PARI Interim Report 2022

submitted by
Prof. Dr. Joachim von Braun and Dr. Heike Baumüller
Center for Development Research (ZEF) of the University of Bonn
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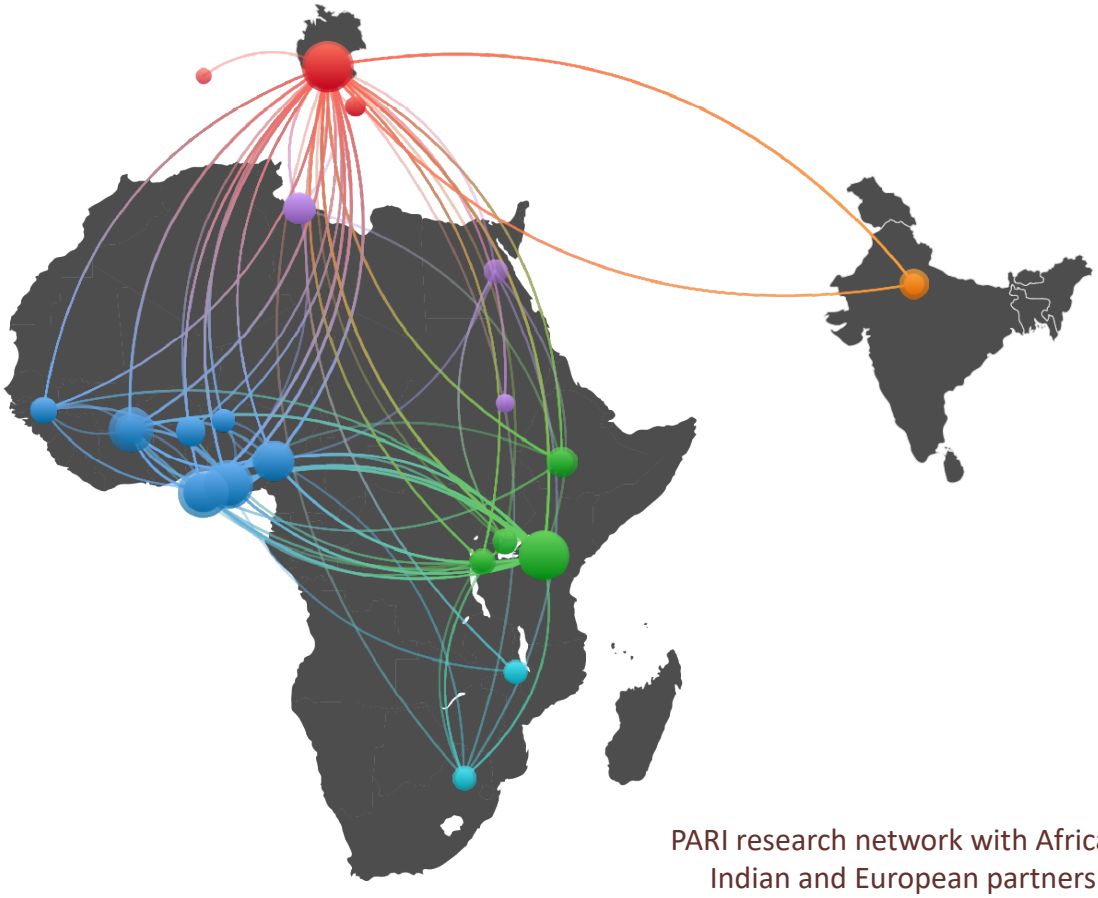

PARI research network with African, Indian and European partners

PARI
Program of Accompanying Research for Agricultural Innovation

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Image on the front cover:

Network map showing collaborative research activities by authors engaged in PARI research in 2014-2022, clustered by country. The size of the dots relates to the number of authors in each country. The thickness of the connections relates to the number of collaborative publications. Colours refer to different regions (see section 1.3). Generated using VOSViewer. Cartography: Heike Baumüller.

Content

Zusammenfassung

Die *Begleitforschung für landwirtschaftliche Innovationen* (PARI) vereint Partner in Afrika, Indien und Deutschland, um zu nachhaltiger Transformation von Ernährungssystemen und Ernährungssicherheit beizutragen. Highlights in 2022:

Verbesserung der Produktivität und Resilienz von Agrar- und Ernährungssystemen

Nachhaltige Produktionsmethoden / Klima-Resilienz: PARI-Forschungsaktivitäten untersuchen die Auswirkungen nachhaltiger Produktionsmethoden auf die Produktivität und Widerstandsfähigkeit der kleinbäuerlichen Landwirtschaft. Die laufende Forschung befasst sich mit den potenziellen Vorteilen agro-ökologischer Praktiken in Afrika, u.a. mit Hilfe einer Meta-Analyse empirischer Forschung. Zudem wird untersucht, inwieweit „carbon farming" in Afrika zur Eindämmung und Anpassung an den Klimawandel beitragen kann, sowie das Potenzial der Agrobiodiversität als Risikomanagementstrategie für Kleinerzeuger.

Digitalisierung in Nahrungsmittel- und Landwirtschaft: PARI-Forschung untersucht, wie sich digitale Technologien auf afrikanische Wertschöpfungsketten auswirken. Eine Umfrage unter landwirtschaftlichen Stakeholdern, einschließlich Händlern von Inputs und Outputs sowie landwirtschaftlichen Beratern, hat gezeigt, dass diese „Vermittler" in hohem Maße von digitalen Technologien Gebrauch machen. Die Technologien erleichtern den Informationsaustausch und die Vernetzung mit verschiedenen Akteuren und senken Transaktionskosten. Eine neue PARI-Forschungsarbeit soll nun untersuchen, inwieweit Kleinerzeuger in Afrika von der Teilnahme an digitalen landwirtschaftlichen Plattformen profitieren können.

Potenzial für die Agroforstwirtschaft in Afrika: PARI-Forschung analysiert die Rolle der Agroforstwirtschaft bei der Förderung der nachhaltigen Entwicklung, der Schaffung von Arbeitsplätzen, des grünen Wachstums und der Verbesserung der Ernährungssysteme in Afrika. Zu diesem Zweck soll eine Studie das derzeitige Ausmaß, die Dynamik und das künftige Potenzial agroforstlicher Praktiken mit innovativen Ansätzen kartieren. In einer wirtschaftlichen Bewertung sollen dann die Kosten und Nutzen einer nachhaltigen Landbewirtschaftung und der Land-Rehabilitation durch agroforstwirtschaftliche Praktiken ermittelt werden.

Sozioökonomische Aspekte der Tierhaltung: Die Förderung des Tierhaltungssektors in Afrika bedarf einer sorgfältigeren Ausrichtung politischer Maßnahmen und Investitionen. Im Geflügelsektor beispielsweise hat die PARI-Forschung ergeben, dass das Wachstum kommerzieller Unternehmen durch eine Reihe unternehmensbezogener Faktoren sowie durch Verbesserungen der Rahmenbedingungen vorangetrieben wurde. Die Forschung hat auch gezeigt, das Nachhaltigkeitsziele bisher in der afrikanischen Viehzuchtpolitik vernachlässigt wurden.

Lernen und Austausch zwischen Indien und Afrika: In zwei laufenden Studien wird untersucht, wie Indien seinen Tierhaltungssektor umgestaltet hat, mit Schwerpunkt auf Geflügel und Milchwirtschaft. Zu diesem Zweck untersuchen die Studien die Rolle von technologischen, politischen und institutionellen Innovationen bei der Förderung von Investitionen, die das Wachstum der beiden Teilsektoren in Indien voranbringen. Die Studien sollen Weg aufzeigen, wie Indiens Geflügel- und Milchwirtschaft weltweit wettbewerbsfähig und ökologisch nachhaltig werden kann. Sie sollen auch Aufschluss darüber geben, welche Ansätze am besten geeignet sind, um das Wachstum des Tierhaltungssektors in Afrika zu fördern.

Beschäftigungs- und Einkommensmöglichkeiten in ländlichen Gebieten

Beschäftigung in der Agrar- und Lebensmittelverarbeitung: PARI-Forschung belegt, dass die Beschäftigungs-möglichkeiten in der Agrar- und Lebensmittelverarbeitung in Afrika vielversprechend sind, aber noch weitgehend ungenutzt bleiben. Obwohl die Arbeitsplätze in diesem Sektor nur etwa 5% der Gesamtbeschäftigung in der Lebensmittelwirtschaft ausmachen, sind sie in den letzten zwei Jahrzehnten rasch gewachsen. Die Agrar- und Lebensmittelverarbeitung ist arbeitsintensiv und bietet ein hohes Beschäftigungspotenzial. Rückmeldungen von Arbeitnehmern haben auch gezeigt, dass die Arbeitsplätze im

Vergleich zu anderen, die denselben Arbeitnehmern zur Verfügung stehen, im Allgemeinen als gute Arbeitsplätze angesehen werden.

Lokale Herstellung von Landmaschinen: Untersuchungen zu den Merkmalen, Chancen und Herausforderungen lokaler Hersteller von Landmaschinen in Afrika haben gezeigt, dass dynamische lokale Maschinenmärkte entstehen, die von kleinen, aber engagierten Unternehmern angetrieben werden, die an die lokalen Bedingungen angepasste Maschinen entwickeln. Allerdings sind politische Maßnahmen und Investitionen in den Bereichen Finanzierung, Bildung, Rohstoffe, Produktionsanlagen und Regulierung erforderlich, um die lokalen Hersteller zu unterstützen und "Made in Africa" zur ersten Wahl afrikanischen Erzeuger und Verarbeiter von Agrarprodukten zu machen.

Stärkung der Rolle der Frauen: Die laufende PARI-Forschung konzentriert sich weiterhin auf die Stärkung von Frauen in Ernährungssystemen. Ein Schwerpunkt ist die Untersuchung von Zeitnutzung und Zeitbelastungen der Frauen. Insbesondere erforschen Studien die Auswirkungen verschiedener Technologien und Innovationen auf die Muster der Zeitnutzung von Männern und Frauen sowie die damit verbundenen Auswirkungen auf die Produktivität, Wohlstand sowie die Gesundheit und Ernährung von Frauen und ihren Kindern.

Einbindung von Jugendlichen im Ernährungssystem: Die PARI-Forschung hat untersucht, wie junge Menschen bei ihren unternehmerischen Aktivitäten unterstützt werden können. Obwohl Arbeitsplätze im Ernährungssystem eine wichtige Rolle in ihrer Berufswahl spielen, bedarf es mehrere Faktoren, um solche Arbeitsplätze attraktiv zu machen, darunter Technologie, Investitionen, Marktchancen und ein angemessenes Einkommen. Um ihr Geschäft auszubauen, benötigen Agropreneure Humankapital, Zugang zu Finanzkapital sowie Sozialkapital durch familiäre Verbindungen und andere Netzwerke.

Entwicklung von Qualifikationen für nachhaltige Landwirtschaft: Im Rahmen der laufenden PARI-Forschung wird untersucht, wie Kompetenzen und Verknüpfung zwischen Forschung und Anwendung für eine nachhaltige Transformation der Landwirtschaft aufgebaut werden können. Um die Ziele für nachhaltige Entwicklung zu erreichen, muss nicht nur die landwirtschaftliche Produktivität gesteigert werden, sondern es muss auch ein Beitrag zu anderen ökologischen und sozialen Zielen wie Klimaresilienz, Erhaltung der Agrobiodiversität und Inklusion geleistet werden. Die Forschung soll Strategien ermitteln, die es landwirtschaftlichen Forschungs-, Beratungs- und Bildungseinrichtungen ermöglichen, diese vielfältigen Nachhaltigkeitsziele besser zu unterstützen.

Landwirtschaftliche Innovations- und Forschungssysteme: PARI-Forschung hat gezeigt, dass eine auf die Landwirtschaft ausgerichtete Investitionsstrategie erheblich zur Erreichung der SDGs und der afrikanischen Entwicklungsziele beitragen und die Widerstandsfähigkeit gegenüber Klimaschocks erhöhen könnte – viel stärker als Wachstumsstrategien, die auf die Industrie oder den Dienstleistungssektor ausgerichtet sind. Um diese Chancen zu nutzen, sind weitere Investitionen in die Innovationskapazitäten lokaler Unternehmen erforderlich. Laut einer PARI Studie sind afrikanische Unternehmen bisher hauptsächlich innovativ, um geschäftliche Hindernisse zu überwinden, und nicht, um ihre Wettbewerbsfähigkeit zu verbessern.

Beteiligung an der Gestaltung der Ernährungs- und Agrarpolitik

Um die PARI-Ergebnisse zu verbreiten und in politische Prozesse einzubringen, haben die Partner des PARI-Konsortiums im Jahr 2022 mehrere Veranstaltungen organisiert. Unterstützt wurden die Outreach-Aktivitäten durch soziale Medien und Publikationen, darunter Policy Briefs, Studien und Meinungsbeiträge. Online-Statistiken zeigen, dass PARI ein breites Publikum afrikanischer politischer Akteure erreicht und einbindet.

PARI profitiert insbesondere von seinen Multi-Akteurs-Partnerschaften mit regionalen und pan-Afrikanischen Institutionen, sowie seinem Netzwerk aus über 300 Forschern aus 74 Organisationen und 25 Ländern, die sich seit 2014 in PARI engagieren, gemeinsam forschen und die PARI-Ergebnisse verbreiten.

Executive Summary

The Program of Accompanying Research for Agricultural Innovation (PARI) brings together partners from Africa, India and Germany to contribute to sustainable agricultural growth, food systems transformation and food and nutrition security in Africa and India. Highlights in 2022 include:

Improving the productivity and resilience of agricultural and food systems

Sustainable production methods / climate resilience: Various PARI research activities focus on the role of sustainable production methods in increasing the productivity and resilience of smallholder farming. An ongoing meta-analysis of empirical evidence on the application of agro-ecological practices in Africa will offer insights on the potential gains from applying these practices on the continent. Looking in more detail at specific agro-ecological practices, research is evaluating the feasibility of carbon farming in African agriculture to mitigate and adapt to climate change impacts as well as the potential of agro-biodiversity as a risk-management strategy for small-scale producers.

Digitalization in food and agriculture: PARI research examines the use and impact of digital technologies in African agricultural value chains. A survey of agricultural intermediaries, including input and output dealers and extension agents, showed that intermediaries make extensive use of digital technologies in their work. The technologies mainly facilitate information sharing and networking with various value chain actors, and reduce transaction costs for input and output dealers. New PARI research was launched in 2022 which seeks to assess how small-scale producers in Africa are benefiting from participating in digital agricultural platforms and how these platforms are changing local input and output markets.

Potential for agroforestry in Africa: PARI research is assessing the role of agroforestry in promoting sustainable development, job creation, green growth and food systems enhancement in Africa. Using innovative approaches, the current extent, recent dynamics and future potential of agroforestry practices is being mapped across Africa. An economic assessment will then identify the costs and benefits of sustainable land management and land restoration using agroforestry practices in Africa.

Socio-economic aspects of animal husbandry: Addressing constraints to livestock sector development in Africa requires better targeting of policy interventions and investments. In the poultry sector, for instance, PARI research found that the growth of commercial businesses was driven by various business-related factors (e.g. vertical integration of value chain activities, product diversification, skills and networks of entrepreneur) as well as improvements in the enabling environment (e.g. digitally enabled access to financial services and local demand growth). Another study also showed that sustainability dimensions, such as impacts on the environment, animal welfare, nutrition and equity, are largely neglected in African livestock policies.

India-Africa learning and exchange: To complement related research in Africa, two ongoing studies are exploring how India has transformed its livestock sector, with a focus on the poultry and dairy sub-sectors. To this end, the studies examine the role of innovations in technology, policy and institutions in stimulating the investments that have been driving poultry and dairy sector growth in India. The studies will chart a way forward for India's poultry and dairy sectors to become globally competitive and environmentally sustainable. They will also draw lessons for the most suitable approaches to stimulate growth in Africa.

Employment and income opportunities in rural areas, especially for youth and women

Employment opportunities in agroprocessing: PARI research showed that employment opportunities in the agroprocessing sector are promising, but remain largely untapped. While jobs in the sector account for only around 5% of total employment in the food economy, they have grown rapidly over the last two decades. The agroprocessing sector is labour-intensive and presents high employment generation potential, both in absolute terms and compared to other sectors of manufacturing. Feedback from employees also shows that jobs are generally considered to be good jobs compared to other jobs available to the same workers.

Local manufacturing of agricultural machinery: Research into the characteristics, opportunities and challenges of local manufacturers of agricultural machinery in Africa showed that vibrant local machinery markets are emerging, driven by small but dedicated entrepreneurs who develop machinery adapted to local conditions. However, policies and investments related to financing, human resources, utilities, raw materials, production equipment, and regulation are needed to support local manufacturers and make "Made in Africa" the first choice of African producers and agro-food processors.

Empowering women: PARI research continues to focus on strengthening women in African food and agriculture. Among the focus areas, research examines women's time use and constraints, and related impacts on productivity, welfare and nutrition. One study seeks to identify the impact of different technologies and innovations on the patterns of men's and women's time use in domestic, own-farm and off-farm work and related impacts on the productivity of time use. A second study will offer insights on the links between the allocation of women's time to various activities and their own and their children's health and nutrition outcomes.

Youth engagement in the food system: PARI research seeks to better understand what is motivating young people to work in the food system and how they can be supported in their entrepreneurial activities. One study found that while food system jobs play a significant role in youth's aspirations, they remain conditional on several factors that are needed to make such jobs attractive, including technology, investment, market opportunities and decent earnings. To grow their business, agripreneurs require human capital gained through formal education and practical experiences, access to financial capital and assets, and social capital through family connections and other networks.

Skill development for sustainable agriculture: Ongoing PARI research is assessing how to build skills and research-extension linkages for sustainable agricultural transformation. Meeting the Sustainable Development Goals requires efforts to not only increase agricultural productivity, but also contribute to other environmental and social goals such as climate resilience, agrobiodiversity conservation and inclusiveness. The research will identify strategies that will enable agricultural research, extension and education institutions to better address these multiple sustainability goals.

Agricultural innovation and research systems: Research in this area focused on the patterns and role of investments in stimulating agricultural growth, innovation and poverty reduction. One study concluded that an agriculture-led investment strategy could significantly contribute to the achievement of the SDGs and African development objectives as well as enhance resilience to climate shocks – much more so than industry-led or services-led growth strategies. Capitalizing on these opportunities will require further investments in the innovative capacities of local firms. A PARI study found that to date, firms mainly innovate as a strategy to cope with business obstacles, rather than to enhance competitiveness.

Engaging with food and agriculture policy making to enhance food and nutrition security

To disseminate PARI findings and input into policy processes, partners in the PARI consortium organized and participated in several events in 2022. Among the highlights, PARI hosted a session "Beyond the Farm: Investment for innovation of food processing in Africa's food system" at the African Green Revolution Forum in Rwanda, which was held again in-person for the first time since the Covid-19 pandemic. Outreach activities were supported by social media and publications, including policy briefs, studies and opinion pieces. Online statistics show that PARI is reaching and engaging a wide audience of African policy stakeholders.

PARI benefits in particular from its multi-actor partnerships with regional and pan-African institutions, as well as its network of over 300 researchers from 74 organizations and 25 countries who have been involved in PARI since 2014 to conduct collaborative research and disseminate PARI results.

1 Project overview

1.1 Objective of the Program of Accompanying Research for Innovation – PARI

PARI brings together partners from Africa, India and Germany **to contribute to sustainable agricultural growth, food systems transformation and food and nutrition security in Africa and India**. PARI offers independent scientific advice to the German government's activities to combat hunger and malnutrition. Among other activities, German government seeks to achieve its objectives through its network of 14 Green Innovation Centres (GICs) in Africa as well as India. The research-based information generated in PARI serves to strengthen the integration of the GICs into national, regional and continental institutional partner settings, in order to enhance value chains contributing to rural and agricultural development. Specifically, the PARI pursues the following strategies:

1. Analysis of the **potential and impact of innovations – policy, institutional and technical innovations** (which innovations to invest in, where and for whom – considering women, youth, small-scale producers),
2. Identification and assessment of **supportive measures to strengthen framework- and policy conditions** for the generation and dissemination of promising innovations in food systems and rural areas, and
3. Engaging food, nutrition, agriculture and rural areas' **science partners and policy makers** to inform reforms and investment decisions that can improve job creation and food and nutrition security.

1.2 Research partners

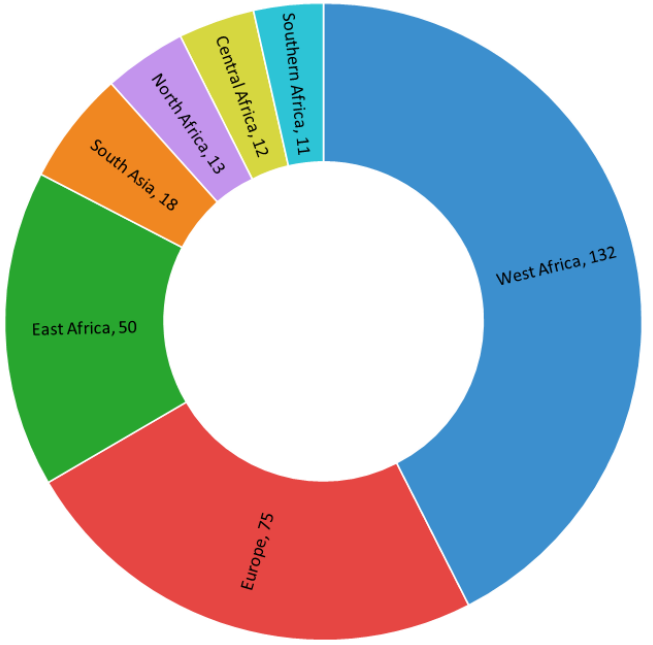
Coordinating partner	**Focal point**
ZEF Center for Development Research University of Bonn	Prof. Dr. Joachim von Braun, Project Director Dr. Heike Baumüller, Project Coordinator
FARA Forum for Agricultural Research in Africa	Dr. Yemi Akinbamijo, Executive Director Dr. Wole Fatunbi, Project Coordinator
AGRODEP African Growth and Development Policy Modeling Consortium (AGRODEP) hosted by AKADEMIYA2063	Dr. Ousmane Badiane, Executive Chairperson, Akademiya2063 Dr. Getaw Tadesse, Project Coordinator
UHO University of Hohenheim	Prof. Dr. Regina Birner, Head of Social and Institutional Change in Agricultural Development Dr. Thomas Daum, Project Coordinator

In addition to the national research partners who have regularly engaged in PARI activities, other experts and institutions are brought in where needed to complement the network's capacities.

1.3 Research network 2014-2022

Between 2014 and 2022, PARI has developed a substantial network of researchers from Africa, India and Europe. A review of all studies published during that period shows that a total of 311 researchers from 74 organisations and 25 countries have co-authored around 200 publications. Just over two thirds of them are based in Africa (70%), primarily in West and East Africa (Figure 1). The most frequently represented institutions include the national agricultural research institutes in Benin (INRAB, 27), Kenya (KALRO, 18), Nigeria (ARCN, 15) and Ghana (CSIR-STEPRI, 15) as well as ZEF (21) and the University of Hohenheim (26). The partners engage in collaborative research activities within and beyond Africa (see front cover and Figures 2 and 3).

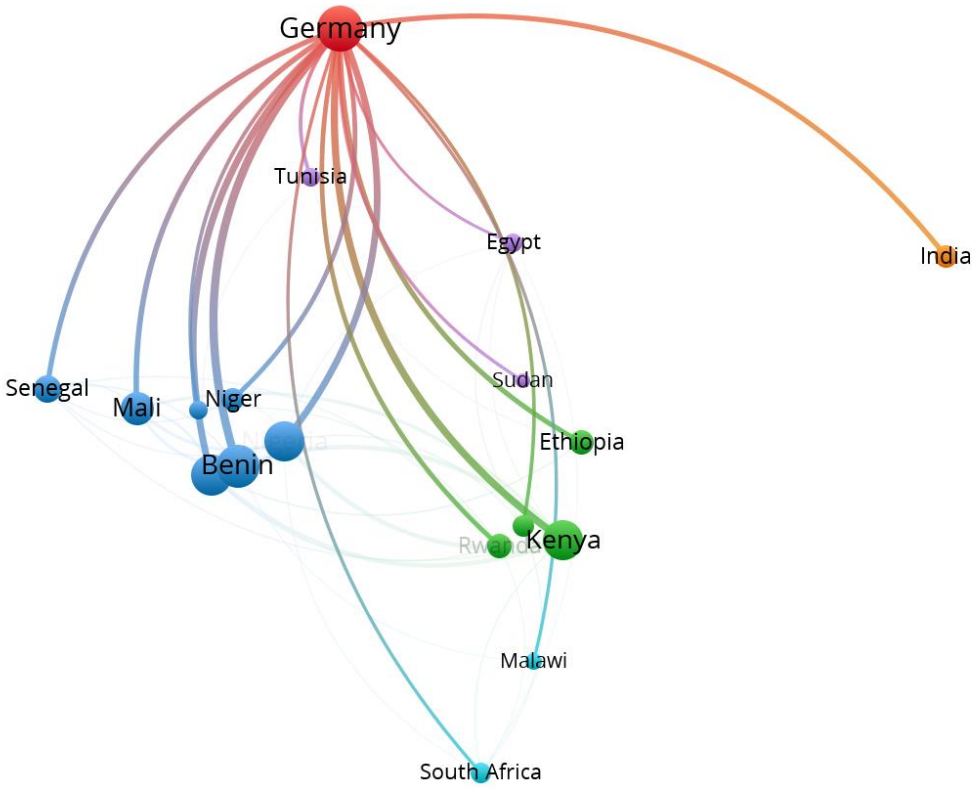
Figure 1: Origin of PARI authors (2014-2022)



Top 10 African countries:

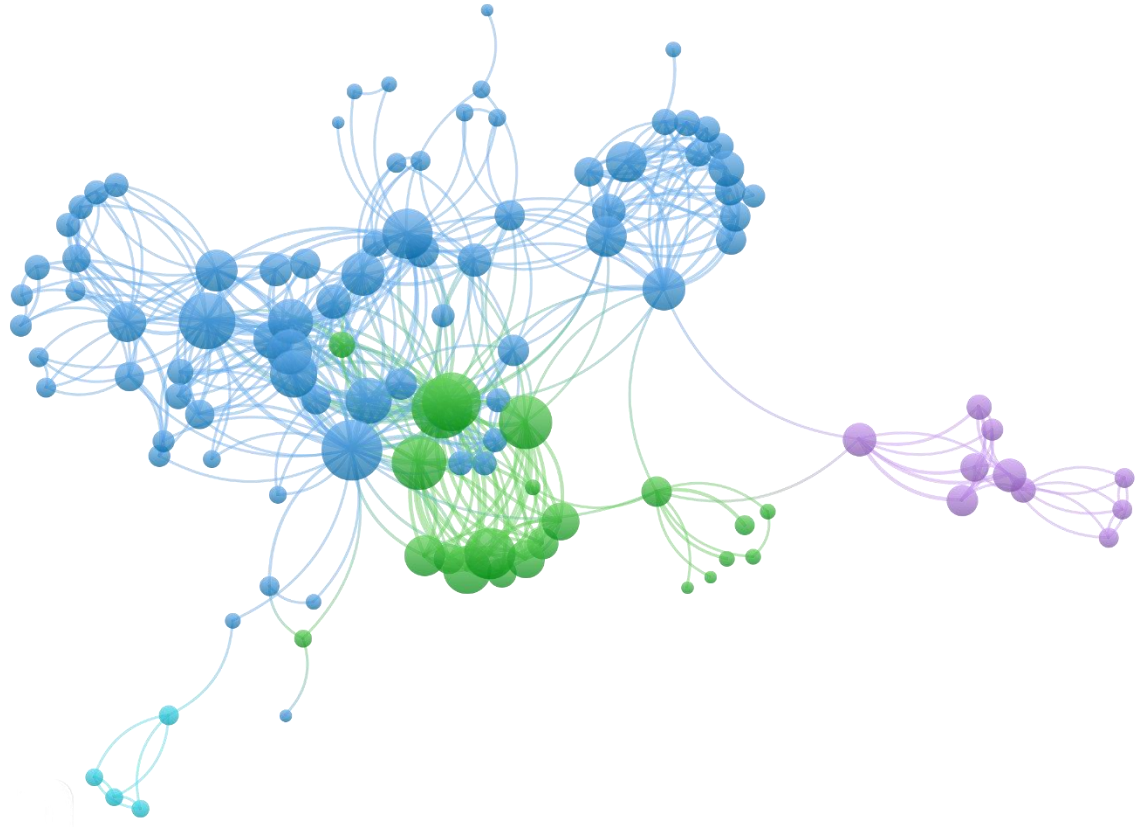
Benin	30
Kenya	28
Nigeria	22
Ghana	21
Senegal	20
Ethiopia	14
Cameroon	12
Mali	11
Tunisia	11
Burkina Faso	11
India	18

Figure 2: Research collaboration facilitated by the German partners



Note: Collaborative research activities between German and African / Indian authors for all publications 2014-2022. Authors clustered by countries. Size of the dot = number of authors in each country. Thickness of connections = number of collaborative publications. Colours refer to different regions (see Figure 1). Generated using VOSViewer. Cartography: Heike Baumüller.

Figure 3: Research collaboration among African partners



Note: Collaborative research activities among African authors for all publications 2014-2022. Dot = author. Size of the dot = number of publications by the respective author. Colours refer to different regions (see Figure 1). Generated using VOSViewer. Cartography: Heike Baumüller.

2 Activities and achievements in 2022

2.1 Innovation investments to improve the productivity and resilience of agricultural and food systems

In this work package, PARI research focuses on the implementation of innovative solutions, in particular the development of strategies and framework conditions for scaling innovations based on a thorough understanding of the critical success factors.

Agricultural mechanization

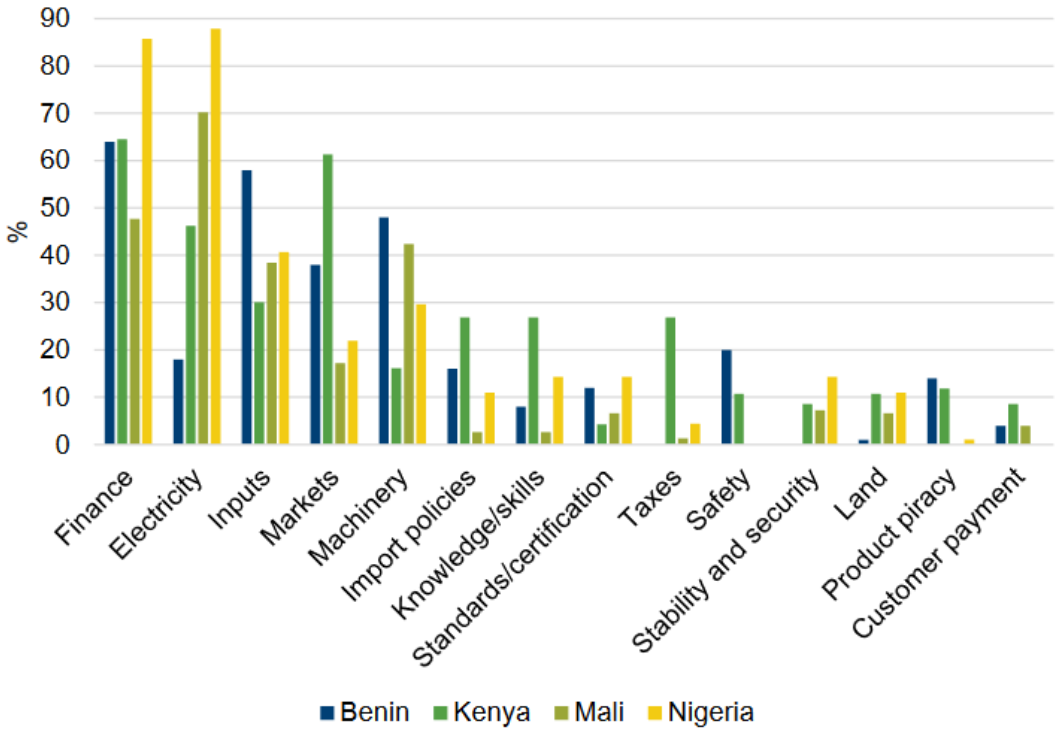
How to expand local manufacturing of agricultural machinery in Africa?

Local manufacturers of machinery could play a key role in scaling agricultural mechanization in Africa, but little is known about how to harness this potential. A cross-country PARI study[1] in four countries (Benin, Kenya, Nigeria, and Mali) on the characteristics, opportunities and challenges of local manufacturers in Africa shows that **vibrant local machinery markets are emerging, driven by small but dedicated entrepreneurs** who develop machinery adapted to local conditions. However, African

[1] Daum et al. (2022). Made in Africa – How to make local agricultural machinery manufacturing thrive, PARI Policy Brief No. 31, and country studies for Benin, Kenya, Nigeria, and Mali.

manufacturers struggle to compete in global markets (Figure 4). Policies and investments related to financing, human resources, utilities, raw materials, production equipment, and regulation are needed to support local manufacturers and make "Made in Africa" the first choice of African farmers and agro-food processors.

Figure 4: Top 10 business constraints for local machinery manufacturers[1]



Different technologies for farm mechanization are used across Africa, including animal traction, two-wheel tractors and four-wheel tractors. To enable governments and development partners to identify suitable technological pathways, a PARI study[2] proposes **a novel "best-fit" framework to assess the comparative advantages and disadvantages of the three mechanization pathways** depending on the agro-ecological and socio-economic context. The framework gives a first approximation on which farm mechanization pathways "best-fit" in different parts of Africa that can then inform further in-depth analyses of the field situation at the country level in cooperation with local farmers.

Which types of mechanization technologies are most suitable in different African farming contexts?

Inputs (seed, fertilizer)

Agrochemicals, such as herbicides, are on the rise across Sub-Saharan Africa. While they may help to raise yields and reduce the labour burden associated with manual weeding, they can also harm environmental and human health. To ensure that agrochemicals are used in ways that are sustainable from an economic, social, and environmental perspective, policies and organizations controlling their environmental and human health effects are needed. An ongoing PARI study examines **governance challenges, needs, and solutions** in this regard, using Zambia as a case study country.

How could the use of agrochemicals best be governed in African agriculture?

[2] Daum et al. (2022) Animal traction, two-wheel tractors, or four-wheel tractors? A best-fit approach to guide farm mechanization in Africa

Sustainable production methods / climate resilience

How are agro-ecological practices performing in Africa?

Agro-ecological approaches are being promoted as one possible pathway towards sustainable agricultural production. However, little is known about the impact of these approaches in the African context. Based on a systematic review of the available literature, an ongoing PARI study will compare **effects of conventional and agro-ecological farming practices to draw conclusions about the potential gains from applying these practices**. The review will be complemented by a mapping of agro-ecological interventions in Uganda, Senegal, Ghana, Malawi and Kenya, including challenges and opportunities for the adoption of agro-ecological practices and the impacts of these interventions on different outcomes.

Could carbon farming contribute to climate change adaptation and mitigation in Africa?

PARI launched new research on the **potential of carbon farming (i.e. agricultural practices that reduce or promote active sequestration of carbons in the soil or vegetation) in African agriculture**. A particular focus will be placed on assessing the opportunities for smallholder farmers to tap into emerging agricultural carbon markets. The first PARI study[3] examined the welfare effects of biochar and compost production training on farm households in Northern Ghana. The results show that the intervention has increased adoption of organic fertilizer and perceived improvements in soil quality which in turn contributed to increasing agricultural productivity and welfare.

What is the role of agro-biodiversity in managing risks on African farms?

Crop genetic diversity, or agro-biodiversity, is believed to be key to making agriculture more resilient to climate change and reducing vulnerability to pests and diseases. The rising genetic uniformity on farmer's fields in many parts of Africa is therefore an increasing concern. Using a comparative case study approach in Burkina Faso and Ghana, an ongoing PARI study assesses the factors that influence farmers' seed management strategies and subsequently crop genetic diversity. It also investigates the **benefits and challenges of using crop genetic diversity as a risk management option**, with a focus on yields and yield risks as well as other impacts, such as nutrition.

How to inform drought mitigation policies to boost agricultural production in the Sahel region?

The African Sahel, a region where the economy is mainly based on agriculture and livestock raising, have experienced severe droughts, resulting in enormous losses and damaging impacts on the socio-economic life and the environment. To better understand drought key patterns and their impacts on economic activities in the region, PARI researchers[4] have developed a **composite drought index (CDI) and a unique drought database for monitoring and modelling droughts and their impacts in the Sahel region**. Among other applications, the database can inform drought mitigation policies, such as the selection of crop species per site based on drought characteristics, the implementation of drought mitigation strategies according to past drought patterns, and the assessment of the efficacy of drought mitigation strategies.

[3] Okyere & Kornher (2022) Carbon Farming Training and Welfare: Evidence from Northern Ghana

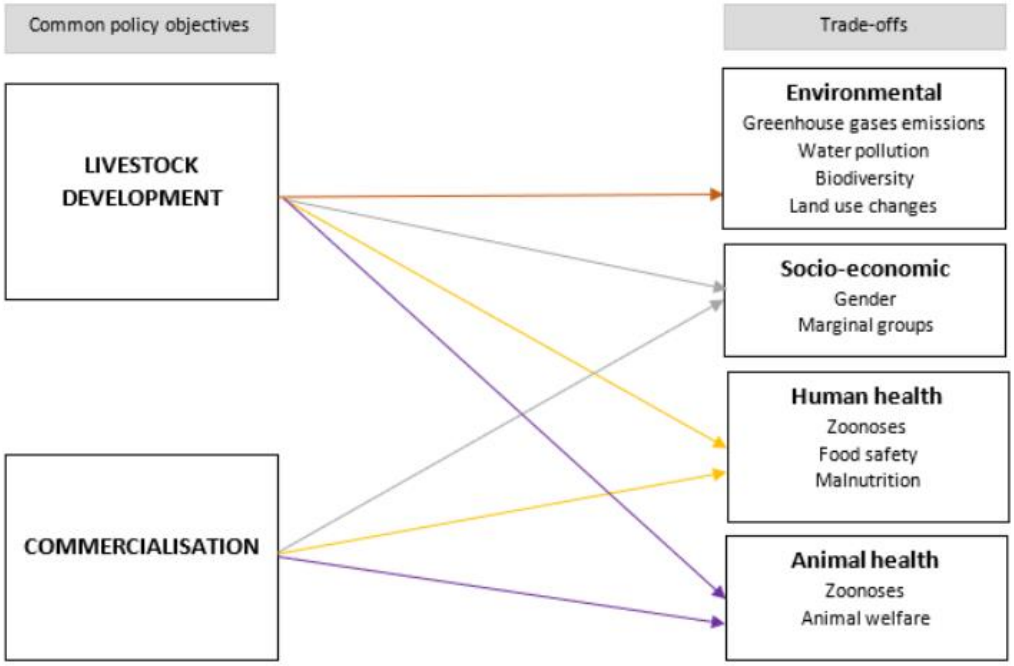
[4] Abdourahamane et al. (2022) Spatiotemporal characterization of agricultural drought in the Sahel region using a composite drought index

Socio-economic aspects of animal husbandry

Do livestock policies in Africa adequately address sustainability trade-offs related to livestock production?

Livestock sector development constitutes a unique development opportunity for Africa, promising to reduce poverty and benefit particular smallholder and female farmers and addressing micro-nutrient deficiency (hidden hunger) which is pervasive in Africa. However, policies and innovations are needed to minimize the trade-offs of livestock development regarding environmental sustainability, human health and animal welfare (Figure 5). A PARI study examined whether African livestock policies adequately address these sustainability trade-offs.[5] The study finds that **many sustainability dimensions are neglected in livestock policies** such as environmental impacts, the distribution of socio-economic benefits between men and women, animal welfare, and the double burden of nutrition. The multiplicity of livestock's positive and negative contributions therefore calls for a more integrated approach to policy design and implementation.

Figure 5: Relationship between livestock sector development and related trade-offs[5]



What is driving the growth of commercial poultry businesses in Africa?

Most Sub-Saharan countries are net importers of poultry products. Country studies conducted in Kenya, Nigeria and Senegal[6] investigated ways to develop the sector to meet the growing demand and reduce dependency from international market. To this end, the studies examined the **success factors of commercial poultry business expansion in the four countries and how that can be leveraged to foster the sector's development across Africa**. Among the success factors, the studies identified risk mitigation through vertical integration of value chain activities (e.g. feed, hatcheries, slaughter, processing, sales etc.), product diversification, digitally enabled access to financial services, skills and networks of entrepreneurs, and local demand growth.

[5] Kariuki et al. (2022) Do African livestock policies address sustainability trade-offs? Evidence from Kenya, Zambia, and Burkina Faso

[6] Ilatsia et al. (2022) Kenya; Sonaiya et al. (2022) Nigeria; Koki Ba et al. (2022) Senegal

How to identify high-potential areas for livestock sector investments?

Targeting policy and investment efforts in the livestock sectors requires not only an understanding of the most promising innovations, but also where these innovations have the highest potential to scale. PARI research[7] developed a **livestock-driven typology for Mali to exemplify a geographical targeting approach**. The study identifies five livestock interventions zones in Mali, based on the potential of livestock zones and the sector's contribution to local livelihoods. Overall, feed, water and veterinary services emerged as key elements of livestock production. In particular government investments in veterinary services have a high potential to boost livestock production in the country. Provision of subsidies for animal feed as well as policies geared towards increased water supply for livestock production should further enhance livestock production efficiency.

Agroforestry

Which regions in Africa have the highest potential for agroforestry investments?

Ongoing PARI research is assessing the role of agroforestry in promoting sustainable development, job creation and green growth and food systems enhancement in the context of climate change adaptation and mitigation. To this end, the research examines the **direct ecosystem benefits and indirect socio-economic benefits of agroforestry in Africa**. The current extent, recent dynamics and future potential of agroforestry practices will be mapped across Africa, with ground-truthing in Senegal, Kenya and Zambia. Building on previous PARI research related to agroforestry in the Sahel, the economic assessment will then identify the costs and benefits of sustainable land management and land restoration using agroforestry practices in Africa.

Evaluation of experiences with the widespread dissemination of relevant technological and institutional innovations – Africa and India

What policies and innovations are driving growth of the poultry and dairy sectors in India?

To complement related research in Africa, two ongoing studies are exploring how India has transformed its livestock sector, with a focus on the poultry and dairy sub-sectors. To this end, the studies examine the **role of innovations in technology, policy, and institutions in stimulating the investments that have been driving poultry and dairy sector growth in India**. The studies also looks at the carbon footprint of this livestock sector and what options smallholders have in tackling this challenge. The studies will chart a way forward for India's poultry and dairy sectors to become globally competitive and environmentally sustainable. They will also draw lessons for the most suitable approaches to stimulate growth in Africa.

2.2 Employment and income opportunities in rural areas, especially for youth and women

In this work package, PARI research is examining options for generating jobs and other income opportunities in the rural economy in general and specifically for the rural youth and women. The focus is on employment along agricultural value chains (e.g. logistics, processing, retail) as well as supporting businesses (e.g. financial services, machinery operators, mechanics).

[7] Dembele et al. (2022) Comprehensive livestock driven typology for food and nutrition security in Mali.

Employment opportunities

Can the agroprocessing sector create jobs in Africa?

A PARI study[8] analysed the potential of the agroprocessing sector to create employment opportunities in Africa, based on evidence from Ethiopia, Ghana and Tunisia. The agroprocessing sectors in the three countries differ greatly in terms of the size and structure, and, accordingly, the stages of industry lifecycle, from nascent industry in Ethiopia to a relatively mature sector in Tunisia. Also, the type and quality of jobs differ between the three countries, but they are generally considered to be good jobs compared to other jobs available to the same workers. So far, the **potential of the agroprocessing sector remains largely untapped**. The formal sector employs between 60'000-80'000 people in each of the countries, and the figure is around five times higher if employment in the informal sector is included. As of now, employment in agroprocessing activities accounts for only around 5% of total employment in the food economy. However, over the last two decades, it has grown rapidly. High employment elasticities suggest that **the sector is labour-intensive and presents high employment generation potential**, both in absolute terms and compared to other sectors of manufacturing.

Youth engagement

What are the main youth employment challenges and opportunities in rural Africa?

To better understand how to productively engage rural youth in Africa, a PARI study[9] reviewed the available literature on youth employment challenges and opportunities in rural areas on the continent, with a focus on employment of youth in food systems and related sectors. Food systems are increasingly recognized as potential catalyst for employment creation, given their future prospects and labour-intensive nature. Farming and self-employment in the agri-food sector are the dominant categories of youth employment. Despite common perceptions, food system jobs play a significant role in youth's aspirations. Close to 25% of young Africans want to work in the food and agriculture sector, and the share is higher in some countries, close to 40% in Kenya, Liberia, Malawi and Tanzania. Accordingly, the average age of African farmers is not rising – it is also much lower than previously claimed, at 34 years of age and not 60. However, **youth aspirations remain conditional on several factors that can make food system jobs attractive, including technology, investment, market opportunities, and decent earnings**. Policies should prioritize interventions that will raise labour productivity in food system, along with the broader labour-market interventions.

What policies and investments are needed to support young agripreneurs in Africa?

Based on this general understanding of opportunities and challenges, four country studies sought to develop concrete proposals on how to enhance youth engagement in productive employment in farming and agribusiness in Ethiopia, Tunisia, Beninand Senegal.[10] Surveys of young agripreneurs showed that most of the interviewed youth were in the food and agriculture business out of choice, not by default. **A number of success factors have enabled agripreneurs to grow their business**, including their human capital gained through formal education and practical experiences, access to financial capital and assets, and social capital through family connections and other networks. Common challenges across the four countries that would need to be

[8] Kubik et al. (2022) Can the agroprocessing sector create jobs in Africa? Evidence from Ethiopia, Ghana and Tunisia
[9] Kubik (2022) The challenges of rural youth employment in Africa: A literature review
[10] Nigus et al. (2022). Ethiopia; Zlaoui et al. (2022) Tunisia; Adegbola et al. (2022) Benin

prioritised in policies and investment decisions include a better supply of raw materials, reducing price fluctuations, helping businesses broaden their customer base and facilitating access to land and machinery.

Skill development

How can the right skills for sustainable agricultural transformation be developed in Africa?

Ongoing PARI research assesses how to build skills and strengthen research-extension linkages for sustainable agricultural transformation. Traditionally, investments in agricultural research, extension, and education have been focused on increasing agricultural land and labour productivity. While this focus continues to be highly relevant, meeting the Sustainable Development Goals requires efforts to not only increase agricultural productivity, but also contribute to other environmental and social goals such as climate resilience, agrobiodiversity conservation, and inclusiveness. In four African countries (Benin, Kenya, Mali and Nigeria), PARI research analyses **to which degree agricultural research, extension, and education institutions address multiple sustainability goals and which strategies are pursued in this regard**. In 2022, a mapping of agricultural research, extension, and education organization was conducted to identify the major institutions in each country. In selected agricultural advisory and ATVET institutions, a survey among students was conducted to better understand their perspective on the skills obtained and needed for sustainability transformation.

Women empowerment

How can women be enabled to use their time more productively and thereby increase household welfare?

PARI research initiated in 2022 focuses on the use of people's and in particular women's time and related impacts on productivity, welfare and nutrition. The first study in Ghana, Ethiopia and Uganda seeks to understand the relationship between the allocation of peoples' time to various activities and their productivity and welfare. A particular focus of the research is to identify the **impact of different technologies and innovations on the patterns of men's and women's time use in domestic, own-farm and off-farm work and related impacts on the productivity of time use**. It will also assess the welfare outcomes for women and children in rural households through the innovations' impact on women's time use. Quantitative and qualitative data were collected from rural areas of the three countries through structured household surveys and Focus Group Discussions (FGDs).

What strategies could help women to mitigate negative impacts of time constraints on household health and nutrition?

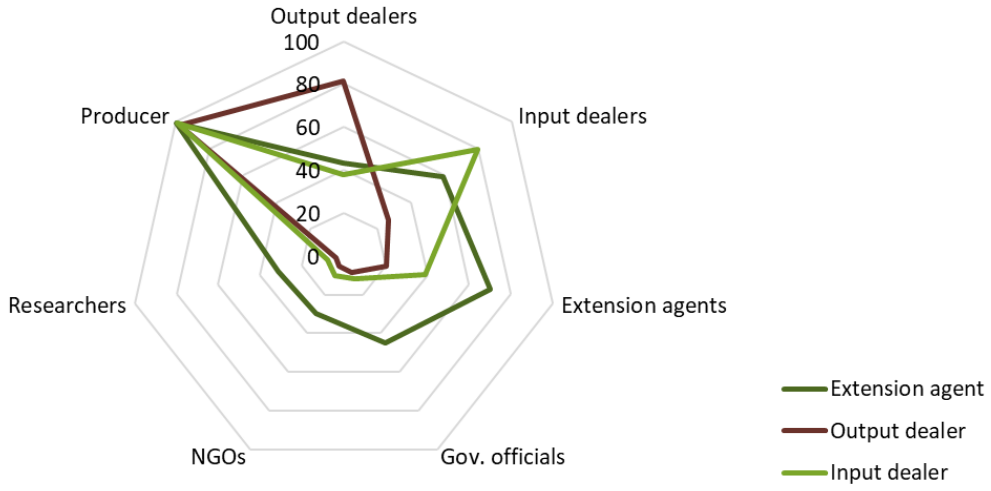
A second study, which is taking place in Ghana, will offer insights on the **links between the allocation of women's time to various activities and their own and their children's health and nutrition outcomes.** Primary data is being collected using a structured survey and a novel mobile phone-based application. The research will evaluate different interventions and innovations that influence time-use (including domestic technologies, infrastructure, services and childcare arrangements) to identify suitable strategies to help mitigate any negative health and nutrition impacts arising from time constraints.

2.3 Supporting sustainable and fair food systems through digital opportunities

How are digital technologies helping intermediaries in African value chains to provide their services to the farmers?

PARI research examined how digital solutions targeted at agricultural intermediaries could improve intermediaries' service delivery while helping digital agricultural (D4Ag) service providers cover the last mile to producers. To determine how to empower agricultural intermediaries with digital technologies, a PARI study[11] assessed how extension workers, outputs dealers and input dealers in Ghana, Kenya, Mali and Nigeria are already using and are impacted by these technologies in their professional activities. The results show that **intermediaries make extensive use of ICTs in their work**. Mobile phones clearly dominate the digital technologies, most commonly smartphones. In particular extension agents make extensive use of the technology to interact with diverse value chain actors (Figure 6). The technologies mainly benefit intermediaries by **facilitating information sharing and networking with various value chain actors, and reducing transaction costs for input and output dealers**.

Figure 6: Mobile phone-enabled networks of agricultural intermediaries[11]



Share of intermediaries who interact with different value chain actors via mobile phones.

Who benefits from the growth of digital agricultural platforms in Africa?

New PARI research was launched in 2022 to assess the **distributional effects of digital platforms in African agriculture**. To this end, case studies of digital platforms operating in Kenya and Nigeria are being conducted to examine what is driving the emergence of such platforms, which and how farmers are benefiting from participating in the platforms, and how the platforms are changing local produce and input markets. Data are being collected through interviews with participating farmers as well as input and output dealers in the region where the platforms are operating.

[11] Baumüller et al. (2022). Documenting the digital transformation of African agriculture : Use and impact of digital technologies among agricultural intermediaries; Policy Brief No. 32; country studies for Ghana, Kenya, Mali and Nigeria.

2.4 Structural transformation of national agricultural innovation and research systems

What is the role of agriculture investments in achieving the SDGs and the objectives of Agenda 2063 and the Malabo Declaration?

Research focused on the patterns and role of investments in stimulating agricultural growth, innovation and poverty reduction. Making the agriculture sector more resilient in light of multiple global crises requires significant and coordinated investments. Using data from Côte d'Ivoire, Ethiopia, Malawi, Mozambique, Niger and Rwanda, a PARI study[12] assessed how the implementation of National Agriculture Investment Plans (NAIPs) in Africa could help to achieve the SDGs, Agenda 2063 and the Malabo Declaration's objectives of agricultural growth, hunger eradication and reduction of poverty and inequality. The simulation results show that **if an agriculture-led investment strategy was pursued, there would be significant progress in terms of reaching the above-mentioned objectives as well as enhanced resilience to climate shocks**. Neither an industry-led nor a services-led growth strategy would produce the same magnitude of results. The findings also show that NAIP implementation would increase smallholder incomes, reduce reliance on food imports, and reduce rural-urban inequality.

How innovative are African firms and what is driving innovation?

Another PARI study[13] explored the patterns and drivers of innovations among firms in nine African countries, including Cameroon, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Rwanda, Senegal, Zambia and Zimbabwe. Overall, despite significant variations across the different indicators and countries, **most African firms display limited levels of innovation**. However, firms in Kenya, Ghana and Zimbabwe were found to be more innovative than others, with over 50% of firms in these countries engaging in at least three of the six innovation indicators. High levels of engagement by firms in R&D investments, though declining over several years, is evident across all firm types and countries. Large firms and publicly listed firms were found to be more innovative than smaller and unlisted firms. Contrary to expectations, firms that were affected by power outages and limited access to finance were more likely to innovate, which suggests that **firms in Africa are innovating as a strategy to cope with business obstacles, rather than to enhance competitiveness**.

2.5 Engaging with food and agriculture policy making to enhance food and nutrition security

Close engagement with and active participation in policy processes has played an important role in PARI since the program's inception. PARI will continue efforts to feed research findings into African and global policy processes through its own policy dialogues, participation in existing processes, and dissemination of research findings.

Support multi-actor partnerships

PARI continued to strengthen its existing pan-African networks in the current phase of PARI through its core partners. Particular emphasis was placed on linking and building the capacities of **AGRODEP members** through joint workshops and research development as well as mentoring by senior AKADEMIYA2063 researchers. Moreover, widespread outreach activities and dissemination of PARI

[12] Diallo & Wouterse (2022) How can CAADP implementation help countries achieve the SDGs and become resilient to climate change? A tale of six African countries

[13] Tadesse et al. (2022) Firm-Level Innovation and Business Obstacles in Sub-Saharan Africa: A cross-country analysis

research findings among **FARA's extensive network of policy actors** in Africa served to raise awareness of PARI among key stakeholders, engage new researchers in PARI activities and foster linkages between the research community and policy makers.

PARI continued its **collaboration with the African Economic Research Consortium** to further strengthen research capacities in Africa related to food systems and agricultural development. To this end, PARI is supporting Master and PhD students as well as research activities by faculty members who are part of the AERC network. PARI researchers directly engaged with students and faculty members to provide input into research activities. Two virtual AERC-PARI Seminars were organised on 11 March and 2 July to offer an opportunity for Master and PhD students from Africa who participate in the AERC and ZEF postgraduate programmes to present and discuss their research findings and broaden their network of students working on related topics.

Multi-stakeholder partnerships were also strengthened through joint research activities. A colleaboration with the **Africa chapter of the World Aquaculture Society** enabled PARI to connect to and support a network aquaculture experts across Africa. In addition, through the collaborative research with **partners in the Sahel region**, including the partnership with the Agrhymet Regional Centre of the Permanent Interstate Committee for Drought Control in the Sahel (CILSS), PARI has significantly strengthened its research network in the region.

Evidence-based input into high-level African policy fora

Policy Briefs

Kornher, L., Baumüller, H., von Braun, J. (2022). G7 Development Assistance for Food Systems to Lift 500 Million People out of Hunger by 2030. ZEF Policy Brief No 39.

Daum, T. (2022). Made in Africa. How to make local agricultural machinery manufacturing thrive? PARI Policy Brief No 31.

Policy Events

7 September

Event @ AGRF 2022: Beyond the Farm: Investment for innovation of food processing in Africa's food system

PARI hosted a session at the African Green Revolution Forum in Kigali to discuss what innovations, investments and policies are needed to boost the performance of Africa's food and agriculture sectors beyond production, including to add value through food processing, reduce post-harvest losses, increase supply-chain efficiencies and foster competitive integration in local and global markets. The focus was on how to achieve an equitable transformation that benefits African small-scale producers and SMEs while ensuring their resilience in the face of current and future global crises and related supply-side shocks.

Speakers and panelists at the PARI event @ AGRF 2022

17 October

Hybrid event: [Strengthening Resilience to Shocks and Stresses in African Food Systems]

PARI hosted a hybrid event at ZEF to explore possible solutions to reducing African countries' vulnerabilities to external stresses and shocks through targeted interventions within the food system. The event also provided an opportunity to launch the PARI book **"From Potentials to Reality: Transforming Africa's Food Production"** in Germany. The book aims to identify how Africa may transform its potentials into realities and actually secure its supply of food for affordable and healthy diets from the sustainable use of resources. Around 100 virtual participants joint the event, almost half of them from Africa.

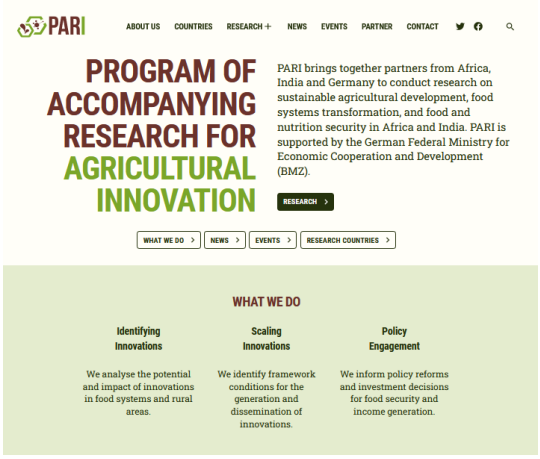
From left to right: Joachim von Braun (PARI Director), Mahamadou Issoufou-Wasmeier (Welthungerhilfe), Heike Baumüller (PARI Coordinator), Dorothy Okello (Makerere University), Dr. Ousmane Badiane (AKADEMIYA2063)

A selection of other key events in 2022 (co-)hosted by PARI partners:

3 March	**Prospects for Aquaculture Development in Africa: A review of past performance to assess future potential.** Etienne Hinrichsen, John Walakira and Heike Baumüller presented a PARI study that assesses African countries' performance in the development of their aquaculture sectors**.**
11 March	**AERC-PARI Seminar: Sustainable agricultural growth, food & nutrition security, and rural development in Africa.** The seminar offered an opportunity for Master and PhD students from Africa who participate in the AERC and ZEF postgraduate programmes to present and discuss their research findings and broaden their network of students working on related topics.
2 July	**AERC-PARI Seminar: Agricultural innovation for productivity and employment.** African students and faculty members presented findings from their research on agricultural innovation conducted as part of the AERC-PARI collaboration.
15 September	**Long-term forecasts on the future of Africa.** The presentation built upon Jakkie Cilliers' book *The Future of Africa: Challenges and Opportunities* and a new website on Africa's long term prospects offering empirical data that informs planning, prioritisation and effective resource allocation.

Relaunch of the PARI website – research4agrinnovation.org

In 2022, the PARI website was re-designed to increase usability and facilitate access to the PARI research findings. To this end, the website was optimized for use on mobile phones which is the main channel for accessing the internet in Africa and India. The homepage was modernized and re-restructured to highlight recent publications and tweets, upcoming events and the PARI Newsletter. The filter was improved for easier searching by themes, authors and years, and an interactive map was included where users can access all PARI research related to a particular country.



Social Media Outreach

PARI is using social media, notably Twitter, to disseminate key research findings, including through dedicated social media accounts hosted by PARI as well as through accounts hosted by PARI partners. **FARA's communication channels** play a critical role in reaching key African stakeholders. The most extensively used channel are FARA's DGroups which allow direct dissemination of research outputs to almost 40'000 members across Africa. The FARA Twitter account is followed by over 33'500 users while the FARA Facebook page has around 77'000 and the LinkedIn page close to 27'000 followers.

In addition, PARI operates its own social media accounts. The **Twitter account @PARI_ZEF** had grown to 3'243 by December 2022. The number of visitors to the PARI Twitter page reached its highest value of 3'200 page visitors in September. PARI's tweets reached between 900 and 9'000 impressions per month.

The PARI team also disseminated research findings via external websites. For instance, the article "Digital solutions are boosting agriculture in Kenya, but it's time to scale up. Here's how" published in *The Conversation* by Heike Baumüller and John Kieti attracted close to 3'000 readers primarily from South Africa, Kenya and the US.

3 Publication List 2022

Publication Title	Lead partner	Geography
What really impedes the scaling out of digital services for agriculture? A Kenyan users' perspective (journal article)	ZEF, UON	Kenya
Prospects for Aquaculture Development in Africa: A review of past performance to assess future potential	ZEF, Africa Chapter WAC	Africa
Spatiotemporal characterization of agricultural drought in the Sahel region using a composite drought index (journal article)	ZEF, CILSS	Sahel
The challenges of rural youth employment in Africa: A literature review	ZEF	Africa
Documenting the digital transformation of African agriculture: Use and impact of digital technologies among agricultural intermediaries	ZEF, KALRO, CSIR-STEPRI, ARCN, IER	Ghana, Kenya, Mali, Nigeria
Can the agroprocessing sector create jobs in Africa? Evidence from Ethiopia, Ghana and Tunisia	ZEF, PSI, CSIR-STEPRI, INRAT	Ethiopia, Ghana, Tunisia
Carbon Farming Training and Welfare: Evidence from Northern Ghana	ZEF	Ghana
Use of Information and Communication Technologies (ICTS) by Intermediaries in the Agriculture Sector: Insights from Ghana	FARA, CSIR-STEPRI	Ghana
Status of Use of Information and Communication Technologies by Agriculture Sector Intermediaries: Insights from Kenya	FARA, KALRO	Kenya
Use of Information and Communication Technologies (ICTS) by Intermediaries in the Agriculture Sector: Insights from Mali	FARA, IER	Mali
How to Enhance Youth Engagement in Productive Employment in Farming and Agribusiness in Africa: A Youth Perspective (Ethiopia)	FARA, PSI	Ethiopia
How to Enhance Youth Engagement in Productive Employment in Farming and Agribusiness in Africa: A Youth Perspective (Benin Republic)	FARA	Benin
Enhancing Youth Employment in Rural Africa: Challenges and Opportunities in Tunisia	FARA, INRAT	Tunisia
Commercial Poultry Success Stories in Kenya – Drivers and Lessons	FARA, KALRO	Kenya
Commercial Poultry Success Stories in Nigeria - Drivers, Challenges, and Lessons	FARA, ARCN	Nigeria
Commercial Poultry Success Stories in Sub-Saharan Africa: Senegal Case Study	FARA, IPAR	Senegal
Opportunities and Challenges for Local Agricultural Machinery Manufacturers: Insights from Benin Republic	FARA	Benin
Opportunities and Challenges for Local Agricultural Machinery Manufacturers: Insights from Mali	FARA, IER	Mali
Opportunities and Challenges for Local Agricultural Machinery Manufacturers: Insights from Nigeria	FARA, ARCN	Nigeria
Status, Opportunities, and Challenges of Local Manufacturing of Agricultural Machineries in Kenya	FARA, KALRO	Kenya
Comprehensive Livestock Driven Typology for Food and Nutrition Security in Mali	AGRODEP/ AKADEMIYA2063	Mali

Publication Title	Lead partner	Geography
Firm-Level Innovation and Business Obstacles in Sub-Saharan Africa: A cross-country analysis	AGRODEP/ AKADEMIYA2063	Cameroon, Côte d'Ivoire, Ethiopia, Ghana, Kenya, Rwanda, Senegal, Zambia, Zimbabwe
How can CAADP implementation help countries achieve the SDGs and become resilient to climate change? A tale of six African countries	AGRODEP/ AKADEMIYA2063	Côte d'Ivoire, Ethiopia, Malawi, Mozambique, Niger, Rwanda
Nutrition-sensitive lockdowns: conceptual framework and empirical insights from Africa during COVID-19 (journal article)	University of Hohenheim	Benin, Ghana, Kenya, Uganda, Zambia
Mechanization, digitalization, rural youth: Stakeholder perceptions on mega-topics for African agricultural transformation (journal article)	University of Hohenheim, KALRO, ARCN, IER, INRAB	Benin, Kenya, Mali, Nigeria
Made in Africa – How to make local agricultural machinery manufacturing thrive		
Animal traction, two-wheel tractors, or four-wheel tractors? A best-fit approach to guide farm mechanization in Africa	University of Hohenheim	Africa
Do African livestock policies address sustainability trade-offs? Evidence from Kenya, Zambia, and Burkina Faso	University of Hohenheim	Burkina Faso, Kenya, Zambia