CHAPTER 5

Education Driving Agriculture-Led Economic and Social Transformation in Africa

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Introduction and Background

Africa Today

Currently, there are 1.2 billion people in Africa, more than five times the population in 1950. By 2050, Africa's population will double to 2.4 billion, eventually reaching 4.2 billion by the end of the century—equal to about the entire world population of 1977 (UNICEF 2015).

Africa is also the world's most food insecure continent, with relatively low levels of agricultural productivity, low rural incomes, high rates of malnutrition, and a significantly declining food trade balance. In 2019 there

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were 422 million people in the sub-Saharan African region who were living in extreme poverty and surviving on less than US$1.90 per day (Hamel et al. 2019)—a surge from the 1990 figure of 290 million (Munang 2013).

Ironically, Africa has sufficient land, water, and human resources to contribute significantly to the world's food balance sheet. The continent has the potential to provide for the growing global demand for both food staples and higher value-added food, as well as to energy markets. Agriculture and the food sector also present significant opportunities for employment and wealth creation. Much of Africa's impressive economic growth has come from metals, minerals, and energy, with little impact on employment and improvement in the living conditions of the rural majority and poor urban dwellers, most of whom migrate from rural areas in search of better opportunities. Yet, agriculture and the food industry offer the prospect of rapidly increasing employment and incomes for the majority of the population (Jayne et al. 2017).

The critical role of agriculture in fostering sustained competitiveness and profitability in the face of a rapidly transforming world knowledge and network economy is acknowledged both within the scientific community and in governments at large (World Economic Forum 2013). In the past two decades, African governments and leaders have begun a number of regional and continental initiatives to facilitate and accelerate the much needed agricultural and rural transformation. Since 2003, under the Comprehensive Africa Agriculture Development Programme (CAADP 2003), many governments have increased their budgetary allocations to agriculture. Despite these changes, government agricultural expenditure (an average 3 percent of total public expenditure in the period 2008–2017) remained below the CAADP 10 percent target (Makombe et al. 2018). By 2018, only 13 member states had met or surpassed their CAADP target of 10 percent public expenditure on agriculture (AGRF 2018). According to the World Bank, average agricultural growth rates across the continent have exceeded 3 percent since 2003—with the exception of 2011 (World Bank 2018).

The Year of Agriculture, Food and Nutrition Security (2014) was a landmark year for African agriculture. It was the 11th year since the Maputo Declaration on Agriculture and Food Security, and the year in which the Malabo Declaration on Accelerated Agricultural Growth and Transformation for Shared Prosperity and Improved Livelihoods was adopted to realize the continent's agricultural transformation by 2025 (AUC 2014a). No less significantly, 2014 was also the year in which the

Science, Technology and Innovation Strategy for Africa 2024 (AUC 2014b)—accepted by Heads of State and government to replace the 2005 Consolidated Plan of Action (CPA) (AUC and NEPAD 2005)—prioritized food and nutrition security and the eradication of hunger as one of six focus areas. In the international arena, food security and the eradication of poverty remain high-priority areas, confirmed by the announcement of the Sustainable Development Goals (SDGs), particularly Goal 1 (No Poverty) and Goal 2 (Zero Hunger) (UN 2015). In addition, 2015 was the Year of Women's Empowerment—announced by the African Union at its 25th Summit, with a clear call to action for the inclusion of African women in agriculture and agribusiness (AWARD 2015).

The Role of Agricultural Innovation Systems in Driving Transformation

Under auspices of the African Union's Agenda 2063, "The Africa We Want" (AUC 2015), political support for African agricultural development, and the role therein of science, technology, and innovation (STI), has reached an apex (AUC 2015). Full advantage, therefore, must be taken of this concentration of high-level political will, and of the effort and energy within the agriculture and STI sectors, for maximum impact across all levels of society and across the entire agricultural innovation system (AIS), but most especially at the level of smallholder farmer and rural communities.

African solidarity around science may potentially be the most significant strategy for achieving this vision. The current nature and pace of change confronting African agricultural research and development (R&D) are unprecedented in the history of organized research and development. Issues of AIS, R&D, or STI are central to the commitment of African leaders to an agriculture-led social and economic transformation of Africa.[1]

Without question, agriculture and capacity strengthening are now back on the development agenda as Africa positions to achieve the SDGs. The seven Malabo Declaration targets contain two critical targets directly related to agriculture: to eliminate hunger and food insecurity, and to halve poverty through inclusive agricultural growth, with both targets to

[1] In this chapter, AIS, R&D, and STI are used interchangeably to mean, more or less, the same idea of driving scientific and institutional inventions to commercial and social success.

be reached by 2025. The Malabo Declaration targets are ambitious, and achieving them requires a massive leveraging of STI or AIS (AUC 2014a).

Carl Eicher's paper, "The Evolution of Agricultural Education and Training (AET)" was part of the World Bank's study of agricultural education and training in sub-Saharan Africa (Eicher 2006). In its 2007 report on "Cultivating Knowledge and Skills to Grow African Agriculture," the World Bank described an AIS as "a blending of institutional capacities, coordination mechanisms, communication networks, and policy incentives that fosters innovation-led gains in agricultural productivity" (World Bank 2007a, xiv). More recent work refers to the AIS as a "web" (Annor-Frempong and Jones 2014, 67). Science can and should drive transformation of agriculture and society in Africa, as a critical part of this "web."

Poorly integrated agricultural innovation systems are, however, a major drawback for African agriculture. In general, the research, extension, education, and training services are poorly integrated and do not effectively reach farmers and entrepreneurs. The extension system in Africa, particularly, has historically been regarded as the weakest link (Davis 2008).

In June 2014, the African Union (AU) summit in Malabo adopted the Science Agenda for Agriculture in Africa (S3A), as central to implementing the CAADP Results Framework and priorities, outlined in "Sustaining CAADP Momentum" (CAADP 2013). The rationale for the S3A is the imperative of having an overarching strategic framework to guide the broad areas of science that must be developed by African countries, their stakeholders, and partnerships. The S3A focus on the necessary transformation of national science and technology institutions within the AIS in order to achieve the desired social and economic transformation of Africa. The S3A refers to the science, technology, extension, innovations, policy, and social learning that Africa needs to apply to meet its evolving agricultural development goals.

Within the AIS, key stakeholders on issues of STI have developed strong networks and partnership on the S3A, including the African Union Commission (AUC); New Economic Partnership for African Development (NEPAD); the Alliance for Green Revolution in Africa (AGRA); the African Agriculture Technology Foundation (AATF); the African Forum for Agricultural Advisory Services (AFAAS); the main education networks, Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) and the African Network for Agriculture, Agroforestry and Natural Resources Education (ANAFE); the Pan African Farmers' Organisation (PAFO); and agribusiness networks. At the subregional

level, the stakeholders include the Regional Economic Communities and the subregional agricultural research organizations (SROs). At the national level, the stakeholders include the Ministry of Agriculture and the National Agricultural Research Systems (NARS), comprised of actors engaged in research, extension, education, production, and agribusiness. At the international level, partnerships include the Global Forum for Agricultural Research (GFAR), CGIAR Centers, other advanced agricultural research organizations, and key multilateral organizations, notably the European Commission, the World Bank, and the Food and Agricultural Organization of the United Nations (FAO). These partnerships are integral components for strengthening the AIS in Africa toward transformation.

This revitalization of African agriculture requires an integrated AIS that produces innovations (technical, managerial, organizational, institutional, and service delivery) in a continuous and sustainable manner. Innovation is the key capacity for the generation, acquisition, and application of knowledge for the purposes of economic and social advancement. It includes both the search for technologies at the frontier of science, driven by R&D, as well as forms of learning and adaptation that might be market-led or socially driven. Innovation is highly contextual and path dependent, but it is at the heart of moving the continent from its present mix of resource-driven and efficiency-driven economic activity to one that is propelled by the generation and application of knowledge. Implicit is the distinction between "invention" (solution to a problem, largely the outputs of research) and "innovation" (the economically successful invention). In the context of agricultural research, innovation in its broadest sense covers the activities and processes associated with the generation, dissemination, adaptation, and utilization of technology and knowledge. This also emphasizes the notion that the responsibility of the research organizations does not end with the production of new knowledge or technology. Success can only be claimed when inventions are being disseminated, adapted, adopted, and used (Chema et al. 2003; Anandajayasekeram 2011). Only when knowledge is converted into products and processes and used by society in an economically meaningful way, can it be termed innovative (Carsan et al. 2014).

Research is integral to innovation and must be positioned at the forefront. Closely linked to research are education and training, which serve as key components for building the requisite skills to drive research and innovation. This idea of building more effective agricultural innovation systems has taken root in capacity building efforts for African R&D institutions, especially at the national level.

A Harmonized Roadmap for Agricultural Education and Training Toward a Transformed AIS

In CAADP's 10-year review and subsequent forward planning, Africa's capacity to generate knowledge, foster learning, and enable skills development among its workforce is recognized as a game changer in the context of the rally to fundamentally reshape African agriculture, and thus, food security on the continent (NEPAD 2013). Within this broad context, "Sustaining the CAADP Momentum" called for a roadmap to serve as an overarching continental-level framework, with a realistic and achievable concomitant strategic plan, to effectively address the core problem of human capacity deficit within the AIS (CAADP 2013). This roadmap, known as the Agricultural Education and Skills Improvement Framework (AESIF), serves as a vision and agenda (Swanepoel and Stroebel 2014), intended to both power and empower agricultural technical and vocational education and training (ATVET), as well as tertiary agricultural education (TAE) in the period 2015–2025. The emergence of AESIF was timely and, given the global and regional demographic, political, and economic conditions, its urgency is ever more pronounced.

AESIF is as much an exercise in advocating for *innovative thinking,* as it is a *call for grounding*, *a search for complementarity*, and an *effort at consolidation*. The idea that Africa act in a smart and unified fashion cannot be overstated: AESIF begins by reiterating how intelligent load-sharing and an integrated approach between the different strategic and policy frameworks, implementers, and financing catalysts will undergird its success and impact over the coming decade.

To achieve this harmonization of the continental agenda, NEPAD has been delivering AESIF through the joint work plan of the Tertiary Education for Agriculture Mechanism in Africa (TEAM–Africa) and ATVET, to be in a position to mainstream AESIF in all related NEPAD and continental capacity-building objectives, which align with CAADP and its new Results Framework, moving forward. Contextualized together, the discussions here clearly demonstrate the invaluable role that education and training (at all skill levels) plays in driving agriculture-led social and economic transformation on the continent. Furthermore, this is also confirmed by an analysis of international evidence, as discussed in the next section.

International Evidence to Inform African AET

International evidence confirms the critical role of AET in agricultural development. There is now a wealth of information supporting and advocating the importance of higher education for accelerated development and transformation in Africa (World Bank and UNESCO 2000; AUC 2006; Kellogg et al. 2008; World Bank 2007b). Yet, according to Swanepoel, Stroebel, and Ofir (2014c), though vital to development, AET has been much neglected in agricultural strategies and action plans in many SSA countries.

The situation, however, is improving, reinforced by, among others, the African Ministerial Conference on Higher Education in Africa (CHEA), hosted in November 2010 by the Government of Uganda and the Regional Universities Forum for Capacity Building in Agriculture (RUFORUM). This seminal meeting "confirmed the African governments' commitment to a 'renewed and vigorous emphasis' on restoring the quality of higher education in agriculture and to increased investment in agricultural education, as part of CAADP Country Compacts and Medium Term Agricultural Productivity Programmes (CAADP 2013)" (Swanepoel et al. 2014c, 11).

AET has been an integral part of national strategies in countries that have developed their agricultural sectors successfully, such as India, Brazil, Malaysia, Chile, and the Philippines (Staatz and Dembélé 2007). These countries have achieved notable successes in establishing productive and financially sustainable AET systems through consistently high levels of investment in AET, both by the countries themselves and by their development partners.

The World Bank (2007a) review identified a set of critical contributing factors for building productive AET systems. These factors include: (1) mobilizing and sustaining political support for AET investments; (2) supporting public investment in capacity building to create the scientific leadership needed to implement the agricultural and rural development strategies; (3) building a system of core AET institutes that make sustained commitments over multiple generations to produce returns; (4) undertaking massive campaigns to develop human capital; (5) establishing closer links between research and higher education institutions and recognizing that the administrative separation of research and higher education in many African countries has inhibited the development of national agricultural innovation systems; and (6) creating incentives to retain the well-qualified and experienced staff in research, extension, and educational institutions. By way of illustration, AET's contributions to agricultural development in selected countries are summarized in Table 5.1.

Table 5.1 International examples of AET contributions to agricultural development

Country	*Key AET investments*	*Results*
Vietnam	In 2001, the government committed to spending 6.9% of GDP on education. Aims to grow participation in the higher education system four times by 2020. Vocational education is a major area for future investment; the aim is to train 40% of workforce (includes extension agents).	Rapid, agriculture-led economic growth and substantial poverty reduction. Tertiary growth: from 120 to 224 institutions in 10 years. Significant tertiary enrollment growth, from 160,000 to 1.5 million in 15 years, with 30% currently in vocational programs.
Malaysia	Massive human capacity-building program; sent thousands of researchers to US universities for postgraduate training.	Developed from a low-income to a middle-income country. Established booming export industry: $6.4 billion palm oil/year.
India	Established state agricultural university (SAU) system (to be built over 40 years). Human capital investment to educate thousands of researchers, with focus on postgraduate education.	Substantial and sustained reductions in rural poverty. Agricultural increases: high adoption rates, with crop yield increase of 1.6% / year for 30 years to 60 million tons grain surplus. Built strong national AET network: 41 SAUs.
Japan	Investment strategy began with explicit focus on building education system first. Invested heavily in developing indigenous education systems focused on smallholder farmers.	Leveraged an agriculture-led development strategy that contributed to its becoming one of the world's wealthiest countries. System of technical colleges with strong links to smallholder farmers.
United States	Supplied permanent funding to build a decentralized, applied, and sophisticated AET system: 60 land grant universities (built over 60 years).	Created one of the most complex but efficient agriculture sectors in the world, including the effective and globally recognized land grant model.

(*continued*)

Table 5.1 (continued)

Country	*Key AET investments*	*Results*
Brazil	Built a cohort of specialized researchers through significantly increasing the number of academic staff with advanced degrees. The national research entity (EMBRAPA spent 20% of its budget from 1974 to 1984 to train Brazilian researchers at masters and doctoral levels. An incentive structure for Brazilian scientists is designed to keep the best scientists at home and thereby prevent the brain drain. EMBRAPA also focused on developing commodities for export.	Moved from a low-income to middle-income country and established a successful export industry (e.g., in the meat and maize markets). Developed one of the most efficient and sophisticated agricultural sectors in the world, recognized for producing adequate amount of affordable food. Has more than 5000 full-time equivalent researchers and its total research expenditure accounts for about half of the total agricultural research spending in Latin America.

Source: Eicher (2006); Staatz and Dembélé (2007); Swanepoel, Stroebel, and Ofir (2014c); Lele et al. (2012)

The analysis of the examples in the table identifies the following strategic points for countries seeking to drive development through agricultural education:

- *Direct investment at country level.* Patterns across Asia and Latin America confirm that AET (and broader agricultural development) require strong country-level institutions.
- *Pro-smallholder farmer (SHF) agricultural development as a national priority.* Without sustained commitment of national governments to continuously improve and invest in the agriculture sector, donor projects are likely to fail. In addition, development literature clearly shows that agricultural growth will not help SHFs in the absence of appropriate policy environments and supportive institutions.
- *Expansion of existing and creation of new programs.* It is important to prioritize postgraduate training to invigorate research and support national agricultural development. This is evidenced by the support of Rockefeller/United States Agency for International Development (USAID, where PhD graduates in agriculture from China have

played a central role in transforming AET development in their country. Recent innovations show the potential of new approaches to rapidly upgrade AET, as illustrated by China's open university system, which serves over one million students per year.

- *Improve quality and ensure alignment with SHFs' needs.* Curricular reform efforts have successfully improved linkages with agribusiness, SHFs, natural resource management, and practical skills, exemplified by, inter alia, Escuela de Agricultura de la Region Tropical Humeda (EARTH) University in Costa Rica.
- *Ensure pro-SHF decision systems.* Agricultural development literature shows that the AET systems most beneficial to SHFs have actively incorporated their needs and aspirations throughout. This is particularly well illustrated by the land grant model in Japan and the success in building the SAU system in India. The Vietnamese agricultural extension system also directly engaged SHFs in the entire process and emphasized the potential role of farmer organizations and local NGOs in developing pro-SHF systems.
- *Improve agricultural innovation systems (AIS).* Development literature indicates that the most effective pro-SHF systems closely link education and training, research, and extension at national and provincial levels. This is also supported by the 2007 World Bank review, as noted earlier, which emphasized the importance of integrated agricultural innovation systems to ensure productivity gains for SHFs (World Bank 2007a). There is some evidence in SSA that land grant-style institutional structures, where AET is closely linked to research and extension, are more successful. Notable examples include the earlier Nigeria land grant initiative, and more recently the Kenyan approach including bold steps to change the organisational structures and the missions the missions of Kenya Agricultural Research Institute (KARI) to become the Kenya Agriculture and Livestock Research Organisation (KALRO) with a broader mandate to make policy, establish research priorities and oversee research centres. The goal is that KALRO's new structure will enable it to administer Kenya's agricultural research and make needed linkages with education and training (ASSAf 2017).
- *Strengthening the funding base.* In Asia, the success achieved through significant investment in agricultural R&D and AET emphasizes the necessity for sustained public funding for AET to achieve impact.

Development partners have been able to leverage strategic follow-up investments across agricultural innovation systems through partnerships and in collaboration with committed national governments.

- *Decentralization of decision-making.* Land grant-style institutional structures have been critical for and highly successful in AET transformation and agricultural development impact in the United States, Japan, and India. The main reason for these successes is that the models in these countries have been demand-driven—and thus, have developed "from scratch."

Challenges and Constraints in the African AET System

As noted earlier, the sub-Saharan AET system has been largely neglected for at least three decades. With some exceptions, it remains inadequately prepared to address the enormous task resulting from the recognition of AET's critical role in development on the continent. Some of the primary challenges are the lack of staff with PhDs, the aging academic workforce, and the limited number of researchers. The most significant challenges facing the system are summarized in Table 5.2.

Recognizing the high levels of political support for African agricultural development, and the role therein of STI, it is a fortuitous time to concentrate efforts and energy in an intentional manner to overcome these challenges.

Toward Transformative Change in African AET

African leaders in business and science are seeking fresh and bold steps that can move agriculture forward toward its full potential on the continent. Political support and resources have been promised, and important coordinating mechanisms for action have been launched (as noted in the introduction to this chapter).

The need for transformative change for success in the AET system is also recognized by strategic initiatives and prominent voices from within and outside Africa (Swanepoel et al. 2014b). This needed transformation can be achieved both through grand plans, as well as incremental change, as long as key levers or potential tipping points are identified, and interventions are structured around such interventions.

Table 5.2 Challenges to the AET system

Misalignment between demographics of graduates and SHF population	Women represent 70–80% of farmers, with limited numbers of women AET students and agricultural workers (e.g., only 10% of extension workforce in Mozambique is female). Students tend to come from urban backgrounds; the few from rural areas are not interested in returning to the rural areas; government and NGOs find it difficult to employ staff (researchers and extension agents) prepared to move or return to rural areas. Employers find it difficult to employ staff who speaks the local languages required to communicate effectively with smallholder farmers.
Misalignment between type of training provided and skills needed in the workforce	Students lack opportunity to develop technical competencies prior to seeking employment and require additional training before taking on their assignments. Employers identify gaps in communication skills, business management and planning, postharvest processing, and marketing. Curriculum and teaching methods include little practical training due to lecturers without appropriate skills, outdated course material, poor facilities (particularly, for research), and a shortage of high quality research projects to engage postgraduate students.
Misalignment between level of training provided and sector needs	Lack of Africa-based postgraduate programs coupled with a reduction in number of scholarships for pursuing training abroad has led to fewer MScs and PhDs. Too few high-level technicians trained for productive work in the agricultural sector. Lack of mobility and articulation within the AET sector, inadequate exit levels into the sector.
AET isolated from research and extension	Administrative separation of agricultural research and higher education into two different ministries has hindered development of an effective innovation system and feedback loop from research to education. AET institutions fail to respond to the need for problem-solvers, facilitators, and practically oriented graduates for extension services. Land grant-style institutional structures have been most beneficial in actively incorporating the needs of SHFs in the agricultural innovation system, e.g., in Japan and India

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Table 5.2 (continued)

Poor feedback mechanisms	Students in AET institutions are rarely directly exposed to SHFs and are engaged primarily in theoretical rather than practical training. Information about labor market needs in agricultural employment is scarce; few AET institutions have tracer studies to understand how their graduates have done in the workplace.
Limited leadership	Immigration has led to an exodus of senior academics (an estimated 30% of all professionals trained in African universities live outside the continent). Overstretched, underpaid lecturers often need to spend more time consulting to augment income than supporting research and postgraduate education. Many academics are nearing retirement age.
Inefficient allocation of scarce resources	AET institutions have proliferated across the continent in Cameroon, five in Ghana). There appear to be opportunities for consolidating some of these investments, and for developing a focus on more cost-effective, integrated approaches.

Source: Vandenbosch (2006); World Bank (2007a); Swanepoel and Stroebel (2012); Swanepoel, Stroebel, and Ofir (2014c)

Many mechanisms have been proposed to achieve this transformation, with various forms of horizontal linkages across the AIS system (see Birner and Spielman (2007) for an in-depth discussion). Capacity-strengthening initiatives (including primary, secondary, vocational, postsecondary and extension education) are at the center of most of these mechanisms, reinforcing the importance of AET within the system. Due to the nature of its strategic position within the larger system, transformative change in AET will, in turn, ripple across the AIS, potentially impacting positively on actors across the value chain—including input suppliers, producers, processors, wholesalers, retailers, and consumers. Potential benefits in the private and public agricultural research systems are also expected as a result of transformative change in AET, as are positive impacts on policy. Together, these changes and ripples contribute to further positive benefits within the broader social, political, technological, and economic systems (Birner and Spielman 2007). In the context of both the status quo of agriculture across Africa and the potential contribution the sector can make to sustainability, development, and in particular, food security, such changes are urgently needed.

As a basis from which to argue for transformative change, it is necessary to understand what is meant by this concept. "Transformative change" is seen as profound, fundamental, and irreversible. It is based on breakthroughs; fundamental shifts in individual, group, institutional, or societal values; and perspectives. Such shifts involve changes in viewpoint, vision, paradigm, life purpose, organizational direction, or sociopolitical reforms, which in turn seed fundamental shifts in behavior or performance. These shifts result in regenerative moments and lead to radical redirections of efforts across a system (Hannum et al. 2007). Transformative change is always more profound in consequence than developmental or episodic change. It tends toward the multidisciplinary and holistic, integrating a range of strategies that focus on peoples' beliefs, values, and attitudes.

Although often unexpected, transformative change can be intentionally planned for or activated. In other words, a system can be transformed over time through a series of incremental changes; transformation may also come about as the result of a shock or strong pressure on the system. The transformation process can be accelerated by understanding what might be "transformative" and by seeking to promote interventions that have a good chance of bringing about fundamental change (Ofir, Swanepoel, and Stroebel 2014).

In seeking to activate transformative change, it is necessary to consider the balance between drivers or enablers (catalysts of change) of existing strengths in the AET system, and drivers of vulnerabilities and constraints that act as impediments to change (Fig. 5.1). Significant or transformative change may come about if the combined effect of the positive influences is more powerful and effective than the vulnerabilities and constraints in the system. If change is to happen, these two types of forces on and within the system should not be in equilibrium. Just a few strategic interventions over time may overcome the constraining forces. This is why it is important to try to recognize which interventions might be transformative for the whole system.

An understanding of what could shift the balance in critical parts of the AET system will help determine the strategies needed to bring about the desired transformative change. The challenge is to identify those factors and interventions likely to be most pivotal for this purpose and those that might be poised to result in tipping points leading to transformation. The interventions have to be combined and sequenced well for best effect and to prevent disequilibrium. If the process is not properly managed, the whole system might become ineffective or even disintegrate.

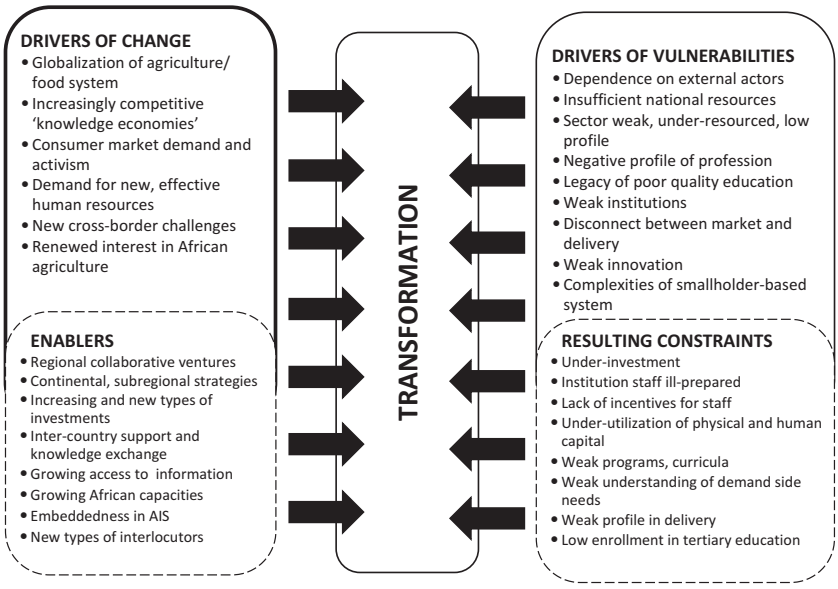

Fig. 5.1 Critical forces and influences that affect the potential for transformation in the AET system. (Source: Authors' construction based on Swanepoel, Ofir, and Stroebel (2014a, Fig. 17.2, 466))

In addition, leaders should be in a position to predict, at least to some extent, the intended and unintended effects of planned interventions—both positive and negative—and ensure that capacities are in place to make fast adjustments as needed. Trajectories toward transformation are hardly predictable, but informed leaders in each institution or set of institutions, country, and subregion can establish, at the very least, enabling conditions to improve the chances of success and develop an AET strategy, which emphasizes those interventions likely to make the most effective and sustainable changes.

Context most certainly plays an important role in this process. There is thus a need for "best-fit" solutions, that is, tailor-made for a specific set of circumstances and able to evolve as the context evolves. Thus, the actual design and implementation need to be managed by leaders at all levels of the system—leaders who truly understand the context within which the changes are to take place and who are committed to working toward success over time—and where necessary, in collaboration with one another.

Experiences in China have shown, for example, that significant progress toward transformation in agriculture can be achieved through a series of purposeful, yet incremental steps, taken with consistency of purpose and investment in traditional systems (Xiaoyun et al. 2016). The Chinese experience showed that putting smallholder farmers' needs at the center of policies and plans is crucial, and that smallholder and large-scale agriculture can exist side by side with mutual benefit. The Chinese developed context-based strategies and facilitated transformation toward a market system by ensuring that critical inputs and services could be accessed in an economical manner. They also enabled gradual market reform to protect smallholders from a "market trap."

Many lessons can be drawn from country examples with regard to achieving transformative change—but should be contextualized in an African framework to ensure relevance and promote ownership of Africa-driven solutions for African problems.

Roadmap Toward Transformative Change in National AET Systems

Despite the contextual diversity, there are many common drivers of vulnerabilities and drivers for change, as well as enabling and constraining factors in the African AIS. With this commonality in mind, it is possible to start constructing an "ideal" roadmap that can serve as a broad indication of which routes might lead to change (Fig. 5.2). The creation of this roadmap has been informed by Eicher (2006); Pal and Byerlee (2006); Stroebel, Swanepoel, and Eicher (2011); and Swanepoel, Stroebel, and Ofir (2014c).

The proposed roadmap is not intended as a blueprint. It is general by design, intended to be part of a process of rethinking, reframing, and reshaping structures and ideas toward the goal of radical transformation of the AET system within the framework established by the AIS. In particular, it emphasizes the interests, concerns, and needs of smallholder farmers.

Emerging from this ideal roadmap, four critical areas for investigation and investment emerge (Fig. 5.3), namely: preconditions and a supportive environment, relevant institutions and adequate resources, appropriately trained graduates, and strong effective partnerships and networks for impact as indicated in Fig. 5.3. Areas in need of future attention are proposed in the framework and discussed next based on the gaps identified in this ideal system.

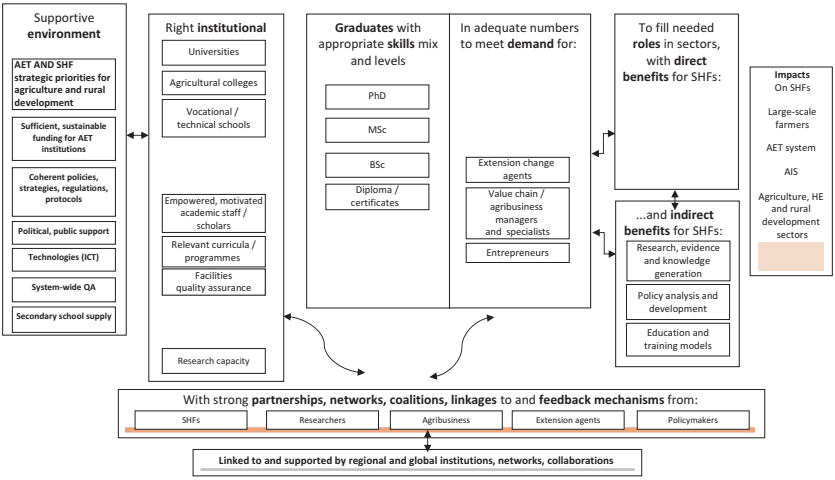

Fig. 5.2 Ideal AET system. (Source: Authors' construction based on Swanepoel, Ofir, and Stroebel (2014a, Fig. 17.6, 474))

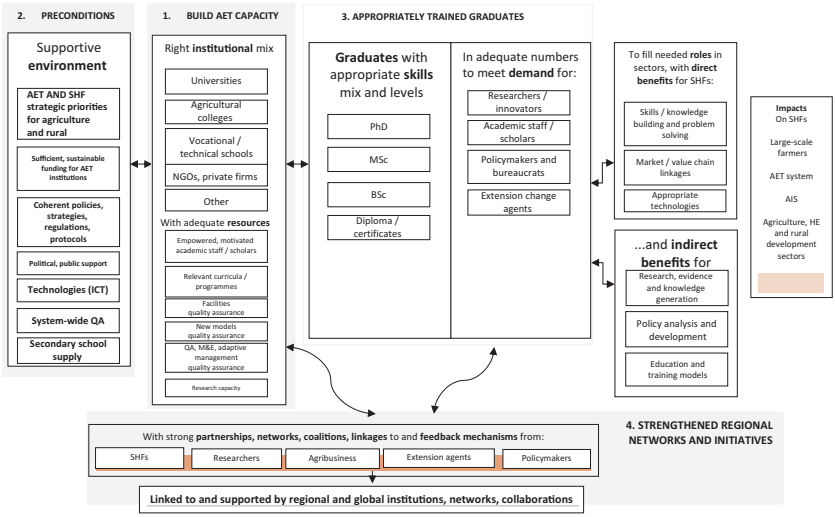

Fig. 5.3 AET system: critical areas for investment. (Source: Authors' construction based on Fig. 5.2)

Preconditions for Success: The Supportive Environment

The characteristics and quality of the external environment determine the level and type of support and resources available to the individuals, institutions, collaborations, and networks in the system as well as the ease with which their work can be done. For this reason, an enabling environment is considered a precondition for success, in the absence of which AET cannot function optimally within the AIS. Attention should therefore be given to the economic, political, policy, sociocultural, environmental, demographic, and technological conditions that affect institutions and their interrelationships positively and that—when synergistically interlinked—create the optimal conditions for AET to function.

Governments have a particularly important role to play in establishing and sustaining enabling environments. Particular examples of countries successful in establishing a supporting environment include the United States, Brazil, India, and Ghana. Government policies, strategies, regulations, and protocols play a highly instrumental role in transformative change given the proliferation of actors, linkages, and markets in the agricultural innovation system. In order to establish a truly enabling environment for AET, policy and strategy on the continent must pay attention to a number of key issues, including: the real needs of smallholder farmers, gender-responsiveness, entrepreneurship and intellectual property protection, the alignment of national incentives and policies to encourage systems-based approaches and multi- and interdisciplinary research, and integration between the higher-education sector, industry/community, and government. Examples of countries particularly successful in integrating the different role-players in the agricultural innovation system include the United States and The Netherlands. The United States created a highly complex but efficient agricultural sector based on the globally recognized land grant model. The Netherlands created Wageningen University and Research Centre through a similar approach by successfully integrating agricultural research and agricultural education, as well as by training role-players. Governments also have the responsibility to create an environment that promotes positive outcomes while guarding and protecting the agricultural sector—in particular the smallholder farmer—against any action that might negatively affect national, sector, or AET system interests. Institutions across the AET system are well positioned to help identify and alert governments to such opportunities and risks and should nurture relationships that will help ensure that expert opinions are sought and heard.

Build AET Capacity: Relevant Institutions and Adequate Resources

Capacity building in Africa, especially in the higher-education sector, was a low priority for donors and governments alike for a long time. This situation has been changing since 2008 (World Bank 2007b); yet it will take exceptional leadership—carefully selected, innovative strategies, and new energy and commitment to ensure that the institutions in the AET system undergo the type of transformative change that has been described in this chapter thus far.

There is extensive literature documenting the challenges facing AET institutions in Africa, including *Towards Impact and Resilience: Transformative Change in and through Agricultural Education and Training in Sub-Saharan Africa* (Swanepoel et al. 2014a). Among these challenges, three issues stand out: resource constraints (that is, lack of funding to provide high quality education), capacity constraints (at institutional and individual levels), and a lack of relevance of AET activities to broader systems and smallholder farmers. Within an enabling environment, it is critical to address these resource and capacity concerns in order to improve the relevance of AET to the AIS.

Appropriately Trained Graduates

Increasingly, new trends and paradigms are likely to influence the sector in coming decades, and the result is that there will be greater demands for better and new types of graduates within the system. These graduates have to be entrepreneurs outside and across international and local value chains; able to work effectively in systems with and as researchers, extension agents, and farmers; and adaptive enough to evolve with new demands and opportunities. Institutions therefore have a series of issues to deal with as part of the transformation of the AET system.

All levels of education and training across the spectrum—vocational, college diploma, undergraduate, and postgraduate education and training—are critical and should work in a synergistic manner. The success of this approach is beginning to emerge in the Ethiopian system, where there is national coordination between various levels of AET training (that is, ATVET and the university system). In addition, it remains important to prioritize graduate education and training to invigorate research and to support national agricultural development. Numerous initiatives across

the continent have echoed the importance of this prioritization, and initial outcomes are encouraging. By way of illustration, as an outflow of their broader activities on the continent, in 2014, the Carnegie Corporation of New York sponsored a workshop focused on the escalation of the production of PhDs in the agricultural and life sciences, held as a side event to the biennial Regional Universities Forum for Capacity Building in Africa (RUFORUM) in Mozambique. The workshop sought to identify critical enhancement opportunities and to consider possibilities for expanding strategically selected partnerships and alliances in the region. A further example is a consensus study commissioned by the Academy of Sciences of South Africa (ASSAf) to identify the challenges facing the agricultural education and training sector (AET) in South Africa. The outcome of the consensus study was a high impact report that provides evidenced-based information and clear recommendations to relevant stakeholders with an interest in an agricultural human capital development and a knowledge system that drives smallholder, farmer-led development initiatives and innovation in order to achieve commercial food production and increased productivity, food security, as well as economic growth and development (ASSAf 2017).

Partnerships between the secondary school and higher education sectors can serve as a medium to improve the quality of students entering into TAE and can stimulate youth interest in agriculture as a career.

Ideally, if resources allow, new and innovative models of formal educational delivery should be considered, such as EARTH University. It is particularly enlightened in its inspirational, yet unapologetic, focus on developing leaders for the AET system and agriculture sector. Other innovative examples include Japan's Education for Sustainable Development of Africa (ESDA), which is an initiative involving eight universities in five African countries with a three-pronged master's program, which is helping to build the next generation of researchers and leaders skilled in sustainable development. The courses are delivered in a manner that takes postgraduate students directly into the field to address practical issues that relate to sustainable development concerns in communities that they are familiar with and understand. A further example, Wageningen University and Research (WUR) has staff and students from over 100 countries. These individuals work primarily in the discipline of healthy food and living environment for governments and the business communities-at-large. WUR combines specialized research from research institutes with the university environment and places value on the combined efforts of the vari-

ous fields of natural and social sciences. This union of expertise leads to scientific breakthroughs, which can quickly be put into practice and be incorporated into education.

Furthermore, new mechanisms to access and share information and learning, facilitated by information and communication technologies and social media, are widely recognized as having significant potential to leapfrog poor infrastructure and enable better scholarship. Advanced information and communication technology facilities can promote collaboration, for example, by sharing expert scholars among institutions and drawing upon non-university experts from various spheres—government ministries, NGOs, national agricultural research organizations, CGIAR, the private sector, and think tanks—to bring their knowledge into the higher education domain.

AET in sub-Saharan Africa must also increase its understanding of African farmers' learning strategies, approaches, and methods. Farmer study groups and learning circles are examples of valuable learning approaches that allow for farmer-centered learning.

Systemwide quality assurance and learning are needed, made possible through appropriate and useful external and internal monitoring and evaluation, supported by an effective accreditation system. These elements are regarded as crucial for the regulation of the system, including ensuring the relevance of the curricula. Importantly, quality assurance and learning provide information for strategic and operational decision-making at various levels within the system, and among those to which the various institutions in the system are accountable.

Strengthened Regional Networks and Initiatives

The success of the AET system requires the coordinated activities of a range of organizations. The role of networks is to reinforce and concentrate on problems that require collective action and to pool talent to reach the critical mass and synergy necessary for realizing creative solutions. These networks are becoming an increasingly popular way of building a strong human capital development infrastructure and harnessing gains from innovation in the research process. Moock (2011) characterized successful professional networks as having the ability to retain researchers in Africa, keep them scientifically active, and encourage and motivate them to make measurable contributions to the broader system of innovation in the agriculture sector. How these networks function, and the nature of

formal and informal interactions within them, are important aspects of the AET system's organizational performance.

AET networks span both public and private sectors and include postgraduate training and collaborations that strengthen institutions. Unimpeded by geography, such a collection of agricultural scientists can capitalize on greatly improved mobility and telecommunications to transcend institutional and national boundaries. Of particular importance is that these networks have the "ability to produce 'scientist entrepreneurs,' create professional career structures, ensure gender equity, build economies of scale and serve as leverage points for translating knowledge into innovation and application" (Moock 2011, iv; Sachs and Alston 2010).

A number of such agricultural networks now exist on the continent—both for academic training and for broader capacity development. The African Women in Agricultural Research and Development (AWARD 2015) initiative is an outstanding example of collaborative efforts to address capacity development, particularly among women in Africa. AWARD partners with more than 300 organizations and institutions, including many national institutes of agricultural research, to offer AWARD fellows a two-year career development program focused on fostering mentoring partnerships, building science skills, and developing leadership capacity. Between 2008 and 2018, 465 African women scientists from 16 countries (including Benin, Burundi, Ethiopia, Ghana, Kenya, Liberia, Madagascar, Malawi, Mozambique, Nigeria, Rwanda, Tanzania, Togo, Uganda, and Zambia) have benefited directly as AWARD Fellows (AWARD 2015). Since 2019 AWARD One Planet fellowships are now offered to either men or women working on climate change issues related to agriculture. Over its duration the One Planet fellowship will invest in 630 African and European agricultural scientists by building a vibrant, highly connected, and intergenerational network of African and European scientists leading climate change research.

Notable networks for academic training are RUFORUM, the Collaborative Masters of Agricultural and Applied Economics (CMAAE), Education for African Crop Improvement (EACI), Biosciences Eastern and Central Africa (BECA), and the Program for Emerging Agricultural Research Leaders (PEARL).

Moock (2011) highlighted a number of challenges that need to be considered when setting up and promoting networks. Despite an array of strong agriculture postgraduate and research networks, the networking

concept is still evolving. All too often, for a variety of reasons (which are listed here), emerging networks fall short of meeting their promise to advance higher learning and ultimately agricultural performance. First, the number of qualified universities for advanced training and participation in research networks is still limited, with many unable to meet fundamental standards for teaching and research and, hence, for accreditation or global recognition of degrees. Second, rushed planning under heavy pressure from potential funders can result in poor design and impeded implementation. Third, attempts to build alliances between universities and larger agricultural innovation systems can lead to frustration if they fail to create added value for all members. Fourth, many networks never reach the take-off point, because they do not use their assets strategically to produce significant public goods. Finally, collaborative arrangements may easily break down if partners do not reach early agreement on common interests, expectations, and contributions. Such prior negotiations offer high organizational payoff, especially in the event of tight fiscal conditions.

This type of analytic approach should inform the inception and design of networks to promote success and avoid pitfalls. For optimal impact, these networks need to concentrate on problems requiring collective action and need to pool their talents to reach critical mass and synergy and realize creative solutions. If well designed and implemented, these types of networks are critical mechanisms for building the next generation of innovation-minded agricultural scientists in Africa (van Rooyen et al. 2001; Posthumus et al. 2013). The networks are major vehicles for launching and maintaining scientific careers, and their unique nature positions them as potential game changers.

Various global networks and partnerships can also be harnessed to enable the escalation of impact within the African agricultural sector. One example is the Global Confederation of Higher Education Associations for Agricultural and Life Sciences (GCHERA), of which the South African Agricultural and Life Sciences Deans Association (SAALSDA) is a member (GCHERA 2019). The consortium aims to include and serve institutions with programs in agriculture, veterinary medicine, and natural resources management, including the biological, physical, and social sciences dimensions of these fields. GCHERA is intentionally designed to be of help to systems of higher agricultural education seeking significant reform, and thus, could be of particular value to AET in Africa.

Impact on the AET System: Toward Resilience

The AET system in sub-Saharan Africa needs to be transformed, with a specific focus on the interests of the smallholder farmer. Taking into consideration the role of the smallholder farmer in Africa, positive transformation in AET will, in turn, have positive impact on these farmers, their communities, and ultimately, on social and economic development on the continent, as well as the resilience of individuals and communities. These are—in theory—the expected long-term expected outcomes sought through transformation of the AET system.

The foreseen transformation will have a major impact on the AET system (see, also, Swanepoel et al. 2014c). If well designed and implemented, the transformation will lead to a more effective, efficient, relevant, and respected continental AET system, with the "ideal" attributes described in the proposed roadmap. However, the scope of and balance between the desired attributes of the system will differ from country to country, depending on the vision, initial situation, and possible strategies.

In the long term, the envisaged transformation should also lead to a more resilient system. In simplest terms, the resilience of a country, society, system, or institution depends upon its ability to be flexible and to adapt readily and effectively to slow or rapid change—or to resist such change if this will lead to better results in the long run. Similarly, the resilience of individuals and the groups to which they belong is determined to a great degree by their ability to adapt quickly and effectively or to resist shocks or evolution in the environment. Strategies and interventions should, therefore, not only transform the AET system to be more relevant, efficient, and effective in its value addition to the AIS, but also make it more respected and in the long term, more resilient.

The starting point for cultivating resilience is to identify the drivers for current vulnerabilities. A concerted effort across the continent is needed to build resilience by working to eliminate drivers of vulnerabilities and the accompanying constraints to cultivating resilience. This places responsibility on each subregion or country working on AET strategies to attend to the issue of resilience to the best of its abilities. This will be essential if Africa is to sustain itself and flourish in today's highly competitive global context—in particular, in a system that is at the core of Africa's increasingly important, yet still weak, knowledge economy.

AET is part of the AIS and interlinked with many other open systems. Its successful transformation will therefore have impacts far beyond the

system itself—on agriculture value chains, on rural development, and in the higher education sector. Eventually, transformations in AET will impact society itself.

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