



Harnessing the potential of diverse intensification pathways for Food and Nutrition Security and Sustainable Agriculture

**Outline for a long-term EU–Africa Research and Innovation
Partnership**

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Towards a long-term Africa-EU partnership to raise sustainable food and nutrition security in Africa

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Executive summary

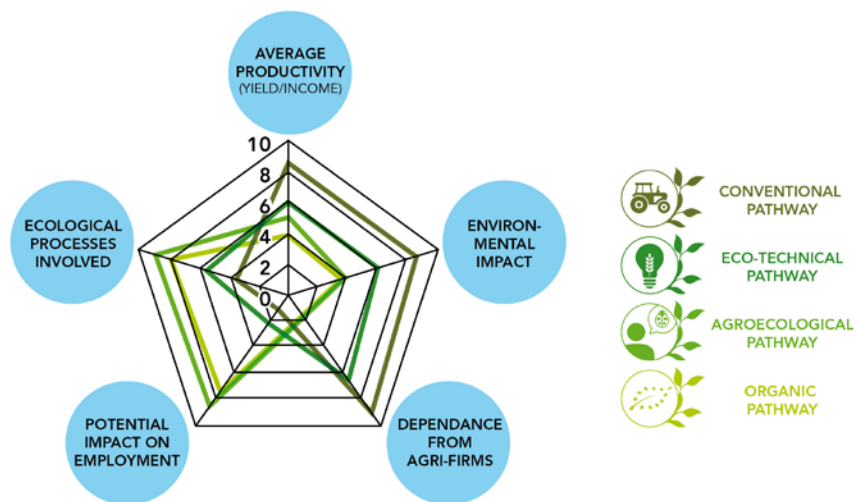
The expected growth of the world population to 9 billion in 2050, the changing diets, the impact of climate change and the constrained natural resources will affect food availability, access, and utilization drastically. Therefore improving Food and Nutrition Security while ensuring the Sustainability of Agriculture (FNSSA) is, and will be, a global issue for the years to come. This holds for Europe, but the challenge is even larger for Africa as Africa's population is expected to double over the coming decades. Yet, Africa also has the potential to become a major food basket. This will require a transformation of African agro-food systems, and the joining of forces to explore and harness the strengths and assets of African agriculture.

Sustainable intensification is generally acknowledged as a major driver for increasing food and nutrition security in Africa. It implies higher agricultural production per unit of resources, labour and/or land. It is not only geared towards increased production of food and biomass, but also towards providing employment and improving livelihoods. Sustainable intensification must play a central role in the management of natural resources such as water, biodiversity, soil nutrients and in the regulation of the carbon cycle.

Realizing that much is needed and much is possible, the IntensAfrica Consortium emerged in 2012 with the objectives to document the variety of pathways leading to sustainable intensification, and to align efforts in doing so. African and European members of the consortium agreed to jointly engage in the preparation of a new, strategic, long-term and ambitious research and innovation partnership between Europe and Africa in the thematic area of sustainable intensification of agri-food systems. A project named PROIntensAfrica was formulated to develop such partnership, and, with funding of the EC, was carried out for two years with active involvement of 23 African and European partners. The present report is the final output of this project.

PROIntensAfrica operated in a changing landscape. Notably, the Malabo declaration and the Science Agenda for Agriculture in Africa (S3A) came into action. Further, the European Union - Africa High Level Policy Dialogue on Science and Technology and Innovation (HLPD) agreed in April 2016 to adopt a road map for their cooperation in the FNSSA domain. More recently, the LEAP-Agri project was launched in December 2016 in support of joint Africa-EU food and nutrition security research. In addition, the African Development Bank has initiated the preparation of a large continental programme with focus on Technologies for African Agriculture Transformation (TAAT), accompanied by a research component, the African Agriculture Research Programme (AARP). In all these initiatives, sustainable intensification is a common denominator. The initiatives show the commitment of many parties to engage, and underscore the need for alignment.

The PROIntensAfrica project identified four different pathways leading to sustainable intensification. These pathways demonstrate the richness and variety of options that are open to farmers. The pathways differ in vision and mission, in organization and governance, in dimensionality, in technology and in the use of resources. They range from conventional agriculture to organic farming, and were studied both through a literature survey and by in-situ case studies. Results shows a trade-off in aspects of impacts and gains between different dimensions (see figure below). They also show, however, that the trade-offs are



context dependent. This illustrates how different situations, different in their biophysical, economic and societal characteristics, call for different pathways, and that there is not one solution which fits all situations. It underscores the need to explore and harness the diversity of pathways to optimize FNSSA. Results, however, also indicate a bias in attention and interest for the studied systems. This may imply that some systems have more unlocked potential than others, and deserve specific attention. This holds, for example, for the rather recently emerging eco-technological pathway, where ecological principles are combined with innovative technologies.

The four identified pathways serve as a typology, there are of course many more pathways and related systems that are in use and/or are possible. Combining elements of various pathways will probably yield systems that are better adapted and optimized than the benchmarked systems. Revealing this potential depends on efficient research and innovation programs, and is expected to be highly rewarding.

The need to unlock the potential of African agriculture is broadly acknowledged, and results in many research and innovation projects and programs. Yet many efforts are scattered. Lack of alignment may well result in missing the potential for synergy and convergence. It may hamper large-scale projects as each individual project is limited in scale. Lack of alignment may be suboptimal for mobilizing resources, expertise and competences that are relevant for improving FNSSA. This may frustrate participation in projects as managerial attention needs to be divided over many different activities. This perception leads to a generally felt need to join forces in research and innovation programs. The EU-AU High-Level Policy Dialogue (HLPD) embraces this perception and developed a well-received road map that seeks to guide research and innovation. A Working Group is now installed and challenged to oversee the implementation of a coherent program leading to improved FNSSA.

A similar perception of the value which alignment adds exists within the European Union. Realizing that much can be gained by collaborating not only at the scientific level, but also and foremost at the policy level involved in the programming of research, several funding instruments were developed that stimulate alignment. Some of these instruments are now

adapted to serve a bi-continental Africa-Europe collaboration, with the LEAP-Agri program as a clear and promising example. The PROIntensAfrica project analysed the various European instruments, and suggests to explore the potential of the Joint Programming Initiative (JPI) instrument. While this European instruments currently already reaches out to African parties, a more coherent structure inspired by the principles of JPI, and with focus on FNSSA, is feasible. The charm of such a structure lies in the fact that it builds upon existing activities, and focuses on a collaboration within and between the scientific and the policy domains. It may serve the needs of the Working Group of the HLPD and as such be instrumental to implement the road map.

In a somewhat different setting, the long-term partnership could also be shaped as an International Research Consortium (IRC). Such consortium, as exemplified by STAR-IDAZ, could reach out beyond a public-public partnership, and mobilize expertise and resources from other stakeholders like NGOs and the private sector. The PROIntensAfrica scientific consortium could well feed into such partnership.

A long-term partnership, be it a joint programming or an IRC type of structure, is a future possibility and requires a transition. It is in response to this situation that the IntensAfrica consortium proposes to establish a support group of informed, willing and resourceful institutions: the Institutions Support Group (ISG). Such ISG could feed into the recently started LEAP-Agri project, and could easily be absorbed by a future structure. As such, it could be a building block for new and broader initiatives.

In conclusion, the PROIntensAfrica project demonstrated the potential of the diversity of pathways for sustainable intensification in agri-food systems. It identified future challenges for science and innovation to address. It documented the salient characteristics of a successful bi-continental research and innovation partnership, and drafted an outline for such partnership. By doing so, the partners that were jointly engaged in PROIntensAfrica showed their expertise and creativity in the scientific field. They showed their commitment to contribute to solutions for the existing and still-growing challenges of improved FNSSA. They pledged to collaborate even beyond the timespan of the project. They did so in the mutual conviction that only together can we tackle the challenge of secure and sustainable food production, now and in the future.

Acronyms

AARP	African Agriculture Research Programme
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
AFAAS	African Forum for Agricultural Advisory Services
ARC	Agricultural Research Council
AU	African Union
BOKU	University of Natural Resources and Life Sciences Vienna
CAADP	Comprehensive Africa Agriculture Development Programme
CAP	European Common Agricultural Policy
CCARDESA	Centre for Coordination of Agricultural Research and Development for Southern Africa
CIRAD	Centre de coopération International en Recherche Agronomique pour le Développement
COP	Conference of Parties
CORAF/WECARD	Conseil Ouest et Centre Africain pour la Recherche et le Développement Agricoles/West and Central African Council for Agricultural Research and Development
CSRI-CRI	Council for Scientific and Industrial Research-Crops Research Institute
CULS Prague	Czech University of Life Sciences Prague
EC	European Commission
EJP	European Joint Programme
EU	European Union
FAAP	Framework for African Agricultural Productivity
FARA	Forum for Agricultural Research in Africa
FNSSA	Food and Nutrition Security and Sustainable Agriculture
GMOs	Genetically Modified Organisms
GRA	Global Research Alliance on Agricultural Greenhouse Gases
HLPD	European Union - Africa High Level Policy Dialogue on Science and Technology and Innovation
INERA	Institut de l'Environnement et de Recherches Agricoles
INIA	Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria
ICT	Information and Communications Technologies
IPM	Integrated pest management
IRC	International Research Consortium
ISA-ULisboa	Instituto Superior de Agronomia - Universidade de Lisboa
ISG	Institutions Support Group
JPI	Joint Programming Initiative
LEAP-Agri	Long term EU- Africa research and innovation Partnership on food and nutrition security and sustainable Agriculture
LCA	Life Cycle Assessment
Luke	Natural Resources Institute Finland
NEPAD	New Partnership for African Development
NGOs	Non-Governmental Organizations
NIBIO	Norwegian Institute of Bioeconomy Research
NRI	Natural Resources Institute
PRIMA	Partnership in Research and Innovation in the Mediterranean Area

PROIA	PROIntensAfrica
R&I	Research & Innovation
S3A	Science Agenda for Agriculture in Africa
SDGs	Sustainable Development Goals
SLU	Sveriges Lantbruk Universitet
STAR-IDAZ	Global Strategic Alliances for the Coordination of Research on the Major Infectious Diseases of Animals and Zoonoses
SZIU	Szent István University
TAAT	Technologies for African Agriculture Transformation
TEAGASC	The Agriculture and Food Development Authority, Ireland
UCL	Université Catholique de Louvain
UCPH	University of Copenhagen
WG	Working Group
WUR	Wageningen University & Research
ZEF	Center for Development Research, University of Bonn

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1. Introduction

1.1. Introducing the IntensAfrica consortium

The IntensAfrica Consortium was established in 2012 as an outcome of a joint CIRAD-WUR proposition to FARA and the African Sub-Regional Organizations. These parties understood the enormous potential of improving food security and livelihood of farmers and society at large through the sustainable intensification of agri-food systems. Tapping into this potential will require a more collaborative approach between Europe and Africa. Though many European and African institutions are already conducting joint research activities pertaining to the intensification of agriculture, none of these investments currently constitutes a coherent approach allowing the identification of effective strategies for producers, consumers and decision makers.

The PROIntensAfrica (PROIA) partners therefore agreed to engage in the preparation of a new, joint, strategic, long term and ambitious research and innovation partnership between Europe and Africa in the thematic area of sustainable intensification of agri-food systems. To further develop their ambition and to provide a basis for discussion with the European and African Commissions, national governments, and other potentially interested parties in Europe and in Africa, the group submitted a proposal in response to a competitive EU-call under H2020. This initial project, PROIntensAfrica, was approved by the EC for funding for a two years period (1 April 2015 – 31 March 2017); the objectives of which are the development of detailed contours of an Africa-Europe research and innovation partnership and the securing of policy support for the initiative. Over the past two years, 15 European and eight African partners collaborated in the PROIntensAfrica project. They were engaged in a number of activities to further develop the partnership proposal.

Box 1 PROIntensAfrica partners

African partners: FARA (Ghana), CORAF/WECAARD (Senegal), CCARDESA (Botswana), ASARECA (Uganda), AFAAS (Uganda), ARC (South Africa), CSRI-CRI (Ghana) and INERA (Burkina Faso).

European partners: WUR (The Netherlands), CIRAD (France), UCL (Belgium), SLU (Sweden), ISA-ULisboa (Portugal), Luke (Finland), UCPH (Denmark), ZEF (Germany), INIA (Spain), NRI (England), Teagasc (Ireland), BOKU (Austria), CULS Prague (Czech Republic), SZIU (Hungary) and NIBIO (Norway).

Over the past two years, 15 European and eight African partners collaborated in the PROIntensAfrica project. They were engaged in a number of activities to further develop the partnership proposal.

The work plan of the PROIntensAfrica project was based on questions regarding the purpose and scope of research, and on how best the partnership should be organised. It concerned questions such as:

- what new or additional research is needed to identify and implement effective pathways to sustainable intensification of the agri-food systems (conventional, ecotechnological, agroecological and organic pathways)?
- in what ways will stakeholders benefit from a partnership on research and innovation?
- how can such a partnership be governed and financed?

To follow up, the PROIntensAfrica project conducted several activities. One of which was the implementation of six in-depth and 11 light case studies. The rationale for conducting these case studies was to collect, in addition to information available in the literature, real-time field data on drivers of changes and transitions occurring in the agri-food systems, and to collect data on the pros and cons of the different intensification pathways. To further define the research and innovation niche for the future strategic research and innovation partnership, a mapping study was implemented. This study analysed on-going research and innovation

projects, the sustainable intensification pathways addressed, and the funding related to these projects. The mapping provided data for the identification of the potential of the future strategic partnership programme to complement the thematic coverage, strengthen scale consistency, and identify new options.

The PROIntensAfrica project not only defined content, it also described and documented the expected impact of joining forces in a long-term partnership on sustainable intensification. It addressed issues of efficiency of research spending, which is one of the main necessities and objectives of the strategic partnership. Through analysing existing joined initiatives such as Article 185 initiatives, ERA-NETs and JPIs, the project documented the expected added value of a future partnership for different end-users, including research funding organisations. Models for an effective and efficient bilateral African-Europe governance structure to support the implementation of an EU-AU joint research partnership has been identified by the PROIntensAfrica project. In addition, modalities for efficient resource allocation in the proposed long-term partnership have been analysed and proposed, based on the assumption that pooling of resources among donors would be the best option to increase the efficiency of research funding. To identify the most appropriate governance models and funding modalities, the partners analysed various Europe – Africa research & innovation partnership instruments such as the ERA-NETs, JPIs and Article 185 initiatives.

1.2. IntensAfrica in a changing policy landscape

The objectives of the IntensAfrica consortium, through this H2020 PROIntensAfrica project, were to develop a shared vision and action plan, and to secure policy support for a strategic, long-term, and large-scale research and innovation partnership between Europe and Africa within the area of Food and Nutrition Security and Sustainable Agriculture (FNSSA). An EU instrument, the Article 185, which is designed for large-scale efforts with pooled resources, was originally considered as the possible target instrument to structure this research and innovation partnership. However, since the start of PROIA in 2015, the policy landscape has changed, and experiences gained from other similar initiatives, like the Article 185 initiative Partnership in Research and Innovation in the Mediterranean Area (PRIMA), have shown that this funding instrument may not be the best or most suitable option.

The EU-Africa FNSSA landscape changed in other ways as well. The European Union - Africa High Level Policy Dialogue on Science and Technology and Innovation (HLPD) agreed in April 2016 to adopt a road map for their cooperation in the FNSSA domain. This road map is based on three pillars: sustainable intensification, agriculture and food systems for nutrition, and the expansion of agricultural trade and markets. A Working Group (WG) in charge of overseeing the implementation of the HLPD Road Map has been created by the HLPD Bureau and is scheduled to hold its first meeting in 2017. The objectives of the HLPD are very similar to those of the IntensAfrica consortium. Moreover, the HLPD FNSSA Road Map makes explicit reference to PROIA for its potential to provide insights particularly on sustainable intensification and on the crosscutting issues outlined in the Road Map such as capacity strengthening, modalities of funding joint activities, monitoring and evaluation.

Yet another change in the landscape includes the LEAP-Agri ERA-NET Cofund, launched in December 2016. This initiative is also in support of the HLPD Road Map. The IntensAfrica consortium has been instrumental in shaping LEAP-Agri, and a number of the PROIA consortium are formally connected to LEAP-Agri either directly or through national research funding agencies. LEAP-Agri aims at contributing to the implementation of the long-term EU-

Africa research and innovation flagship partnership on FNSSA. It is built upon the ERAfrica and IntensAfrica concept of pooling African and European resources and capacities. While one of the two main objectives of LEAP-Agri is to fund joint projects, its second objective shares with the PROIA the intention of developing innovative joint governance and joint programming instruments to sustain in the long term as well as consolidate and broaden the bi-continental partnership.

Other changes in the landscape include the African Development Bank programme: Technologies for African Agriculture Transformation (TAAT). This continent-wide programme will be accompanied by a research component, the African Agriculture Research Programme (AARP, up to 150 million USD, over 5 years), which will also contribute to the implementation of the HLPD FNSSA Road Map.

Beyond the EU-Africa bi-continental dimension, the FNSSA landscape has also changed with the adoption of the United Nations Agenda 2030 Sustainable Development Goals (SDGs) and with the coming into force of the Paris COP 21 agreement. Food and nutrition security is a high priority for the entire world and the improvement of the sustainable use of natural resources and agriculture as well as innovations are identified as important components in achieving several of the SDGs. The same goes for the role of agriculture in contributing to climate change adaptation and mitigation.

The changes outlined above reinforce the IntensAfrica consortium's dedication to the core concepts: the required alignment of the fragmented efforts of the predominating short-term initiatives that occur within most FNSSA initiatives, and the value of exploring and making use of a diversity of pathways toward sustainable intensification of agri-food systems. The IntensAfrica consortium, thanks to the expertise and resources of its members, the mutual learning they have acquired since 2012, their direct involvement in multi-actors on-the-ground activities, and their connections to the policy domain, is well positioned to contribute to realize the objectives of the HLPD FNSSA Road Map by bridging policies and implementation.

The proposed outline will be discussed in the following chapters. It describes how the IntensAfrica consortium views challenges related to the sustainable intensification of agriculture and agri-food systems and specifies what a required response to this situation would entail in terms of a long-term partnership, an appropriate research and innovation agenda, as well as a support system for policy/decision-making. The proposed outline also indicates how this would contribute to sustainable development in the area of food and nutrition security, livelihoods, and the environment.

2. The need for change

2.1. Challenges and interests

The expected growth in the world population from seven to nine billion in 2050 and the changing diets will require a significant increase in food availability, access, and utilization. Improving FNSSA is a global issue, also for Europe, though it is more challenging for Africa. With Africa's population expected to double, it has a major stake in FNSSA as it faces the double challenge of ensuring and maintaining food self-sufficiency and ensuring and maintaining the livelihoods, which for a large part of its population comes from agriculture. Though vulnerable today, Africa has the potential to evolve to become a major food basket. This requires, however, a transformation of the African agri-food systems, and calls for joining forces to explore and capitalise on the strengths and assets of African agriculture. As no one-size-fits-all solution exists, optimal use should be made of the rich diversity of agricultural pathways that exist or could be further developed. This requires a profound understanding of the current agri-food systems and the development of instruments that aptly assess the social, economic and environmental efficiency and effectiveness of the different intensification pathways.

Box 2 Sustainable Intensification of Agriculture

According to Pretty (2011)¹, a sustainable production system would exhibit most or all of the following attributes:

- utilizing crop varieties and livestock breeds with a high ratio of productivity related to inputs; avoiding the unnecessary use of external inputs; harnessing agro-ecological processes such as nutrient cycling, biological nitrogen fixation, allelopathy, predation and parasitism; minimizing the use of technologies or practices that have adverse impacts on the environment and human health; making productive use of human capital in the form of knowledge and capacity to adapt and innovate;
- making use of social capital to resolve common landscape scale problems; quantifying and minimizing the impacts of system management on externalities such as greenhouse gas emissions, clean water availability, carbon sequestration, biodiversity and dispersal of pests, pathogens and weeds.

In the concept of sustainable intensification, 'intensification' cannot be equated with 'more intensive' modes of production. It rather refers to achieving the full potential of agricultural production in view of what is required to achieve social, economic, and environmental sustainability.

Agriculture faces some unprecedented challenges at the global level. However, for Africa, these challenges are particularly acute on several fronts. The agriculture sector (in the broad sense, including crops, animal production, forestry, aquaculture, etc.) represents the major part of the economy in most African countries and provides the bulk of employment and livelihood options, and hence will play a central role in the development of the

continent. Also, African agriculture and its associated value chains play a key role in local food and nutrition security, preservation of biodiversity, provision of work opportunities in rural areas, and in catalysing development of related economic sectors. As the African population will continue to rise in the midterm, African agriculture will need to grow and evolve quickly, in particular to adapt to changes in demand. Beyond the expected surge in productivity, African producers will need to engage in a process of intensification in a sustainable way (see Box 2). This involves increasing yields in the midst of a scarcity of

¹ Jules Pretty, Camilla Toulmin & Stella Williams (2011): Sustainable intensification in African agriculture. *International Journal of Agricultural Sustainability*, 9:1, 5-24.

natural resources, and threats to fragile livelihoods, while at the same time facing new constraints linked to climate change, competing energy chain values and dwindling natural resources. Increasing food and nutrition security in Africa therefore implies much more than intensifying the agricultural production per unit of labour or land. This means that food and nutrition security is not only a question of availability, but also involves quality, utilization and accessibility of food for consumers. Similarly, agriculture is not only a question of production of food and biomass, it is also a provider of jobs and livelihoods and plays a central role in the management of natural resources such as water, biodiversity, soil nutrients, and regulation of the carbon cycle.

Many challenges must be addressed simultaneously before increased food production will result in a more sustainable food security and economic growth of the agricultural sector. In addition, many aspects of agrifood systems need to improve to enhance the agricultural-driven economic growth of African countries. This concerns for example farmer organizations, processing industries, contributions by the private sector, improvement of the chain performance for local, regional and international market access, infrastructure, and enabling institutional and policy environments. The question of how sustainable intensification could be achieved and through which “intensification pathways”, is still very much part of an open debate in science, society and policy. In Europe, this debate has often been one of confrontation and fragmentation. Examples include the societal and political divide on the use of genetically modified organisms (GMOs) or the potential of organic farming. Science is challenged by those controversies but, too often, has not been able to provide factual evidence and coherent advice. Africa is no exception in this. However, the current context in Africa for this transformation of agriculture is radically different from the European (or American) context, in the 19th and 20th century, when agriculture transformation occurred under the push of the industrial revolution. Nowadays, population growth in Africa is faster, energy is more expensive, opportunities for jobs outside agriculture (in industry and services) are fewer, markets are more globalised, and climate change further complicates the picture. African leaders are also aware of the long-term negative impacts of the conventional intensification processes in Europe.

On both the European and African continents, decision makers do not have sufficient information on how prices and availability of some factors which have a key influence on agriculture, will develop in the mid to the long term. For instance, what will be the cost of energy in 2050, and will world trade become more open or be confronted with more technical, economic or political barriers? These controversies and unknowns have led to fragmentation and lack of alignment not only in the research domain but also among (public and private) investors in agricultural research for development.

The analysis developed through the initial work of PROIntensAfrica shows that four major constraining conditions need to be addressed to enhance the ability of strategic research and innovation (R&I) partnerships to respond effectively and appropriately to the expectations of governments and citizens, in European and African contexts. These are:

- Each of the sustainable intensification pathways has its pros and cons in terms of their characteristics, their impacts on economic, social and environmental conditions and their impacts/implications for the short-term and long-term. Advocating for just one specific pathway in very diverse conditions limits the ability to harness the

potential of each of the pathways and their complementarity in light of different social, economic, and/or environmental conditions.

- Contexts in which different intensification pathways are applied are diverse. What leads to sustainability gains in one place may not have the same results in other places in view of both social, economic and environmental concerns. Though these thoughts are generally accepted, researchers and decision makers lack appropriate frameworks to analyse the pros and cons of the different pathways to be able to identify the best solution from the multiple intensification options.
- Investments tend to be mainly in scattered small scale projects, which either have an R&I focus or a development focus, but there is a lack of coordination, comparison, and keeping of a track record. As a result, potential synergies and possibilities for mutual enhancement of efforts have not been harnessed; it also has led to repetitions of similar initiatives.
- In general, projects tend to be funded for a relatively short period, typically three years which is not sufficient to build a strong evidence-base, to achieve synergy through interaction with other initiatives, to effectively communicate with policy/decision-makers, and to monitor and evaluate project results and impact.

2.2. The way forward

The identified constraining conditions point to a need for appropriate response in five different areas.

Engaging with a diversity of pathways

Both European and African agriculture encompass a multitude of farming systems and sustainable intensification pathways. While the dominant trend continues to be towards larger farms and industrialisation of agrifood systems, European agriculture has moved from a phase of input intensification to resource-use optimisation. Market diversification has led to a growing niche for speciality products, reflecting a partial change from agroindustrial to agroecological and organic food systems. On both continents, agriculture supports a wide range of farming communities and livelihoods. Clearly not all can or will move along an agroindustrial intensification pathway. In order to sustain and expand the livelihood basis for rural populations, policies and research must address and care for this diversity. This will contribute to food and nutrition security for all, by exploiting the full potential of sustainable agricultural intensification.

Enhancing alignment between research institutes, private sector and civil society

Research and innovation expertise on agricultural development often remains scattered among numerous African and European institutions. Very few have the capacity to cover comprehensively the whole of the agricultural sector with its diverse challenges. Private businesses and civil society wishing to invest in agriculture often have no access to relevant research expertise in their country or region. With rapid transformations in the agricultural sector, such knowledge deficiencies are likely to become more severe and will have a negative impact on exploring the potential of agricultural development. Hence, there is a need to develop research and innovation networks across borders, in order to bring partners from private sector, research and civil society together in joint projects.

Connecting funders to long-term research and innovation partnerships

Developing long-term research and innovation networks across borders and across stakeholders will also enhance the connection between development investors and research and innovation institutions. This will have a double advantage: research better informing investors on trade-offs and implications of investment options, and investors better informing research about their knowledge gaps and ambitions for up-scaling and outscaling of innovations for impact at scale.

Connecting policies to research

Agricultural development policies and agendas are often poorly connected to research. Both policy makers and development organisations often opt for approaches and priorities for which there is no clear evidence of their effectiveness. Also, for many countries, national research may not be comprehensive enough to provide such evidence base for policy-making and design of interventions, particularly in a dynamic sectors such as those of agriculture and food. Strong links for improved knowledge circulation need to be build between research and policy-making, in order to support evidence-based policy formulation and development of the development agenda.

Connecting to other sectors in agricultural development

There is a need and opportunity for a wider connection of the opportunities presented by other sectors in agricultural development. Information and communications technologies (ICT) offer avenues for smart solutions in agriculture. Examples within the ICT domain include knowledge sharing between producers, connecting consumers with producers, organising supply chains or market information, providing climate information, and developing decision support systems for input use or crop management. Environmental impact monitoring, labelling and quality assurance can also be facilitated by a combination of remote sensing, mobile sensor technologies, farmer reporting and community networks. Rapid developments in food and material science and local energy solutions offer huge potential for local processing and value addition of for example, agricultural products, and storage to reduce food waste. Finally, transformation of African agriculture is widening the playing field, enabling potential for a wider range of actors than those traditionally involved in development research. The rapid transformation offers possibilities for technology shortcuts such as seen within the mobile banking sector in a number of African countries, which have developed faster there than in Europe.

2.3. Emerging policy responses

Challenges as discussed in the section above, have been identified in the FNSSA Road Map which was approved by the European Union (EU) Commission and the African Union (AU) Commission, and in a number of other continental initiatives like the Food 2030 Directorate General for Research and Innovation initiative, the conclusions of the Directorate-General for Agriculture and Rural Development Conference (January 2016) on 'Design the Path for EU agricultural research & innovation', or the "Rural Futures" programme of New Partnership for African Development (NEPAD) and national initiatives.

As all other parts of the world, Europe faces the challenge to increase the sustainability of its agriculture and its food systems, while ensuring food and nutrition security. This is acknowl-

edged by the European Common Agricultural Policy (CAP), which is currently being revised with the intention to obtain an effective policy for a more competitive and sustainable agriculture and to enhance vibrant rural areas. The CAP and Horizon 2020 (the EU 2014-2020 framework programme for research and innovation) have highlighted the need to improve agricultural productivity through research, exchange, knowledge transfer and promoting co-operation and innovation.

African political leaders are aware of these conditions and have therefore set, with the Malabo declaration in 2014 and the Comprehensive Africa Agriculture Development Programme (CAADP) process, very ambitious goals for the improvement of African agriculture productivity. There is a growing mobilization amongst different stakeholders, from farmers' organizations to research institutions, to face these challenges. The Science Agenda for Agriculture in Africa (S3A), led by the Forum for Agricultural Research in Africa (FARA), is the most recent step in involving scientific research communities of the continent in this dynamic initiative.

2.3.1. The Malabo Declaration

The Malabo declaration (see Box 3) sets ambitious targets, such as increasing land and labour productivity, providing more and better rural jobs, strengthening smallholders, and increasing resilience. Clearly African leaders hope to “navigate” between intensification pathways with a vision for transforming African agriculture.

Box 3 The Malabo Declaration

The Malabo declaration, endorsed by African Heads of State in June 2014, includes 7 commitments:

1. Recommitment to the Principles and Values of the CAADP Process
2. Recommitment to enhance investment finance in Agriculture
 - o Uphold 10% public spending target
 - o Operationalization of Africa Investment Bank
3. Commitment to Ending Hunger by 2025
 - o At least double productivity (focusing on Inputs, irrigation, mechanization)
 - o Reduce Post Harvest Losses at least by half
 - o Nutrition: reduce stunting to 10%
4. Commitment to Halving Poverty, by 2025, through inclusive Agricultural Growth and Transformation
 - o Sustain Annual sector growth in Agricultural GDP at least 6%
 - o Establish and/or strengthen inclusive public-private partnerships for at least five priority agricultural commodity value chains with strong linkage to smallholder agriculture.
 - o Create job opportunities for at least 30% of the youth in agricultural value chains.
 - o Preferential entry & participation by women and youth in gainful and attractive agribusiness
5. Commitment to Boosting Intra-African Trade in Agricultural Commodities & Services
 - o Triple intra-Africa trade in agricultural commodities
 - o Fast track continental free trade area & transition to a continental Common External tariff scheme
6. Commitment to Enhancing Resilience in livelihoods & production systems to climate variability and other shocks
7. Commitment to Mutual Accountability to Actions and Results Through the CAADP Result Framework - conduct a biennial Agricultural Review Process

These commitments indicate that African Heads of State are well aware of the need for agriculture and food systems to evolve in ways which are conducive and specific to Africa. They will work to avoid the negative trade-offs that have been observed in other countries: loss of rural employment due to conventional intensification (as has been the case in Europe), and the possible negative impact of the green revolution on the nutritional status of rural population (as is the case in some parts on India).

African Heads of State aim to create their own African agricultural revolution. They will achieve this by exploring and documenting the diverse possible intensification pathways and then combining them in a portfolio of options.

2.3.2. The Comprehensive Africa Agriculture Development Program (CAADP)

The African Union, through the NEPAD has elaborated the agricultural development strategy called CAADP established in 2003 to alleviate poverty on the continent, and to improve food security and nutrition, farmers' livelihoods, resilience and the national added value in agriculture. The AU promotes institutional development and federates bi-lateral and multilateral co-operation to implement its strategy. CAADP will make these contributions by catalysing sustained inclusive agriculture growth through five core results, namely:

- increased agriculture production, productivity and value addition;
- better functioning national and regional agriculture markets and trade;
- increased public and private investment in agricultural value chains;
- increased access to food, better nutrition and increased access to productive safety nets;
- improved management of natural resources for sustainable agricultural production.

The outline for a long-term EU-Africa partnership proposed will contribute to all five results, but in particular to the first core result, for which the target has been set to a doubling of productivity by 2024.

2.3.3. The Science Agenda for Agriculture in Africa (S3A) of FARA

The rationale for the Science Agenda for Agriculture in Africa (also referred to as the *Science Agenda* or S3A) is the imperative of having an overarching strategic framework to guide the broad areas of science that have to be developed by the African countries, their stakeholders and their partnerships. The Science Agenda is about the necessary transformation of national science and technology institutions in order to achieve the desired social and economic transformation of Africa.

The key priority of the S3A is a more productive and efficient food and agricultural sector that as a minimum guarantees food and nutrition security. The Science Agenda is an organizing framework of issues, science options, and partnerships to bring about that desired future. It is operationalized within the larger framework of CAADP. The S3A is the structure for the implementation of the Framework for African Agricultural Productivity (FAAP), which is a reference document for implementing the CAADP objective on agricultural science and technology (CAADP Pillar IV). S3A also provides African decision-makers with the rationale for increased investments in science and technology.

Overall, the Science Agenda provides the framework and guidelines for:

- identifying the broad areas of science to be developed in partnership with the main stakeholders;
- facilitating the necessary transformation of national science and technology institutions;
- helping to focus on the need for human capacity building at all levels;
- facilitating increased funding from diversified sources to support science;
- facilitating alignment of actions and resources to ensure value-for-money and desirable impact;
- facilitating effective partnerships among mandated African institutions at sub-regional/regional levels and between these actors and their external partners;
- committing to solidarity in science by sharing information, technologies, information, facilities and staff in pursuit of common challenges and opportunities.

2.3.4. High Level Policy Dialogue and Road Map on FNSSA

In April 2016, during a senior officials meeting of representatives of the High Level Policy Dialogue (HLPD) in R&I between the European Union and the African Union, the 'EU-AU R&I Partnership on Food and Nutrition Security and Sustainable Agriculture road map' (the HLPD FNSSA Road Map) was adopted. Its main objectives are to strengthen the collaboration between the two continents in this domain and to contribute to the innovative solutions related to societal challenges, in Europe and in Africa.

The road map indicates that Africa and Europe share the challenge of producing more food for growing populations while reducing the environmental impact of food production system and their demands on ecosystem services. The two regions' food production systems and value chains differ substantially in many ways, for instance in their influence on global food supply, in the access of farmers to knowledge, services, and technologies, in their productivity, and in the availability of uncultivated land. Yet, while demographic trends that are demanding increased production are concentrated in the global South, Europe and Africa share the aim of enhanced sustainability of their production systems. In addition, both regions are facing significant structural and organizational transformations in agricultural and rural settings entailing far-reaching social change, although the trajectories of these changes differ in the two regions.

Key features of the envisaged HLPD partnership are the enhanced coordination of FNSSA-relevant research and innovation policies, programs and funding mechanisms between Europe and Africa. This will build on experiences to create synergies, optimize investment, and identify gaps. The partnership should operate across the entire value chain, linking research to innovation, and involving all relevant stakeholders for enhanced impact at the local level. Research programs need to be jointly designed, owned, managed and resourced. An integrated approach is required, recognizing the crosscutting nature of entrepreneurship, research infrastructures and research and innovation capacity building.

An EU-Africa Working Group (WG) has been created for the road map and should hold its first meeting in 2017. This WG will oversee the implementation of this road map and report on its progress, in particular on its three thematic pillars - sustainable intensification; agricul-

ture and food systems for nutrition; and the expansion of agricultural trade and markets- as well as its crosscutting activities issues like innovation facilitation and capacity strengthening.

3. Towards a Strategic Research & Innovation Partnership

The main objective and expected result of the PROIntensAfrica project is a proposal to set up a strategic research and innovation partnership that addresses the complexity of sustainable intensification of the agri-food systems in Africa. Such proposal needs to include vision and mission of the partnership, the research and innovation agenda, and the governance and funding modalities, and expected impact. In this chapter, we outline the main characteristics of the proposal. More detailed information can be found in the PROIA deliverables².

3.1. Vision and mission

The intentions and ambitions of the future strategic Research and Innovation partnership is summarised in its **vision**, which is an aspired future characterised by:

Efficient mobilisation of knowledge, expertise, capacities and investments, from both Europe and Africa, in a long-term research and innovation partnership which delivers on food and nutrition security and sustainable agri-food systems through a deeper understanding and the promotion of the diversity of intensification pathways.



Figure 1 Research informs policies to enable complementary and evaluation of pathways to sustainable intensification.

² <http://www.intensafrika.org/documents/?wpdmc=deliverables>

The proposed efforts to contribute to seeing this vision become reality are based on a three-dimensional **mission**:

- to improve efficiency and efficacy of R&I through coordination and collaboration through an long-term partnership arrangement;
- to provide contextual evidence on the potential of a diversity of sustainable intensification pathways by using an innovative R&I agenda;
- to tailor research & innovation outputs and outcomes to needed information for policy and decision-making in support of sustainable development.

3.2. Dimensions of the mission

3.2.1. Dimension one: A long-term partnership for alignment

A key dimension of the mission is to provide a mechanism for long-term partnership between EU and Africa linking policy formulation to projects implementation, involving wide stakeholder representation, and building on what already exists.

The strategic research and innovation partnership will focus on the improvement of the food and nutrition security and the livelihoods of the African rural population by exploring and capitalising on the diversity of pathways to sustainable intensification of African agri-food systems. The partnership will benefit from the rich expertise and experiences from leading scientists in both Europe and Africa. With the advances made in Europe and in Africa on agricultural research for food and nutrition security, there are good opportunities for further knowledge exchange and co-learning between the two continents to work together in addressing shared challenges, and specific challenges, in particular in Africa. In addition, the partnership should result in better pooling of resources for large and coordinated research and innovation projects at scale, thus minimizing the overlap and maximizing the complementarity between the projects.

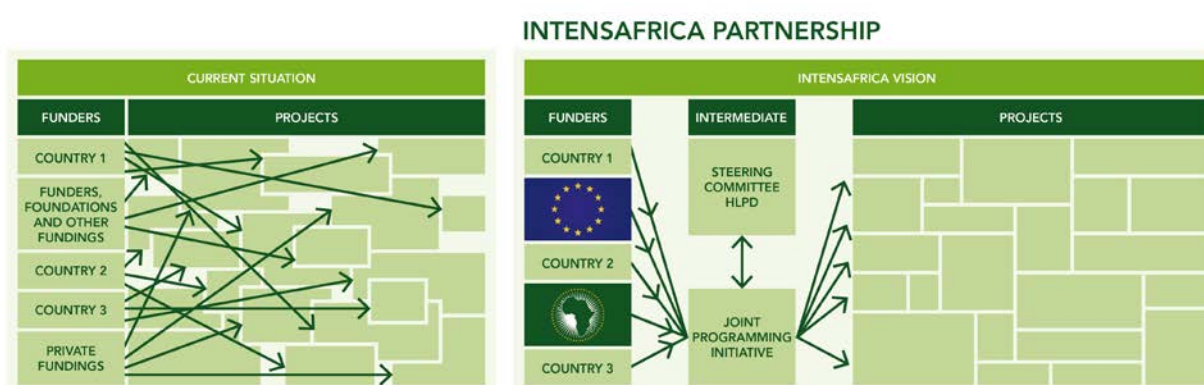


Figure 2 Pooling of resources in the new IntensAfrica Partnership for a more effective R&I activities to enhance FNSSA.

Such a partnership will require a concerted effort of different types of institutions to jointly implement the proposed agenda. It adds value by connecting experiences from different situations that are all affected by rapid change caused, for example, by population growth, urbanization, climate change, market development and use of ICT.

The IntensAfrica consortium represents research and platform organizations, which are well linked to a wide array of partners in their respective regions, especially policy institutions and the private sector. This puts the consortium in good position to drive its vision of long-term partnership for research and innovation and support projects that favour the mission. The rationale is that, in this way, the consortium in itself reflects a broad partnership.

3.2.2. Dimension two: An innovative R&I agenda harnessing the potential of diversity of sustainable intensification pathways

Different sustainable intensification pathways are promoted and described in the literature. It is unrealistic to expect that only one of these pathway options would achieve sustainable intensification of agri-food systems. Due to the diversity of the agro-socio ecosystems, a one-size-fit all solution does not exist. Instead, the strategic partnership will explore, compare and document the diversity of intensification pathways, thus helping decision makers (starting with farmers) to exploit the full potential of each pathway. It is the starting point of the IntensAfrica consortium that combining elements of different pathways and learning to navigate between pathways will yield innovative systems that are optimally adapted to specific contexts.

The strategic partnership will assess the efficiency and effectiveness of different pathways to improve agri-food systems and the livelihoods of African rural population. At the same time, it will contribute to exchange knowledge and lessons learned between European and African producers and consumers. The sustainability aspects of the different pathways explored and used in the comparative analysis include environmental, economic and social externalities along the whole value chains and in the food networks.

The strategic partnership also supports the view expressed in the HLPD FNSSA Road Map that there is a continuum between research and innovation. Knowledge generation and technology development and adoption of the technologies together are not a one-way and linear process. This has two practical implications:

- the activities of the strategic partnership will be implemented using multi-stakeholder approaches;
- the partnership strategic agenda will be a combined Research and Innovation agenda.

3.2.3. Dimension three: An impact-oriented partnership contributing to sustainable development

The partnership will design and implement novel agricultural production systems with the aim to transform whole agri-food systems. In conjunction with economic development, the approach also includes many other aspects such as value-chain and market development, processing, institutional and governance issues, alliances among diverse sets of rural and urban actors and creating the enabling environment for business to thrive with the policy makers.

The strategic partnership programme will actively contribute to empowering women and youth. These groups are to be key players in making smallholder farmers and other actors of the agri-food systems more entrepreneurial. By supporting this transition, the strategic partnership will contribute to poverty reduction and food and nutrition security at scale.

The strategic partnership will be strongly aligned with the policy environment and will pay particular attention to engaging the national and regional policy makers in a shared science and innovation agenda.

3.3. Unifying principles for the strategic partnership

The strategic partnership will be anchored on the following six core principles:

- Embracing complementarity: the partnership will actively promote the coexistence of different sustainable intensification pathways, as their performance will vary widely across systems and across the diversity of both African and European farming realities. One single sustainable intensification pathway cannot cater to all needs.
- Recognising that sustainability is a multi-criteria objective with many possible trade-offs: the choice of a pathway will inevitably include elements of societal choices and making trade-offs.
- Mobilising existing and new knowledge through a multi-stakeholder approach: sustainable intensification of the agri-food system is a complex societal problem that cannot be addressed only by technical researchers. The strategic partnership will enhance actively the required cross-sector interaction in research and innovation processes, by wide stakeholder inclusion and crosscutting calls for proposals involving technical and social sciences.
- Providing evidence-based policy support tailored to different levels of decision making: outcomes have to be made available for decision makers at all levels, ranging from individual farmers, rural innovation knowledge managers, private businesses and local, regional and national policymakers. Fundamental research may be facilitated when such knowledge is emerging as needed from the applied and policy oriented research activities.
- Being aware of 'lock-ins' (path dependencies) and of the need for adaptive practice: development trajectories often lead to lock-ins, in particular when specialised production reduces resilience because of limited options for adaptive practice, which leads to vulnerability. The concentration of power in a small number of global companies in the agro-industry sector may exacerbate this threat of lock-in and paradigm dependency.
- Being ready to engage in a long-term partnership: Sustainable intensification of the agri-food systems in Africa and Europe is a complex issue, involving many stakeholders with a variety of interests. Building strategic alliances will take time. Ensuring continuity in the partnership will also add value, promote coherence and generate impact.

4. The sustainable intensification pathways concept

The comparative pathways approach adopted by PROIntensAfrica project has proved very useful in analysing and exploring the diversity of various current agricultural transformation processes and development options, in characterizing their effects, and in identifying R&I issues. It is proposed to extend and systematise this approach in the future R&I agenda on sustainable intensification of the agri-food systems. In this chapter, a general introduction to the pathways is provided and key arguments for exploring a diversity of sustainable intensification pathways discussed.

4.1. Typology of pathways

Four pathways were pre-identified in the 2014 initial project proposal: the “high input pathway”, the “sustainable intensive agriculture” pathway, the “agro-ecology pathway” and the “organic agriculture” pathway. The work carried out in 2015 and 2016 by PROIntensAfrica and in particular, the case studies and the literature review have led to a revised and improved typology as described in Box 4.

The four pathways do not match exactly with all specific individual intensification trajectories, nor do they cover all possible intensification pathways. These are rather simplified constructions, based on identified agricultural sets of practices, principles, and schools of thought but

Box 4 PROIntensAfrica’s typology of pathways

	Conventional Pathway	This pathway is characterised by high use of external inputs (such as improved varieties and breeds of crop and livestock, GMO, pesticides and mineral fertilizers) and extensive use of irrigation and mechanization. This pathway is a continuity of the green revolution and commends the use of high-tech provided that such will improve productivity. It typically refers to maximizing production as its goal in the short term.
	Eco-technical Pathway	The eco-technical pathway seeks to integrate indigenous knowledge and ecological services to ensure a sustainable intensive agriculture. It primarily seeks intensification through rational use of biotechnology (including GMO), modest external inputs, irrigation and mechanization in such a way that the ecological cycles are maintained.
	Agroecological Pathway	The agroecological pathway is based on a convergence of agronomy and ecology. Maximization of productivity or production are not the main goals of this pathway rather the optimization of outputs while the farm systems are retained in a healthy version. Intensification in this sense is subordinated to food sovereignty and justice, welfare development and autonomy of the production system and of the farm.
	Organic Pathway	The organic agriculture pathway refrains from the use of pesticides and mineral fertilizers and emulates ecological systems and cycles. Intensification for this pathway means a shift to better quality products and certification to get better prices for the produce.

with an attempt to clarify contrasts between options. The different pathways presented show a particular orientation that is implicitly or explicitly linked to a broad political vision on development strategy. Different pathways, however, can co-exist in space and time. This coexistence might involve recurrent competition for resources, but pathways can also be complementary and even interact in positive ways.

This typology is the result of an iterative process, starting from an initial preliminary typology, then revised and refined through an extensive literature review (Project Deliverable 2.1), 17 cases studies in Africa (Project Deliverable 2.3)³, and several workshops with experts and stakeholders.

The concept of pathways is used here in a double perspective: to classify the current systems, as well as to highlight the socio-technical trajectories for sustainable intensification.

This classification into pathways is helpful to compare the paradigms in terms of their performance. In addition, the typology helps the R&I stakeholders and public policy makers in positioning themselves and their actions and initiatives. The pathways are not “models” in the sense of possible technical packages of intensification, but proxies allowing for a structured consideration of the large diversity of intensification situations. Current farming systems reflect these pathways as well as many combinations of these options, which means that boundaries of pathways are open and farmers’ practices may shift between as well as combine pathways in space and time under the influence of multiple factors.

4.2. Pathways, contexts, and trade-offs

The diversity of the climatic, soil, social, economic and political conditions results in a diversity of production systems that match specific conditions. The pathways will differ in function, performance and impact in terms of:

- means: the intermediary inputs and other means mobilized beside the classical assets for producing;
- outputs: the products and services resulting from agricultural performances, land productivity, income and livelihood;
- outcomes: the direct effect of production and income, such as quality of food and food security, equality and equity, social and environmental sustainability;
- organization: the interaction between farms and the interaction of farms and farmers with the prevalent institutional environment, as well as the impact on wider agri-food system;
- impact: e.g. changes in productivity, environmental impact, effect on employment, dependency on external inputs, and ecological processes.

Figure 3 shows an example of some performance variables regarding impact that can be used to compare the advantages and trade-offs of pathways.

³ The case study reports can be accessed at <http://www.intensafrica.org/documents/?wpdmc=case-study-reports>

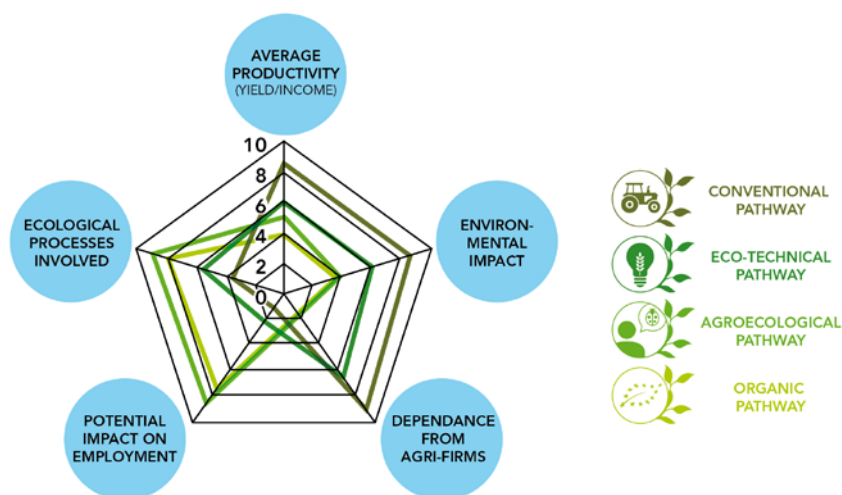


Figure 3 Illustrating the multi-dimensional performance of pathways an example (numbers used were chosen partially to highlight pathways diversity)

In addition, the literature review and case studies pointed out that intensification models imply different factors and drivers of intensification:

- factors include the three classical production factors: land, labour and capital. Other factors are human and social capital (including knowledge, innovation, power), as well as ecosystem services and ecological processes.
- drivers relate to four levels of change: macro level, local level (community/territory), the household level and the field level. Understanding the actual dynamics that make a farmer, a community or a government take decisions towards the choice of a particular intensification pathway is of utmost importance for policy making.

4.3. Detailed pathway description

Based on the results of the PROIA project, an updated and fine-tuned definition of the pathways and a framework for pathways description has been developed. This framework used five key aspects to describe and differentiate the pathways:

- vision, mission and values;
- organization of stakeholders in the food chain, markets and governance;
- dimensions addressed by the agricultural model; agricultural practices;
- agricultural techniques, technologies and approaches being used, and
- source of, and flows of, energy and materials.

Table 1 describes the pathways using these key aspects.

Table 1 Detailed description of the pathways along five dimensions

Aspect	Description	Conventional pathway	Eco-technical pathway	Agroecological pathway	Organic pathway
1 –Vision, mission and values with regard to sustainable intensification as declared by their supporters	An intensification pathway is more than a simple set of techniques. Convictions, ideology, or epistemic and social community membership define a school of thought in which the pathways arise and develop. A pathway is embedded in a vision of the role agriculture should play in national economic transitions and widely in development.	Dominant focus on maximizing production and/or productivity. It seeks to strengthen the utility of the natural production assets to ensure continuous production to meet human needs and foster profitable models. It assumes that resulting negative effects generated by intensive production can be repaired by science.	Focuses on maximizing resource potential for increasing production. Promotes balanced productive, environmental, economic, and social development model. This pathway is strongly supportive of biotechnologies, but introduces itself as the improved green revolution, by taking into account its excesses.	Promotes a family model of agriculture that is based on environmental, economic, and social values. Labour and land optimization goals are considered subordinate to local autonomy and sovereignty, natural resources management, as well as to welfare, better livelihoods and food sovereignty.	Originally very close to the agroecological pathways visions and values. Human, animal and plant health are the main drivers. In its later development, intensification means a shift to better quality that should allow better prices.
		Labour productivity has to rise in order to achieve the shift of labour forces from agriculture to the others sectors until productivity equality.			
2 - Organization of stakeholders in the food chain, markets and governance	Agrifood systems differ in their organization scheme, especially in terms of degree of concentration of stakeholders and relationships between stakeholders, leading to specific governance models and norms.	These pathways tend to lead to food chains with high levels of concentration, especially in the processing and commercialization segment. Private investments and public-private partnership are highly compatible with these pathways, which may lead, especially in pathway 1, to encouraging large-scale farms and their dependency to agro-supplies. In pathway 2, coexistence of diverse farm structures is implicitly promoted. These pathways together aim to provide standardized products for mass trading and consumption. Economy of scale is a common goal along the value chains.		This pathway mainly focuses on medium and small-scale farms and local and national, markets; it favours a network of multiple local stakeholders; and long value chains integration requiring specific conditions is involved.	Organized around specific market chains allowing certification for additional value creation, both at local and international scale. International movements and regional organizations support organic agriculture, but dedicated policies are currently few and of limited scope.
3 - Dimensionality	Pathways might focus on techniques for increasing productivity or include an environmental and/or a social dimension.	Focuses on technical dimensions.	Focuses on technical and environmental dimensions.	Focuses on technical and environmental dimensions. Social dimension is inherent to this pathway.	Focuses on technical and environmental dimensions. Social dimension is often present but not necessary.
		Recent advances in mainstreaming the social policy dimension for trade, input supply and infrastructural development.			
4 - Agricultural techniques, technologies and approaches being used	Practices are different from one pathway to another. Practices that are radically different across systems include the use of pesticides, fertilizers and GMOs. Other practices are frequently used in the different pathways.	High external inputs used, notably breeding (including GMO), pesticides and mineral fertilizers.	Rational use of biotechnology (including GMO), external inputs, irrigation and mechanization; and increasing use of natural processes in cultivation processes.	Technical rationale and main goals are to maximize natural processes involved in cultivated process in order to diminish external inputs, and their related costs. Autonomy of the production systems is also a key objective.	Strict option of no-chemicals, no-artificial inputs. The organic pathway refrains from the use of synthetic pesticides and mineral fertilizers and emulates ecological systems and cycles.
5 - Source of, and flows of, energy and materials	Source of energy and degree of use of external inputs for production are different across pathways.	Massive use of fossil fuel, agrochemicals and mineral fertilizers from industries. Seeds provided by firms.	Use of fossil energies, but open-minded to alternative sources. Seeds largely provided by firms.	Seeks to minimize the use of fossil energies and favour renewable energies. Seeds locally grown and selected.	Seeks to minimize the use of fossil energies and favour renewable energies. Carefully monitored seed production.

4.4. Stepping stones for an R&I agenda

Results from the analysis of PROIA Case Studies⁴ reveal a number of issues that helped to shape the R&I agenda. It was found that:

- in most parts of the world, the conventional pathway led to strong increases in land and labour productivity and accompanied rural and economic structural transformation. In Sub-Saharan Africa, however, efforts to improve productivity by applying this pathway have often resulted in limited production increases, much lower than expected. In addition, these production increases were not sustainable. One of the reasons for this limited impact relates to a lack of inputs like mineral fertilizers. The amounts used per surface unit are much lower than those applied in Europe. However, the reasons for low input use are complex. Issues such as labour opportunities, effective land-use intensity, food markets on local, regional and international scales, collective action, public goods, as well as policy formulation and implementation are important aspects to take into account. It is essential that they be included in the research for sustainable intensification.
- the case studies clearly show multiple concerns about the conventional pathway regarding the future: environmental threats in combination with alarming messages on uncertain food and nutrition security. Loss of soil fertility, increased erosion and multiple vulnerabilities of production and food systems have forced farmers to explore more sustainable alternatives.
- some local successes in terms of yield increase and market integration have been identified and analysed. Most case studies describe promising options for intensification, but the analysis is usually coupled to more pessimistic reflections about the sustainability. This is partly due to scattered project implementation of short-term research and innovation actions. There is a need for long-term collective and organized action to address the different components of sustainability.
- the case studies show the risks, and sometimes the ambiguity, involved in alternative solutions proposed by researchers and extension services. Most of the studies argue for a greater use of conventional pathway factors of intensification (genetic engineering, mineral inputs, mechanization, accompanied by credits, collective action, etc.) and for a modernization of production structures. This is inspired by structural transformation that has occurred in developed countries and in emerging economies. At the same time, the case studies highlight the difficulties encountered in making this shift and its weak compatibility with the environmental sustainability requirements. There is now an appeal to shift from the conventional pathway towards the ecotechnological pathway.
- the production intensification patterns of the different commodities are not equally distributed between pathways. For example, fruit production intensification is mainly addressed through agroecological pathway projects, and only secondarily by ecotechnological and organic pathway projects. Animal production intensification, however, is mainly addressed through ecotechnological pathway projects, and secondarily through conventional and agroecological pathways projects.

⁴ For more detail, please visit <http://www.intensafrica.org/blog/download/d2-3-light-case-study-and-in-depth-case-study-reports-of-identified-cases-including-a-synthetic-cross-analysis-report/>

5. The Research and Innovation (R&I) agenda

New approaches to research and innovation are required since sustainable intensification is about not only increasing outputs, but also about prudent and efficient use of resources, ecosystem services, social and economic impacts, induced technological dependency, and limits of natural and energetic resources. New exciting pathways of sustainable intensification are emerging as alternatives to conventional intensification, such as eco-technological, agroecological, and organic farming. These pathways need to be analysed and compared, with the appropriate tools and metrics, in order to evaluate their performance and resource-use efficiency, and their sustainability. Comparative research is needed to fully unlock the potential and limitations of related approaches. Responding to this situation, the PROIntensAfrica project has developed an innovative research and innovation agenda.

5.1. The R&I framework

The PROIntensAfrica proposed R&I agenda will connect pathway-orientated comparative R&I in relation to performance domains, dimensions, levels, and conditions. The figure below illustrates this ambition.

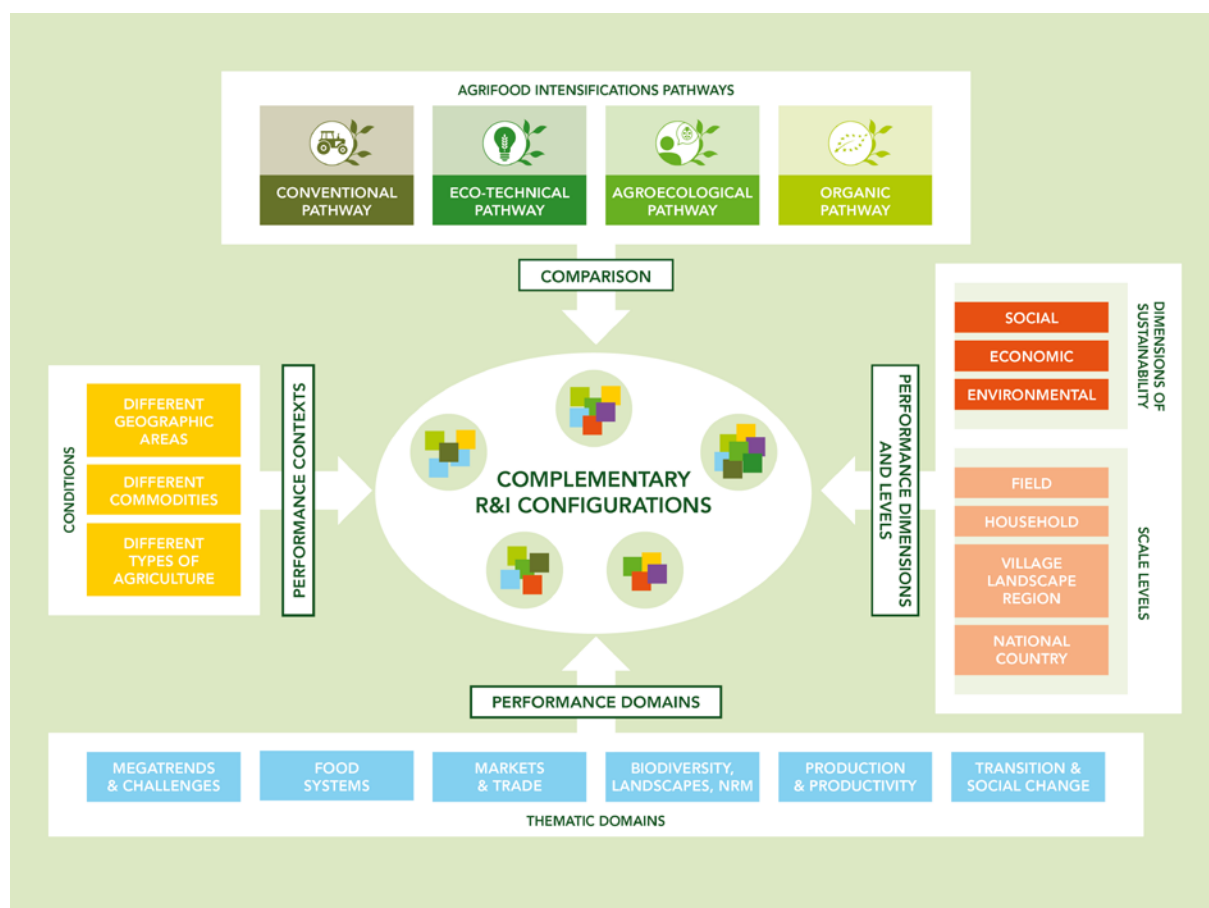


Figure 4 A framework for the configuration of the R&I agenda.

The R&I framework on the configuration of R&I efforts have three concrete implications:

- The research and innovation agenda needs to work with a diversity of intensification pathways and provide keys to comparing the pathways. Research on one pathway can still be considered under the condition that the evidence provided can be used for comparison. The agenda should also avoid “blind spots” and promote a balanced approach between pathways, or at least require a justification of funding distribution between the pathways.
- Products from the implementation of the agenda need to address the main controversies regarding how to achieve sustainable intensification and food and nutrition security. Such products should emerge from effective, multi-criteria and multidisciplinary comparisons.
- The potential of different pathways needs to be explored equally in relation to the range of different commodities and to the variety of geographic areas. R&I budgets should be allocated in ways that allow for the exploration of the full potential of the different pathways.

5.2. Performance dimensions, levels and conditions

Comparing the potential and performance of the intensification pathways needs to be done in relation to a range of parameters in different contexts. The proposed R&I agenda therefore focuses on comparison in relation to the three dimensions of sustainability, levels of scale, and conditions.

5.2.1. Dimensions of sustainability

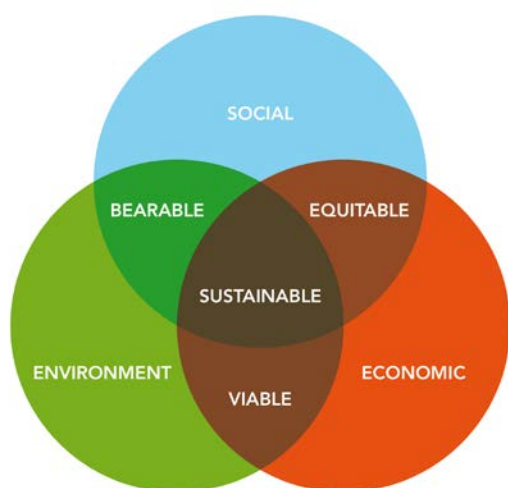


Figure 5 Dimensions of sustainability.

Environmental sustainability is the ability of the environment to support a defined level of environmental quality and indefinite natural resource extraction rates. Even though this is regarded as being the foremost challenge for the world, many consequences of unsustainable practices will only be obvious in the future, and therefore this problem tends not to receive the attention it deserves.

Economic sustainability is the ability of an economy to support a defined level of indefinite economic production. It includes for example, ensuring farmers livelihood, the replacement of retiring farmers by a new generation, affordable prices for consumers, fair distribution of revenues along the agricultural value chains.

Social sustainability is the ability of a social system, such as a country, family, or organization, to function at a defined level of social well-being and harmony indefinitely. Problems like

war, endemic poverty, widespread injustice, and low education rates are symptoms of a system that is socially unsustainable.

Resilience is a key dimension of sustainability. Resilience refers to the ability to adjust easily to or to recover from changes that had affected the agri-food systems negatively. The research and innovation agenda is geared towards enhancing resilience of agri-food systems by harnessing the potential of a diversity of sustainable intensification pathways. This creates opportunities for responding appropriately to both the existing and the emerging vulnerability context of trends and shocks that affect agri-food systems.

5.2.2. Levels of scale

Pathways will perform differently at various levels of scale: what shapes the pathways as well as what do affects the characteristics of the pathways. These levels include:

- field level: for specific activities on parts of production and food systems, relevant for one specific pathway or for several pathways;
- household level: it is the farmers' decision-making level for choices and implementation of sustainable intensification measures for agricultural production. Issues to be addressed include trade-offs between sub-household activities, decision making processes, also in relation to external factors;
- village/landscape/regional level: wider agri-food and innovation system, markets, institutional dynamics, processing, and employment;
- national/country level: national and international agendas and policies, world markets, national and international trade.

5.2.3. Conditions

The African continent is enormous, and has a large variety in agro-ecological and socio-economic conditions. From a biophysical point of view, climatological conditions vary from very humid (more than 4000 mm of rain/year) to semi-arid agricultural lands. Land can be flat or very hilly; altitudes vary from sea level to high-lying plateaux and mountainous areas. Soils can range from sandy to clayey, strongly influencing hydrology and fertility of the soils. The socio-economic characteristics occurring in Africa range greatly for example, in population density, ethnic group composition, areas of urbanization, and access to markets.

All these conditions result in diverse agricultural production systems and the related food systems, each with its specific characteristics. This high diversity determines also the challenges and opportunities for sustainable intensification and the ways to achieve it.

Scaling-out and scaling-up of results and outcomes of the future R&I partnership programme can only be enhanced by taking into account the prevailing conditions of the area where the sustainable intensification activities were successfully implemented.

5.3. Performance domains

The six R&I thematic domains detailed below are aligned with the main themes of the Science Agenda for Agriculture in Africa. Their joint implementation will facilitate a crosscutting

approach of diversity and allow informed comparisons (see Part 3.3 on strategic partnerships). Main concepts leading to the choice of the six thematic domains for the strategic partnership include:

- considering agriculture models and intensification not only in terms of production and markets, but as part of a food-system;
- tackling the role of agriculture in a more generic human or societal development;
- agriculture and food system transition are complex, an integrated perspective is needed, rather than a sector approach;
- reframing research regarding the challenges and opportunities faced by sustainable intensification of the agri-food systems;
- anticipating future transitions towards sustainable agri-food systems under changing factors and drivers.

The six thematic domains are given in Figure 6. The six thematic domains and the four intensification pathways form a matrix which allow cross-pathway comparison and exchange as well as cross-thematic performance analyses.

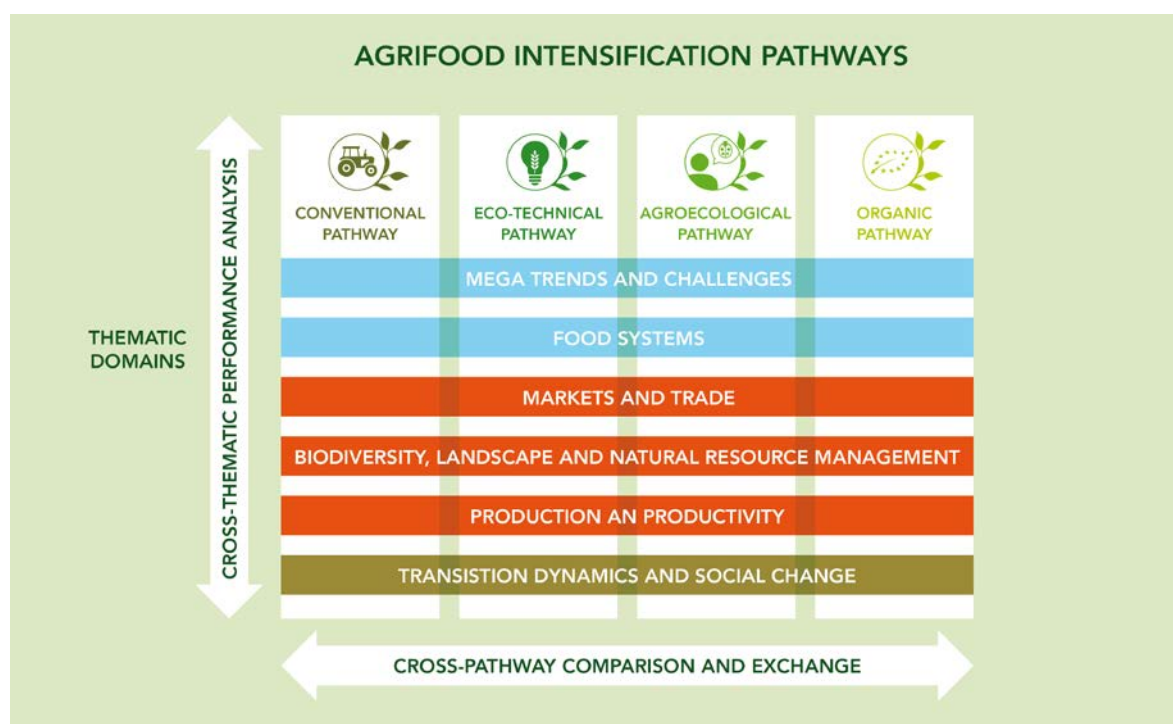


Figure 6 Comparative analysis of pathway performance in thematic domains.

5.3.1. Megatrends and challenges, drivers of change for agriculture in Africa (theme 1)

Context and objective

The PROIntensAfrica case studies clearly show the discrepancy between the drivers for intensification in Africa, the limited improvement in production and performance growth, and the reduced success in achieving structural transformations. Apart from specific dynamic regions that benefited from important investments (such as irrigated areas), or in urban and

peri-urban contexts where market and land access incentives are particularly strong, production increase is essentially due to the extension of the cultivated land. This means that there is a need to better understand the effects of the mega-drivers. It also means that the possible thresholds for real changes and the concrete consequences and implications of reaching these thresholds have to be better documented and anticipated.

Research and innovation actions proposed under this thematic domain aim to document the specificity of African agriculture and food challenges, the opportunities that different pathways provide, and the way they support agriculture and food-system transformations. This thematic domain provides evidence for designing the most suitable options (or combinations of options) regarding intensification pathways. Research and innovation needs to help understand how agriculture is both impacted by and plays a role in global transformations.

Box 5 Demography, employment, and economic transformation

In order to connect agricultural intensification to population dynamics and their implications in terms of structural changes, research is needed on the labour dimensions of African agriculture and food systems. The massive growth of African population underscores the dead-end of “business as usual” pathways, but alternative pathways will need a clear focus on rural and urban labour demand and availability. Comparative research should address questions such as:

- what are projections of how many young people will enter national and local labour markets, and with what skill-sets, expectations and ambitions?
- how many person-days will each intensification pathway require under specific conditions, in the farms, but also all along the value-chains and food systems? What are typically related job conditions and what does this mean for attractiveness for youth?
- what would be the expected future need for labour in each pathway? How could this demand be influenced or rather influence technical choices and demographic and urbanization trends? Do the expected labour conditions match with workforce availability and demand?
- what is the potential of each of the pathways to address and/or connect to labour conditions and economic transitions in Africa?

Research and innovation issues

- Climate change realities and foresights, putting attention to mitigation issues as a way of intensification.
- Demographic and urbanization trends and their implications for land and job requirements, compared to actual and potential land occupation and job creation under the different pathways (see Box 5).
- The opportunities and constraints to structural changes and the role of agriculture and food systems in these transformations, including political and institutional changes. Research should allow comparing potential contribution of the different pathways to these transformations.
- Socio-economic and cultural changes, including livelihoods standards, diets, intra-household organization and dynamics of rural and urban communities.

5.3.2. Food systems (theme 2)

Context and objective

The PROIntensAfrica literature review confirmed that in addition to production and quantity of food, FNS necessitates also to document and to address access to food while taking into account the institutional, economic and social functioning of food systems. In a multi-

dimensional analysis, an intensification pathway is also a combination of various factors and of multiple stakeholders working together to enhance the FNS.

The proposed PROIntensAfrica R&I agenda allows the comparison of the main intensification pathways, in relation to all the interconnected processes within the food systems. Food systems can be seen as a network of articulated segments, from production to a final consumer, including various service providers such as food processors, traders, and even support services and supporting policies. Intensification pathway implementation also implies globally specific organizations, stakeholders' networks and markets. Food systems reveal, in that sense, a coherent set of ideologies, policies, practices, knowledge and stakeholders that also fit pathway dynamics. An original agenda should evaluate these global transformations and performances.

Research and innovation issues

- How the different pathways work out in relation to the different dimensions and dynamics of food systems.
- Value distribution within the food systems; where does it go and what are each stakeholder's benefit depending on the different intensification pathways?
- What are the characteristics of the food losses within each food systems segment like production, food processing and distribution and how are these losses related to the intensification pathway?
- How to integrate informal and formal knowledge to enhance a diverse food supply tailored to locally available resources and habits.

5.3.3. Trade and access to markets within the food systems (theme 3)

Context and objectives

This thematic domain aims to document the dynamics, benefits and costs, promises and risks of the different options of trade and access to markets offered by the implementation of different intensification pathways and food systems. The objective is to capture the diversity and the conditions of coexistence of different pathways, at local, domestic, national and international levels. Research and innovation should include not only economic perspectives and price competitiveness, but also institutional and political changes that affect markets dynamics and the condition of the competition. Research and innovation also focus on the eco-systemic and environmental cost and benefits of the different pathways. In this context, it is important to consider also non-monetary costs and benefits to society as they may add value to the food system and to the consumer as well as to consider infrastructures that facilitate or prevent farmers' access to the market.

Research and innovation issues

Results of PROIntensAfrica suggest considering and anticipating markets expansion, paying attention to quality, social sustainability and emerging opportunities, as well as physical and non-physical constraints in three main directions:

- Trade and markets normativity in each intensification pathway and within the food systems (including seeds, fertilizers and pesticides markets and transformation and packaging inputs), and the way in which these norms standard and trade rules are implemented

(including investigating public and private dimensions of norms building and implementation) and how it affects pathway development.

- Social and environmental goods and services, their costs (including animal and human health, and controversies on debates on insurances) in the different intensification pathways, their economic valorisation and their potential role as a driver of changes.
- Connecting these issues with the question of prices volatility and of markets governance at continental and international level, and in the context of different intensification pathways and food systems.

5.3.4. Agricultural biodiversity, landscape and natural resource management (theme 4)

Context and objectives

The often competing relationship between agricultural activities and ecosystems evolution remain at the heart of R&I concerns. On the one hand, the sustainability challenge is about maintaining healthy ecosystem for future generations. Agricultural progress also relies directly on good access to healthy natural resources and on enhancing and using beneficial ecological processes.

Box 6 Landscape dynamics

Landscape ecology has strongly contributed to the land-use related sciences. Heterogeneity feature of landscapes has two major consequences. The first is that areas of land are composite, made of identifiable patches. The second one lies in the nurturing of biodiversity. Higher structural diversity corresponds with more habitats for flora and fauna and higher resilience of the area to external perturbations, including climate change.

For farmers, what matters is the relevance of the landscape approach for all the intensification pathways (taking into account positive or negative interactions). It provides a contribution to the agricultural intensification debate, and may feed a wide spectrum of criteria that characterizes sustainability. Thus, multidisciplinary research on multifunctional landscapes should contribute to feed the ambitions and combat the limitations of all the options. This involves addressing research questions such as:

- How to qualify the attributes of a landscape, through specific procedures, composite index or indicators?
- How can landscape metrics and spatial statistics be related to ecological functions?
- What models help in understanding the flows of organisms, materials, and energy in landscapes managed under different intensification pathways?
- What are the effects in land use and land cover change of the different intensification pathways?

Sustainable intensification requires a clear understanding about interactions between ecosystem functions and human agricultural activities. Ecological and agronomic sciences need to work together in exploring evidence of options to improve both natural resources quality and access, and cropping systems and landscape productive and environmental performances.

Research and innovation issues

- Biodiversity assessment regarding the intensification pathways and its impacts on ecosystem resilience and on local populations livelihoods, elaborating tools and methods of sustainable management of systemic issues of cultivated biodiversity.
- Revisiting and enhancing research on eco-systemic and environmental services produced by landscapes to agricultural and food systems.

- Revisiting and enhancing landscape issues, with a focus on crop pest management impacts at landscape level, documenting scaling-up issues from the plot to the territories.
- Revisiting and enhancing research and innovation on soil fertility and degradation under human and natural pressure, evaluating eco-system and environmental cost and benefits of soil management along the four different pathways and promoting good soil management and fertility transmission practices.
- Evaluating eco-systemic and environmental costs and benefits of agroforestry systems.
- Documenting and capitalising on local knowledge on natural research management and their mobilization in production and environmental processes.

5.3.5. Production and productivity (theme 5)

Context and objectives

The proposed R&I agenda will support family farmers, and small and medium-sized industrial farmers in adapting their technologies and their farm organization adapted to the new and evolving contexts. The basic building blocks for the transformations in the production systems are at the field-level scale, but the targeted increasing performances have to be integrated at farm and landscape level, taking into account the three dimensions of sustainability: environmental, economic and social.

Box 7 Crop protection

Sustainable agriculture considerations started mainly with a view to counteract pesticide misuse and abuse. Integrated pest management (IPM) was the first concept that emerged during the second half of the last century, based on the perceived need to break away from the dominant paradigm that gave rise to an intensive type of agriculture associated with artificial conditions, biodiversity reduction and reliance on non-renewable and toxic inputs.

In relation to the use of chemical pesticides, and genetically modified plants, private and public research is mobilizing huge amounts of human resources, money and technology. More recently, discoveries on biodiversity properties have given a new impulse to research, with the creation and mobilization of new concepts such as landscape management and ecological engineering. Along these new issues, and in parallel with the conventional research system, capturing and testing local knowledge and experiences from stakeholders is becoming increasingly important, and opening new avenues. Human health considerations, relayed by consumers, policies, laws and rules have often been the drivers for innovative practices. New considerations have emerged, and are inspiring guidelines to all forms of intensification pathways. Research topics in relation to these issues would include:

- Identifying pests, their natural enemies, their host-plants in the semi-natural habitats to explore the potential of landscapes in boosting natural enemies of pests;
- To understand the dissemination of toxins expressed in GM crops, and correlative resistances acquired by living organisms.
- To develop the options of weed control by ecological processes using natural covers in conservation agriculture systems, to reap the full benefit of undisturbed soil biological activity
- Enhancement of biological processes as replacement of chemical inputs as "starters" to mobilize biological processes for farmers' benefit with a view to their eventual suppression ultimately.

Technological development strategies should be based on research conducted in a locally grounded systems approach. Different systems can co-exist and the choice for specific pathway(s) to improve agricultural production is ultimately in the hands of the farmer.

Research and innovation issues

Research and innovation dynamics will be directed towards the following subject areas:

- Annual cropping systems, including roots and tubers, are actually the main systems to support the basic nutrition needs for the African population. Quantity, but also quality and diversity are key issues for these systems.
- Tropical tree crops systems are highly productive, meet global demands and promising trends but are increasingly being operated in fragile environmental and social situations.
- Horticultural cropping systems are considered as beneficial to human health. As high value systems, they also can provide excellent income-generating opportunities for small farmers.
- Livestock constitutes a substantial component of African agricultural production, through the provision of animal-sourced foods. It is a stable source of income and capital assets, as well as a source of draught power and manure for farming.
- Improved water management (large and small-scale irrigation schemes, landscape and field-level improved water management) is a key component of all intensification pathways. New cropping and farming patterns need to be tested to meet the water and other natural resources uses in ways which are more efficient, more diversified and more sustainable, especially regarding other (and competitive) potential water uses.
- Mechanization needs to adapt to the diversified conditions and pathways towards intensification, and research should be able to advice on appropriate and coherent socio-economic environments for policy development.
- Africa is increasing its capacity to play a major role in developing and deploying new plant breeding techniques to address food security and sustainability of the natural resource base. Research is needed on crop biotechnology through integrated methods that take into account the global principles undertaken by the different intensification pathways.

5.3.6. Transition dynamics and social change (theme 6)

Context and objectives

Agricultural change involves non-linear processes and intensification pathways, and is by nature dynamic. This means that farmers can shift from one pathway to another, can employ several pathways simultaneously, but change the combination of practises over time, or they can evolve within a single pathway while adapting their strategy to capitalise on incentives or solve constraints. It also affects different groups in society in different ways that are often gender and youth related.

PROIntensAfrica agenda proposition aims to document the drivers of these transitions and the ways they are implemented. The complexity of challenges to be addressed by agricultural systems implies the need for new methods to describe the process of change. Theories of transition are based on a multi-level perspective combining the context, the present regime of innovation and new niches of innovation. It provides tools to discuss the dynamics of interactions between different pathways.

Research and innovation issues

- Transition dynamics are multi-actor systemic processes and require a prior assessment of the diversity of farming systems and value chain in Africa.
- Technical and cognitive lock-ins are impeding some transition processes. Their identification is a prerequisite for developing “enablers of change”.

- Depending on local and regional contexts and on the structure of value chains, transition pathways could be in competition. Organization of forums with the different actors including policymakers will contribute to organize the coexistence of pathways at different scales.
- Niche innovations are drivers of change. In their initial stages of development, they require support and protection.
- Transition processes are based on a hybridisation between local farmer knowledge and scientific research output.
- Around the globe there is evidence of linkages between public goods supply, trade policies, social protection instruments and agriculture intensification. Africa lacks policy evaluation and adapted methodologies to address the way policies influence agricultural intensification pathways.
- How are the pathways affected by Gender and Youth? Deepening gender and youth thinking in agricultural research will open the door to reflections on the social, environmental and cultural values of agricultural sustainable intensification.
- Individual strategies need collective support to spread innovations. Collective action has a key role to play, but all the organizations representing smallholders are not structured along these lines. Empowering research and innovation is needed.

5.4. The Research and Innovation approach

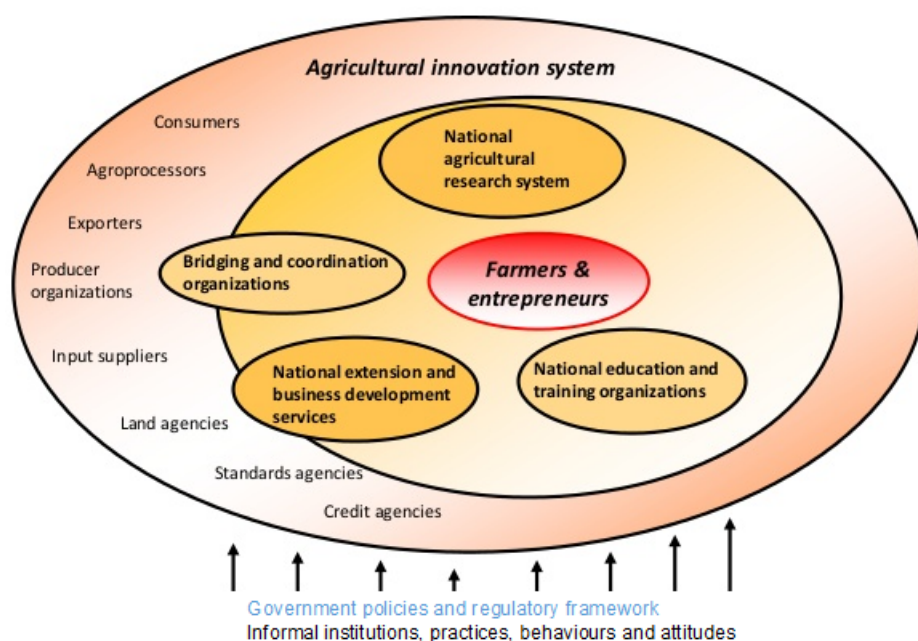
5.4.1. General approach

To tackle the world's pressing development-related societal issues, research for development has to apply more innovative interdisciplinary and participatory approaches. Simply studying agriculture, nutrition, development economics, or food technology without considering the broader context is increasingly considered inadequate. Developing the required innovations in research for development is, however, a huge challenge. What are the best ways to work across disciplinary boundaries, what roles are to be assigned to non-scientific stakeholders in the research and implementation process, and how can a lasting impact be assured?

It is argued that integrative projects are complex and call for a new scientific attitude. The challenge is to develop non-linear R&I approaches, while placing researchers within the complexity they study and accepting to embrace uncertainty. Research developed within the proposed agenda will have to respect this principle.

Agricultural research has traditionally used a linear model of innovation, in which researchers produce knowledge and new technologies, pass them over to an increasing diversity of extensions services (public even though their numbers and funding were greatly reduced in the last two or three decades, not-for-profit such as NGOs, or private for the better-off farmers), who in turn teach and train farmers in the hope of inducing adoption. In this model, it is through large-scale adoption of "improved" technology by farmers that the expected and desired impacts (such as increased yields) are achieved. However, many studies have reported limited adoption, especially by African smallholders. One of the key reasons why such approaches often fail to work in Africa has to do with the fact that adoption does not follow a linear process, and that linear approaches are poorly adapted to the challenging context faced by most smallholder African farmers.

The agricultural innovation systems perspective underscores the highly interactive nature of innovation, usually involving a diversity of stakeholders over time (Figure 7). For the future partnership, from a research perspective and an innovation perspective, the implementation of the research and innovation agenda will be based on more integrated and participative approaches needed to tackle the complex issue of the sustainable intensification of the food systems in Africa.



Source: World Bank (2012)

Figure 7 The agrifood innovation system.

5.4.2. Methodological approaches

This section draws on methodological principles that guided research and innovation efforts during the two years of PROIntensAfrica. As indicated in the previous section, to activate the general R&I approach, matching R&I methodological approaches are needed. In the following, three advocated approaches are highlighted.

Promoting interdisciplinary and transdisciplinary approaches

A joint effort of relevant research disciplines is needed to tackle complex societal challenges. Working together in problem definition and research question formulation, developing and executing the research activities, and drawing conclusions will result in scientific outcomes and innovation better linked to the reality, not biased by a discipline in case of disciplinary or multi-disciplinary research methods. In this, informal and tacit knowledge are important sources. Interdisciplinary research and innovation groups often involve stakeholders in the research, but these are mostly target groups and resource persons for interviews. Their role can be upgraded to being fellow researchers. This is what is often phrased as transdisciplinary research. Stakeholders can help connect assure research to the pertinent questions, they can be sources of information, and can be co-creators of required innovation.

Promoting systemic approaches of R&I

Systemic approaches help to address the complexity at each level of study, and the scaling-up and integration between these levels of observation and research. Systems research considers phenomena in their coherence and interaction. This is highly relevant for considering trade-offs within and between different systems.

A systems approach is relevant to tackle complex issues, which involve many interacting factors and dynamics. It favours a global vision of the issue studied, taking into account the general context, the various elements of the system in which these the research object and theme occur, and most important the relationships and interactions between these elements.

Not all issues which have to be addressed in the proposed R&I agenda require neither an integrated, nor a system approach. Some specific research questions at the plant or plot scale can be dealt with in a disciplinary way. However, these kinds of research activities have, in most cases, to be part of a larger integrated research and innovation project.

Box 8 Responsible research and innovation

The R&I approach is based on principles of responsible research and innovation: anticipation, responsiveness, inclusion, and reflexivity. These principles need to be activated in considering trade-offs and implications of intensification pathways to support responsible investment in agri-food systems. Moreover, they will also need to be activated in research and innovation efforts by e.g. considering not just short-term performance of pathways, but also the anticipated longer-term performance. Similarly, performance and impact of pathways may change as the use of innovations goes to scale and to different contexts, which calls for a responsible scaling approach.

Promoting a programme approach for knowledge sharing and joint learning

To enable coherence and complementarity of R&I efforts, a programme approach is proposed. It will involve project formulation and execution to respond to a shared framework, so that projects outcomes and impacts can be easily shared with other projects and stakeholders.

To enhance the sharing of results and impacts, mutual learning within the program will be organized. This should also include cross-project analyses, common meta-analyses for all projects and systematic communication.

Such a programme approach and joint learning will allow for better results than having a (large) number of individual projects. It will facilitate adequate flow on information between stakeholders and across regions and support effective feedback loops for research prioritisation.

5.5. Support to policy/decision-making

5.5.1. Connecting R&I to policy/decision-making

Sustainability issues require researchers to develop methodological tools to assess the impact of products and services on the environment, economics, and social parameters. Moreover, they must be clear and understandable to a broad public, notably policy makers. In addition, the conceptual and methodological choices made in order to analyse them should be explained clearly. In evaluating complex systems, uncertainty often arises and the quality of decision processes can be of great concern. Defining integrated approaches to assess

and compare sustainability of innovative agricultural practices requests a multidisciplinary, multi-methodological, and systemic approach.

Comparative research on different pathways can provide appropriate guidance in considering alternative future scenarios. This includes guidance on potential long-term effects of decisions.

5.5.2. Multi-criteria tools and methods for comparative research in support of policy decisions⁵

To provide information and guidance, which matches the information needs of policy/decision-makers, appropriate assessment tools and methods need to be used.

Indicator-based assessment tools have been designed for public policies, but also in order to assist different stakeholders at local and regional level in taking decisions. Indicators aim to measure agricultural intensification or sustainability, or both. There are biophysical, economic and social indicators. Assembling a set of indicators (index) offers ways of comparing situations and guiding decisions. It is important to define properties according to the way they may be fed and to state clearly that indicators make it possible to represent and analyse a specific phenomenon. Indicators are more important than the variables composing them and they help to build a simplified representation of reality. Indicators need to have a clear link to questions that they help answer to prevent that sets of indicators would lead to meaningless data collection.

In parallel to multi-criteria models, one of the most comprehensive environmental assessment methodologies is the Life Cycle Assessment (LCA) tools. It enables evaluation of the environmental impact of anthropogenic activities along a supply chain. LCA assessment tools can help to guide production methods, regulations, and are powerful tools to compare pathways identifying the critical parts of an agri-food chain.

Trade-off analysis has become an increasingly important approach for evaluating system level outcomes and for prioritizing and targeting management interventions in multifunctional agricultural landscapes. It is useful to address social, economic and environmental dimensions of sustainability for a given technology or solution. This does not solve, however, the fundamental challenge: trade-off analyses without substantial stakeholder engagement often have limited practical utility for informing practical decision-making. We suggest ways to integrate approaches and improve the potential for societal impact of future trade-off analyses. Meta-analysis combines the results of multiple scientific studies. The option of weighting the results of the individual studies, provide a flexible and efficient tools to build shared and comparative approaches of complex and controversial issues. Regarding the comparative analysis of intensification pathways, a meta-analysis may help to analyse production, environmental, and social practices, and may provide the other methods with parameters, averages, confidence intervals with associated probabilities that help strengthen the other comparative methods.

⁵ Fully detailed tools and methods can be accessed <http://www.intensafrica.org/blog/download/d2-4-research-and-innovation-agenda/>

Understanding the gaps between potential and actual farm yields (including animal production) can inspire and guide intervention with farmers, their organisations, input suppliers and public policies. A yield gap assessment that can be applied, upscaling from local to global, allows a quantified, prospective and comparative reflexion on public policies. Crop simulation modelling is the most reliable way to estimate the gaps, to capture variability and difference in intensification pathways.

Big data management. Digital technology is the new driver of growth in Africa. The challenge in the use of new information and communication technologies in agriculture is the ability for Africa to access and use the new ICT platforms now available to make science and technology information available to a wide range of end-users across the continent. The challenge facing digital infrastructure and agronomic research is the large volumes of very heterogeneous data.

In parallel with all these issues, coordinated and long-term observatories on the consequences of the different intensification pathways should be promoted. The PROIA case studies have highlighted examples of how to observe simultaneously biophysical and socio-economic issues and to what observations mean for intensification dynamics.

6. The partnership approach

A long term, large scale, bi-regional partnership must establish a mechanism to link policy formulation to projects implementation. This is also the way forward proposed in the HLPD-FNSSA Road Map. Building on this perception, a partnership approach is proposed for the long-term and a transition model for the short-term. The following chapter elaborates on these concepts.

6.1. Guideposts for establishing long-term, large-scale, and bi-continental partnerships

PROIntensAfrica analysed the effectiveness and success of Africa-EU partnerships. Its findings and recommendations are described in deliverables 4.2 and 5.2 (see www.IntensAfrica.org). It was found that partnerships take different forms:⁶ the AU as a group and the EU as group; a group of AU Member States or a region and the EU; the AU as a group and Member States of the EU acting bilaterally outside the EC; a group of AU Member States and a group of EU Member States; and a group of African institutions and a group of European institutions (not necessarily working through and/or with member states of the two Unions).

Some key factors were identified to specifically contribute to the success of bi-continental partnerships:

- The future of a partnership is contingent upon African and European participation and the countries honour their commitment to make voluntary financial contributions. To achieve this, it is important to strengthen the political engagement of countries in the governance structure.
- The legitimacy and ownership of the partnership must be clear and balanced. A major pitfall is that most of the research projects have been funded by, and have been largely dominated and controlled by, European institutions.
- The effectiveness of the partnerships and the level of outcomes are determined by the level of resources available. The ambitions must meet the level of committed resources.
- Roles and responsibilities of the various technical committees and the project leadership within the partnerships must be clear. Confusion and tension leads to ineffectivity.
- “Rules of the game” must be clear. An enforceable consortium agreement is necessary.

Based on these analyses, PROIntensAfrica recommends establishing the future “IntensAfrica Partnership” on five key features:

- *Flexibility*. The context in which the IntensAfrica Partnership will operate is constantly changing. New unanticipated economic and political changes taking place in Africa, EU and around the world will affect the intended outcomes of our partnership. Therefore, prudent governance that allows flexibility to anticipate and respond to changes is essential.

⁶ For a typology bi-regional partnerships and collaborations see EC (2014), *Mapping of Best Practice Regional and Multi-country Cooperative STI Initiatives between Africa and Europe*. European Commission, Brussels.

- *Inclusiveness*. The IntensAfrica Partnership initiative is set out against a background of other bi-regional initiatives that have sought to tackle common challenges between Africa and Europe. One of the issues raised repeatedly in the consultations is the importance of inclusivity. Many existing partnerships seem to be centred on limited stakeholder categories to the exclusion of others. For instance, the private sector, scientific groups and civil society do not always feature in these partnerships.
- *Accountability*. A mechanism for accountability needs to be built into the partnership structure and is considered key to ensure that resources invested can be accounted for at the right level. This will be greatly enhanced by the incorporation of a feedback loop, which will also enhance learning for maximum impact as expanded below.
- *Co-ownership*. The proposed long term partnership structure should be developed to support a sense of co-ownership of the partnership with all partners from both continents assuming the role of contributing to the decision making process and supporting the structures created for that purpose. This will ensure that the successes and failures in the partnership belong to all partners.
- *Differentiated capabilities*. Partners are likely to be at different levels in various respects, including the resource levels available, to give effect to the partnership. One key consideration is to build a partnership model to ensure the recognition of different types of contributions including non-monetary or in-kind contributions.

6.2. A vision for the future

The aims of the IntensAfrica Partnership will persist in the future regardless of the type of funding tool available. Making true advances in the FNSSA landscape requires working in a new, more coherent and more ambitious way. All of the evidence provided by the PROIA project activities and the results of the scientific reviews conducted are quite clear: impact calls for joint funding, aligned strategic research initiatives, balanced ownership, and good governance. In addition, learning for impact should be a guiding principle. This can be done within the current funding context but may also ask for new funding instruments that meet the needs outlined above.

Table 2 summarizes the European instruments currently developed for alignment of research and innovation. Some instruments are also used for alignment with African countries, while others may offer interesting options for the future.

Table 2 EC Instruments developed for aligning national research and innovation activities.

Instrument	Characteristics	Participation	
		EU	AU
ERA-Net / Cofund	Joint calls	+	+
Joint Programming Initiative	Alignment of programmes at national level, incl. joint calls	+	-
Article 185	Joint vision, joint management and joint calls	+	+
European Joint Programme Cofund	Implementing a joint programme of activities	+	-

The objectives of the Joint Programming Initiative (JPI) instrument are to develop a joint vision, a joint strategy and joint activities to align research and innovation around specific societal challenges. These largely coincide with the objectives of the IntensAfrica Partnership.

While the JPI instrument is currently largely European based, it currently reaches out to other continents as well, and served as a source of inspiration for an envisaged long-term IntensAfrica Partnership. Of interest may also be the European Joint Programme Cofund (EJP Cofund), a new funding instrument developed under H2020 and currently being explored. It is relevant to note that the EJP Cofund instrument enables the participation of both programme managers and programme owners, and may well serve the needs of the future partnership.

Another emerging mechanism for alignment in programming and funding research and innovation is the so-called International Research Consortium (IRC) instrument like STAR-IDAZ, which is an IRC on Animal Health. The consortium includes public research funders and programme owners as well as companies and international organisations. The partners agreed to coordinate their research programmes to address agreed research needs, share results and deliver new health strategies for priority diseases.

Taking advantage of the JPI experiences and the EJP Cofund and IRC concepts, taking into account the specific environment of FNSSA, and building on the features described in the former paragraph, the IntensAfrica Partnership is proposed to be organized as summarized in Figure 8. A Governing Board forms the core of the partnership with representatives of countries and institutions with a mandate for programming and/or funding research and inno-

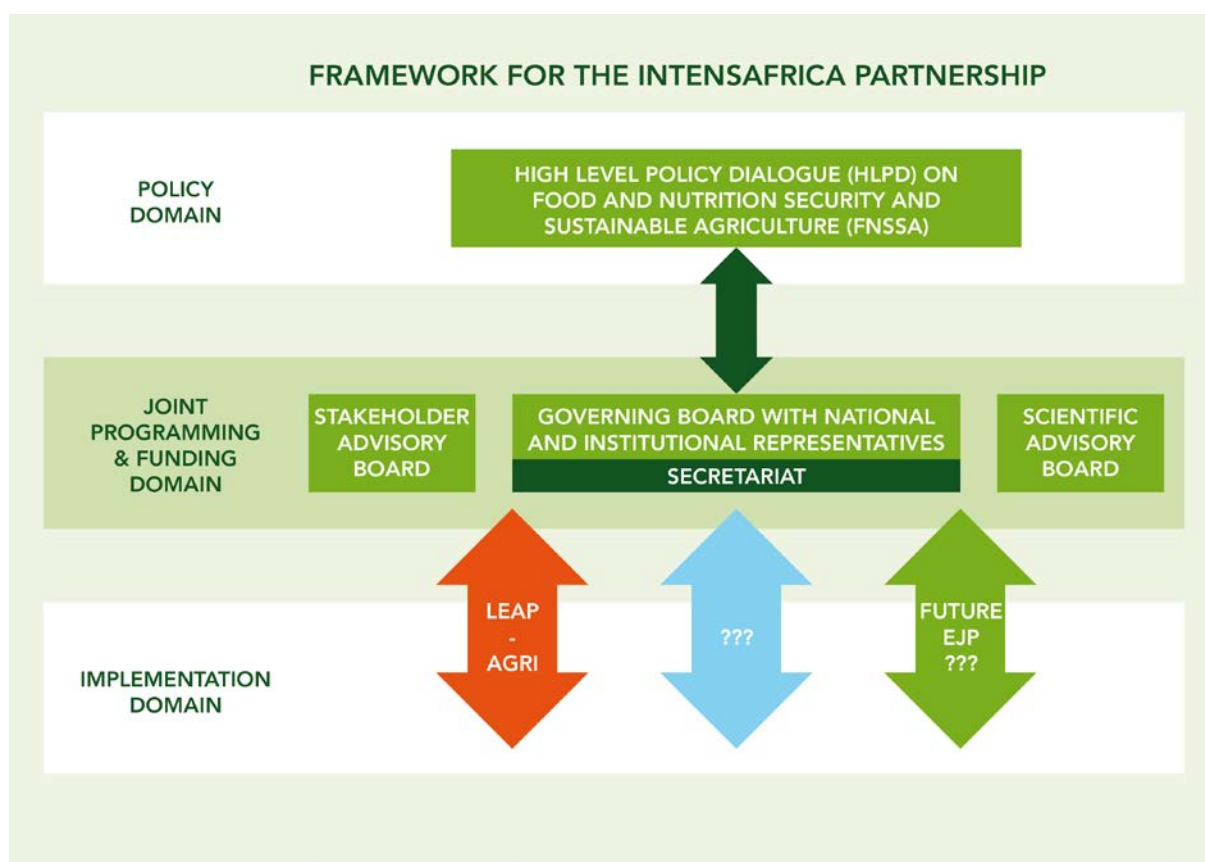


Figure 8 Conceptual frame of the IntensAfrica partnership

vation in the FNSSA domain. This Board can build on already existing structures like those developed in LEAP-Agri. The Board will be supervised by the HLPD-FNSSA WG, and as such, assists the HLPD-FNSSA WG in implementing their road map. A Stakeholder Advisory Board and a Scientific Advisory Board, bringing stakeholders and scientific organizations on board, will advise the board. The Scientific Advisory Board can easily build on the PROIA consortium, as this consortium was engaged in developing a research agenda directly related to the domains of the road map. A rich pallet of instruments like, for example, LEAP-Agri projects can be developed and implemented to realize the vision and strategy. A “lean-and-mean” secretariat is needed to facilitate the partnership.

A mechanism as proposed above builds on existing structures and proven experiences. It is flexible as it allows parties to join the Partnership at all times and can opt for a variety of implementation instruments. The mechanism is inclusive, as stakeholders and research organization are linked in Advisory Boards. Accountability will be one of the key-responsibilities of the governing board, and often will be a prerequisite for implementation instruments. It will force all parties to value impact as one of the major drivers of each instrument. It will also stimulate parties to collaborate and align, as this is a prerequisite to reach impact. Considering a bi-continental partnership, all bodies obviously need to have a balanced composition, ensuring co-ownership. Lastly, a variety of implementation instruments will allow different parties to participate in those that fit them best.

6.3. The transition phase

The mandate of the HLPD FNSSA Working Group (FNSSA-WG) is large and demanding, while its members are appointed on a part time basis and without significant funding. This Steering Committee will therefore need to receive the support of willing institutions, having relevant knowledge and sharing the objective of the long-term EU-Africa FNSSA partnership. It is in response to this situation that, considering that the expertise of PROIA could be useful to the FNSSA WG of the HLPD in a transitional phase until the a more permanent mechanism is in place, that a support group of informed, willing and resourceful institutions is proposed: the Institutions Support Group (ISG). The ISG model is an adaptation of the concept of the Global Research Alliance on Agricultural Greenhouse Gases (GRA).

This ISG would take advantage of existing resources of the PROIA partnership, while remaining open to other supportive institutions. Its strength lies in the commitment to a science-based approach and the fact that the African and European partners are well positioned to work in the interface between policy and implementation. As the first form of an IntensAfrica Partnership, this ISG would serve three functions: as advisors in matters of research and innovation for FNSSA to the WG of the HLPD, as interface between the HLPD bureau, the HLPD FNSSA-WG and the various projects implemented in the FNSSA domain, and as facilitators of the multi-stakeholder dialogue required for the implementation of the HLPD Road Map. The ISG will provide insights on research and implementation and can tap from their large IntensAfrica network that is dynamic and open and grows as new research questions arise.

The first focus of the ISG is on pillar 1 of the HLPD Road Map: the sustainable intensification of agriculture in Africa. However, the ISG can also inform and support the other two pillars of the Road Map, Nutrition and Trade, welcoming the consortia addressing these topics to join.

By acting as such, the ISG will assist the HLPD FNSSA WG achieving their goals while at the same time contribute to building the future partnership as explained above. It will effectively act as an advisory board that can easily be transformed to a body fitting the proposed long-term partnership model.

A number of the IntensAfrica consortium partners of the ISG are involved in the additional actions programmed in the LEAP-Agri project. In particular, the outcomes of the various aspects of the Strategic R&I Partnership will be further developed in WP6 of the LEAP-Agri work plan.

And last but not least, the ISG will explore on a permanent basis new emerging opportunities for the various partners and stakeholders to deepen existing and extend cooperation to new partners to tackle the main challenges related to FNSSA in Europe and Africa.

The FNSSA WG of HLPD, should they accept the service of this transitional ISG, would benefit in a number of ways:

- The strategic research agenda as proposed by PROIntensAfrica is based on extensive literature review completed by in-the-field analyses of case studies of various pathways towards intensification of agriculture.
- The new knowledge is generated through the tangible cooperation of researchers and farmers addressing specific farming problems.
- The pathway approach proposed provides a lens that could aid the FNSSA WG to understand the current intensification of African agriculture landscape. This deeper landscape understanding comes from the feedback component of the agenda; new knowledge from problems solved by farmers and researchers together is fed into new approaches toward identifying and solving other key problems.
- Working with the ISG will also facilitate collective actions with stakeholders, learning and innovating together and transforming agricultural knowledge into impacts. This is based on a bottom-up feedback system that will directly engage the intended beneficiaries, as detailed in deliverable 7.3 of the PROIntensAfrica project. This feedback mechanism is expected to provide opportunities for stakeholders to participate in problem identification, prioritization and program evaluations. It will support learning for impact that is considered key in any effective partnership.

7. Research and Innovation for Sustainable Development

The current report summarizes two years of exploration by PROIntensAfrica of options to establish a long-term research and innovation partnership in support of sustainable intensification in agri-food systems. The report reflects on the content as well as on the partnership approach that jointly serve a common objective: sustainable development. The activities need to contribute the sustainable development goals in general, and to those pertaining to food and nutrition security, livelihoods, and the natural environment in particular.

Many sustainable development goals calls for transformations, and research and innovation can kick-start this transformation. That does, however, require that R&I connects seamlessly to policy and wider decision making at all relevant levels, including at farm-level. It requires a long-term endeavour and matching commitments. Engaging in such long-term collaborative effort has more advantages than the prospect of generating good outputs and outcomes. It will also entail a number of shifts from constraining conditions to enabling conditions:

- from fragmented research and innovation to concerted and coordinated efforts between R&I institutions in Europe and Africa;
- from ad-hoc partnerships to long-term partnerships which can build up momentum and synergy;
- from isolated resources which are invested by donors and funding agencies, to pooled resources which make more possible and enhance resource use efficiency;
- from sustainable intensification pathways as conflicting and competing approaches, to a capitalising on the full potential of a diversity of pathways which enhances resilience of agri-food systems;
- from a one-size-fits-all approach to sustainable intensification, to contextual analysis and tailor-making of transition pathways;
- from methodological innovations in R&I as a marginal phenomenon to the mainstreaming of systems, interdisciplinary, and multi-stakeholder approaches.



Over the past two years, the IntensAfrica consortium has laid a foundation for this collaborative effort by developing good relationships between knowledge institutions in Europe and Africa and between the research and the policy domain. The consortium explored options regarding the R&I agenda, partnership setup, and performance assessment. The consortium did so with a deep commitment, a commitment they plan to continue even beyond the timespan of the PROIntensAfrica projects. It shows their joint dedication to contribute to the sustainable developing goals.

The next steps will involve further development of concrete plans and procedures. The IntensAfrica consortium is looking forward to take these steps together with both potential funders and partners, including in particular those from the private sector and civil society.

PROIntensAfrica
Towards a long-term Africa-EU partnership to raise sustainable
food and nutrition security in Africa

