the result of isolated or disparate issues but rather results from interconnected institutional factors, including short funding/implementation cycles, siloed disciplinary structures, and weak links between research, policy engagement, and learning systems. Effectively addressing climate resilience, therefore, requires coordinated and structural changes across research design, strategic planning, partnership models and policy interfaces. This perspective paper takes this systems framing as its analytical foundation.

## 2 Portfolio analysis framework

The portfolio analysis framework triangulates four complementary methods to assess alignment between institutional activity and strategic priorities. The framework assesses IITA’s project portfolio from 2013 to early 2025 with the CGIAR 2030 Research and Innovation Strategy (CGIAR, 2021) and the earlier mentioned IITA 2024–2030 strategy (IITA, 2024). The guiding question asks: How can IITA strengthen its impact on climate resilience from the local to the global level? To address the overarching question, three sub-questions were developed: first, how does IITA’s project portfolio contribute to the wider CGIAR 2030 Research and Innovation strategy and reflect the charge of the new IITA 2024–2030 strategy; second, which elements of the CGIAR strategy are not being addressed; and third, what is IITA’s comparative advantage? Conducted between February and May 2025, the research formulates actionable recommendations, including how to fill gaps identified, to move from individual climate-resilient projects to a more comprehensive institutional and integrated climate strategy and resultant impacts.

### 2.1 A multi-method triangulation approach

Systematic portfolio assessment requires multiple lenses to capture the gap between strategic intent, documented activity, research

outputs, and practitioner experience. The framework integrates four methods: discourse analysis, publication reviews, key informant interviews, and stakeholder mapping. In the following sub-sections, the methods are detailed with the correspondent IITA specific findings in the *Results* section. The *Discussion* section offers five transferable lessons and perspectives on how the research findings relate to agricultural research institutions beyond IITA.

#### 2.1.1 Discourse analysis

The structured discourse analysis examined how climate resilience and related strategic themes appear across project documentation (i.e., progress or technical reports), identifying patterns of IITA’s contribution, thematic gaps, and inconsistencies. The discourse analysis followed three steps: identifying climate-relevant projects, confirmatory coding (Saldaña, 2021) against predetermined categories, followed by systematic coding using NVivo combined with a peer-review process to accurately and efficiently capture the frequency and depth of alignment.

In practice, the discourse analysis included 23 climate-relevant projects within the 2013 to 2025 timeframe. The confirmatory coding mapped these projects against the key impact areas, pathways, and action areas identified within CGIAR (2021) and IITA (2024) (see Table 1). NVivo coding, validated through peer review, revealed key thematic areas, contributions to the respective strategies, and gaps requiring further attention. Supplementary Appendix A offers additional details for the discourse analysis.

#### 2.1.2 Publication review

In addition to project objectives and impacts, agricultural research institutes share findings via research publications. In a second step, the portfolio analysis framework draws on a review of all relevant peer-reviewed journal articles authored by IITA-affiliated researchers. Inclusion criteria (climate change, adaptation, resilience, mitigation, climate, and vulnerability) enable triangulation of how projects and publications relate to strategic plans.

In practice, using the online systematic review platform Covidence, the review identified 239 journal articles, reduced to 153 articles after further screening based on review of study focus and exclusion criteria (such as year, language, or authorship). Specifically, articles were excluded if they were published prior to 2013, not in

TABLE 1 Categories for portfolio coding based on new CGIAR and IITA strategies.

Category type	CGIAR 2030 research and innovation strategy/IITA 2024–2030 strategy
Impact areas	<ul style="list-style-type: none"> <li>• Nutrition, health, food security</li> <li>• Poverty reduction, livelihoods, jobs across Africa</li> <li>• Gender equality, youth, social inclusion in agriculture</li> <li>• Climate adaptation and mitigation for smallholder farmers</li> <li>• Environmental health and biodiversity and soil health</li> </ul>
Impact pathways	<ul style="list-style-type: none"> <li>• Capacity development</li> <li>• Innovations</li> <li>• Policy</li> </ul>
Action areas	<ul style="list-style-type: none"> <li>• Systems transformation</li> <li>• Resilient agrifood systems</li> <li>• Genetic innovation</li> </ul>

*Italics indicate where the strategy of IITA (2024) differs from CGIAR (2021).*

English, and lacked any author affiliated with IITA. The review employed frequency-based thematic analysis mapped against [Table 1](#) strategic themes and identified emerging themes beyond predetermined codes. [Supplementary Appendix B](#) offers additional details on the included articles the Publication Review.

### 2.1.3 Key informant interviews

This third step—interviews with project managers responsible for the identified project portfolios—provided insights into how projects contribute to climate mitigation, adaptation, and resilience beyond the written documentation. In addition to project-specific insights, interviewees were asked to describe the organization's strategic positioning in addressing climate change, including the role of partner organizations and government entities in the process.

In practice, out of the 23 projects identified, interviewees were randomly selected. Seven interviews ranging from 30 to 60 min were conducted, with resultant findings strengthening the triangulation of how IITA's work aligns with IITA's and CGIAR's climate strategies.

### 2.1.4 Stakeholder mapping exercise

The fourth step applied a comparative advantage analysis approach previously developed for CGIAR centers ([Meinke et al., 2023](#)). The adapted stakeholder mapping enabled understanding of desired deliverables, identification of potential partners, and assessing tradeoffs.

In practice, the authors completed two stakeholder mapping exercises. The first stakeholder mapping exercise involved IITA's relationship to eight other CGIAR centers with the shared geographical focus of Africa. The list included ICARDA (International Center for Agricultural Research in the Dry Lands), CIAT (International Center for Tropical Agriculture), ICRISAT (Institute for Semi-Arid Tropics), CIMMYT (International Maize and Wheat Improvement Center), ICRAF/World Agroforestry (International Center for Research in Agroforestry), IFPRI (International Food Policy Research Institute), Africa Rice, and ILRI (International Livestock Research Institute). The second mapping focused on mapping over 50 donors based on overlapping goals: existing ones supporting IITA's climate resilience portfolio; current funders of IITA at-large; and prospective donors.

## 3 Results

Triangulating the four methods clarifies IITA's current positioning within relevant strategies (IITA and CGIAR). The triangulation found that compared to IITA's new strategy (see [Table 1](#)), IITA's current and past climate portfolio already consistently positioned climate-resilient agriculture as a key climate adaptation strategy and as an avenue for achieving poverty reduction. In the discourse analysis, around 4 out of 10 projects explicitly addressed climate adaptation and 8 out of 10 poverty reduction, livelihoods, and jobs. In the publication review, these numbers increased to 9 out of 10 articles specifically referencing climate adaptation and 7.5 out of 10 articles referencing poverty reduction, respectively. Key informant interviews confirmed that nutrition (the other thrust of IITA's strategy, alongside climate resilient agriculture), health, and food security form the foundation for improved climate resilience in project design. The frequent co-occurrence of climate adaptation, poverty reduction, and food security demonstrates that IITA integrates climate work into the broader development context rather than siloing it. The portfolio

analysis framework also revealed a consistent strength of IITA's around capacity development, innovation and policy engagement, with IITA's leadership in crop breeding, agronomy, and applied agricultural research emphasized. The stakeholder mapping emphasized IITA's historic role in setting the climate resilience agenda through genetic improvements of tropical crops (e.g., cassava, yam, or cowpea). The systematic review of research articles confirmed that IITA builds climate resilience primarily through yield optimization, resistance to pests and diseases, and varietal improvements.

While these strengths demonstrate IITA's comparative advantage in technical research domains such as breeding and biotechnology, they remain largely concentrated in production-oriented systems. The analysis suggests that stronger cross-linkages between technical research, socio-economic drivers, institutional incentives and policy processes would be needed for the institute to deliver system-wide climate resilience outcomes. This highlights the importance of moving beyond technical excellence alone toward integrated research and learning approaches, particularly from the start of research design and planning. While there is significant work at IITA related to commercializing and scaling solutions to reach smallholder farmers, this wasn't explicit in the research and documentation.

In contrast, the discourse analysis revealed that while projects broadly acknowledged gender (8 out of 10 projects) and youth (4 out of 10 projects), neither served as a central component. Less than half of gender mentions in project documentation were substantive (4 out of 10), with much of the references as fleeting acknowledgments of the topic. The absence of detailed gender and youth considerations reduces the ability of research to inform inclusive institutional strategies. Strengthening gender- and youth-responsive approaches requires embedding these dimensions at the design stage, ensuring meaningful participation in data collection, and integrating disaggregated indicators that capture the distribution of resilience benefits. Climate change itself also did not often form an analytical focus of the research. Climate mitigation remained comparatively underemphasized, appearing in only 1 out of 10 project documents and 2 out of 10 research articles. Compared to climate adaptation, climate mitigation was three times less likely to be explicitly mentioned in project documents and resultant research reports. Importantly, key informant interviews highlighted the relevance of work to climate mitigation (e.g., agroforestry), revealing a potential disconnect between research and practice, as well as limitations in communicating more systemic impacts. These shortcomings are relevant given the increased demands from donors at the impact level. Interviewees also identified digital tools and gender-responsive approaches as opportunities for improving IITA's work on climate-resilience, highlighting the value of more inclusive innovation systems to attain more holistic interventions.

## 4 Discussion

### 4.1 Five transferable lessons

The results yield five broader lessons relevant to other agricultural research institutes. First, the gap between climate adaptation and mitigation is expected to extend across the sector, as institutions underdocument climate mitigation efforts as a research focus, even as practices or projects often contribute to both mitigation and adaptation at the same time. A common example is

the promotion of climate-smart agriculture practices for smallholders. These practices have been shown to reduce the amount of greenhouse gases released (e.g., through low/no tillage, perennial crops) as well as support farmers to be more resilient to climate shocks and stresses. By not highlighting work (e.g., mitigation or gender), there are missed opportunities to promote success stories or learn from failures and to better engage donors who may be looking for key findings and results in these sectors. Second, gaps between formally documented work (i.e., in the form of project documentation and research publications) and actual practice limit policy influence and funding opportunities for agricultural research institutes. Embedding climate change not solely as a framing device but as an analytical variable opens up new possibilities to engage both donors and policymakers. Third, the lack of deeper integration of gender and youth is expected to reflect the wider challenge in development practice of fulfilling donor requirements without targeting more resources toward addressing their unique climate challenges. To successfully address climate change, a more explicit participatory engagement of these groups at the beginning stages of research and funding proposal development is essential. Fourth, while projects and research hold clear policy relevance, limited capacity for policy engagement undermines agricultural research institutes' excellence in technical work. To translate practice and research into policy, institutes should invest in additional staffing capacity, dedicating additional resources (including time) or better leverage existing synergies with other partners (e.g., IFPRI, civil society, national government, think tanks etc.). Fifth, research institutes should proactively articulate and provide evidence for their comparative advantages in funding narratives. This is not a single event, but rather should be a continuous process of engaging with other national and international institutions to refine the messaging and strategy and ensure that the advantages are well understood. Building on the earlier point, cross-institutional collaborations create stronger funding proposals and better address climate change's multidimensionality. Taken together, these five lessons represent interconnected components of a broader systems transition for agricultural research institutions. They illustrate how changes in framing, organizational structures and incentives, and partnership models can collectively shift institutions from siloed, project-based approaches toward integrated, learning-oriented climate resilience strategies. Rather than discrete recommendations, the lessons function as mutually reinforcing dimensions of a system that link research, policy, partnerships and practice.

## 4.2 Translating findings into practice

Taking advantage of the insights gained from the portfolio analysis, the following four main points emerge for empowering agricultural research institutes to better address the climate crisis from a systems perspective in general, and IITA's work to achieve their new strategies in particular:

First, given their stronger emphasis on activities in areas related to climate adaptation and productivity, it is recommended that institutions expand their research and project portfolios to include explicit climate mitigation and resilience-building strategies. Traditionally, research organizations hire experts in specific fields of science. Only recently

have universities started offering interdisciplinary PhDs from which research organizations can hire. Neither nature nor farming exists in silos and the climate challenge requires interdisciplinary research and implementation. By creating incentives to break down silos, one can foster inclusion of climate change into dominant research domains (e.g., breeding, gene banks, biotechnology) and better plan for future climate scenarios. Embedding climate change from the research design phase will improve integration, develop synergies, and encourage systems thinking can cascade these interdisciplinary approaches through implementation and measurement. In regard to incentives, donors are increasingly looking for holistic solutions to problems, and institutions should adapt to mobilize new resources to effectively address the climate crisis. As an immediate step, they could build staff capacities to better engage in the complementary domains of climate mitigation and resilience building aligned with local, national and regional priorities.

Second, agricultural research institutes exhibit strong bilateral relationships with national governments and regional actors (including donors). Successfully tackling the global challenge of climate change at scale requires expanding engagement to multilateral institutions (e.g., the World Bank Group), global initiatives (e.g., UNFCCC's Koronivia Joint Work on Agriculture), and climate finance mechanisms (e.g., the Green Climate Fund). Beyond securing additional funding, such engagement offers pathways for knowledge exchange, agenda setting and capacity building beyond traditional research networks. They also offer further opportunities to elevate the profile of local knowledge and actors that are too frequently missing from the regional and global stages.

Third, research institutes should make their existing work more accessible. With communication too frequently limited to (open access) journal publications, annual reporting, or the occasional conference presentation, more accessible and adaptable products—such as briefs, websites, mobile-friendly toolkits, or digital climate advisory apps—are needed. Research institutes tend to protect and subsequently silo their existing innovations. Collaborating with other institutions and the private sector, offers opportunities to increase the visibility of what already works for scaling and combining solutions to address the climate crisis. For example, the umbrella term of climate-smart agriculture captures diverse aligned efforts and enables packaging of synergetic solutions for policymakers and funders. Integrating communication and policy engagement from the outset—not as an afterthought—would go a long way toward empowering change for both stakeholders at local to global levels. This could form part of the work under the cross CGIAR—Climate Action Science Program (CGIAR, 2025b). Creating institutional learning systems, such as producing annual climate portfolio reviews and cross-project synthesis briefs assessing progress to integrating climate change across the organization, would help ensure that insights from individual projects systematically inform strategic planning.

Fourth, adopting a systems perspective reveals root causes of the fragmentation, and their relationships, as well as openings for more transformative actions. Short time frames for developing funding proposals, as well as short durations of project implementation, are detrimental for achieving more participatory, collaborative efforts and impactful interventions. Widespread funding cuts across agricultural development, and the increased political polarization of climate change further undermines efforts at breaking down silos. To counteract these root causes, institutional support is needed to overcome the fragmentation challenges. Beyond dedicated core

funding, investing in staffing is crucial. [Meinke et al. \(2023, 6\)](#) for example note how greater capacity for inclusivity can fuel “systems innovation among marginalized populations and agricultural systems.” Donors play an important role in redirecting their funding toward more collaborative efforts that demand integrated approaches and influence policymaking and agenda setting. Another example from the donors’ perspective is efforts to foster knowledge sharing and adaptive capacity through communities of practice that move beyond the traditional project cycle ([Nicklin et al., 2021](#)). [Schut et al. \(2015\)](#) also developed a helpful diagnostic tool used in a multi-stakeholder context to unlock complex challenges through agricultural innovation systems.

In conclusion, climate impacts do not wait for institutional readiness nor are they moved by printed words in new strategies. A shift in the directionality of programming within agricultural research institutes – similar to steering a large container ship – will take time to translate into a change in course to address climate change, and even longer to translate into improved impacts. The portfolio analysis framework presented here offers agricultural research institutes a systematic method to get us there. Steps include diagnosing strategic alignment, articulating comparative advantages, and redirecting resources toward comprehensive climate action. As development and climate finance flows are changing, the ability to assess and articulate one’s climate portfolio becomes not only an analytical exercise, but essential toward strengthening one’s organization to achieve its stated mission and better respond to the climate crisis. The five lessons identified provide actionable entry points along this transition pathway, illustrating how research, partnerships, institutional structures and policy engagement should evolve together to mainstream climate resilience in research organizations.

## Data availability statement

The original contributions presented in the study are included in the article/[Supplementary material](#), further inquiries can be directed to the corresponding author/s.

## Author contributions

JC: Conceptualization, Investigation, Project administration, Resources, Supervision, Writing – review & editing. OT: Conceptualization, Investigation, Methodology, Writing – original draft, Data curation, Formal analysis. ZJ: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft. SM: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft. RH: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft. SL: Conceptualization, Investigation, Methodology, Writing – original draft, Supervision.

## References

CGIAR (2021). CGIAR 2030 research and innovation strategy: Transforming food, land, and water systems in a climate crisis. Montpellier: CGIAR System Organization.

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## Conflict of interest

The author(s) declared that this work was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fsufs.2025.1728611/full#supplementary-material>

CGIAR (2025a). Research Centers. Available online at: <https://www.cgiar.org/research/research-centers/> (Accessed October 15, 2025).

- CGIAR (2025b). Climate action. Available online at: <https://www.cgiar.org/cgiar-research-portfolio-2025-2030/climate-action/> (Accessed November 17, 2025).
- IITA (2024). IITA'S 2024–2030 strategy: Science, research and delivery innovations for African agrifood system transformation. Ibadan: International Institute of Tropical Agriculture.
- IITA (2025). Mission and vision. Available online at: <https://www.iita.org/about-iita/mission-and-vision/> (Accessed July 15, 2025).
- Meinke, H., Ash, A., Barrett, C. B., Smith, A. G., Graff Zivin, J. S., Abera, F., et al. (2023). Evolution of the one CGIAR'S research and innovation portfolio to 2030: approaches, tools, and insights after the reform. *NPJ Sustain. Agric.* 1, 1–8. doi: 10.1038/s44264-023-00005-x
- Nicklin, C., Chancellor, T., Garcia, A., Linnet Gohole, L., Hausmann, B., Kajjage, P., et al. (2021). Funder-initiated communities of practice as a means for sharing and creating knowledge in order to strengthen the adaptive capacity of systems. *Found. Rev.* 13, 70–83. doi: 10.9707/1944-5660.1554
- Saldaña, J. (2021). The coding manual for qualitative researchers. 4th Edn. London: SAGE Publications.
- Schut, M., Klerkx, L., Rodenburg, J., Kayeke, J., Hinnou, L. C., Raboanarielina, C. M., et al. (2015). RAAIS: rapid appraisal of agricultural innovation systems (part I). A diagnostic tool for integrated analysis of complex problems and innovation capacity. *Agric. Syst.* 132, 1–11. doi: 10.1016/j.agsy.2014.08.009
- UN FAO (2024). UN global climate report: A stark reminder of the urgent need to leverage agrifood solutions. Available online at: <https://www.fao.org/newsroom/detail/un-state-of-the-global-climate--a-stark-reminder-of-the-urgent-need-to-leverage-agrifood-solutions/en>. (Accessed October 14, 2025).
- WMO (2024). Africa faces disproportionate burden from climate change and adaptation costs. Available online at: <https://wmo.int/news/media-centre/africa-faces-disproportionate-burden-from-climate-change-and-adaptation-costs> (Accessed November 17, 2025).