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TERRAFRICA
REGIONAL SUSTAINABLE LAND MANAGEMENT

**Landscapes for
People, Food and Nature**
An International Initiative for Dialogue, Learning and Action

Priorities for Research in African Landscapes

Integrated, multi-disciplinary, and Africa-focused scientific research is essential to understanding the complexity of African agricultural landscapes and making them more productive, sustainable, climate-resilient, and socially inclusive (FARA, 2013). This paper synthesizes findings from several recent publications related to the science of integrated agricultural landscape management, as well as information shared at the Landscapes for People, Food and Nature in Africa conference in July 2014 (African Landscapes Action Plan, 2014). It recommends actions and platforms for building scientific knowledge and capacity in Africa to design and manage landscapes so that they can fulfill the multiple goals of sustainable food and energy provision, generation of livelihoods and human wellbeing, and conservation of biodiversity and ecosystem services.

State of Knowledge

Agricultural Research and Development in Africa

In a world confronting climate change and growing demands for food, energy, water, and resources, many parts of Africa are challenged by a combination of weak natural resource governance, labor constraints, and limited access to agricultural inputs and technologies, which reinforces persistent yield gaps and rural poverty traps (SDSN, 2013). Key to addressing these challenges, investments in agriculture have been shown to generate 40-60 percent returns in many different contexts, and research and development (R&D) commitments by African governments, which currently account for approximately 10 percent of global spending, can unlock R&D investments by global donors and the private sector (FARA, 2013).

African Scientific Capacity

To implement integrated landscape approaches, Africa will need a broader, deeper base of scientific capacity. During 2001–2008, public R&D in sub-Saharan Africa averaged more than 20 percent growth, and supported more than 12,000 agricultural researchers, with primary emphasis on recovering from under-investment in the 1990s (Beintema and Stads, 2011). However, R&D levels vary widely across countries, with large investments made in Ethiopia, Kenya, Tanzania, and Uganda. Research support by global donors has tended to prioritize a small number of countries (FARA, 2013) and a subset of critical agricultural research topics.

Limited R&D funding is compounded by under-investment in monitoring, which has resulted in data gaps, inconsistencies, and scale mismatches that impede evaluation of key metrics of agricultural landscapes such as production, land use, food availability, ecosystem services, and socio-economic conditions, as well as their associated drivers (SDSN, 2013). Training of new researchers, especially at the post-graduate level, does not appear sufficient to meet rising demand for scientists among universities, international non-governmental organizations (NGOs), and companies (FARA, 2013). Regional organizations play a key role in fostering shared research agendas and collaborative research activities (Beintema and Stads, 2011), and they have been pivotal for promoting strong research networks and continued scientific investment, as well as articulating African priorities in global research funding discussions (FARA, 2013).

Sustainable Intensification in African Agriculture

To meet food, feed, fuel, and fiber needs while minimizing agricultural expansion and associated impacts on natural ecosystems, researchers around the world are advancing 'sustainable intensification' strategies that use land, water, nutrients, and ecosystem services more efficiently, with fewer negative environmental impacts (Beddington et al., 2012). A global review of 219 published studies assessed how successful five 'agroecological intensification' methods (i.e. conservation agriculture, holistic grazing management, organic agriculture, precision agriculture, and System of Rice Intensification) were at increasing yields and maintaining the provision of ecosystem services. The analysis determined that these practices are largely beneficial, but noted significant variation across methods and agricultural systems and challenges for using existing literature to rigorously evaluate the global potential of agroecological intensification methods (e.g. studies tend to be short-term; measured variables are not consistent) (Garbach et

al., in submission). However, for specific regions or cropping systems there may be an adequate empirical basis for evaluation. For example, in a recent *ex ante* study, no-till practices and agricultural technologies for improvement of drought tolerance and nutrient use efficiency were projected to have particularly strong positive effects in sub-Saharan Africa (Rosegrant et al., 2014).

Achieving Multiple Climate Benefits in Agricultural Landscapes

As global greenhouse gas (GHG) levels rise and climate change impacts intensify, the global research community has turned its attention to opportunities in agroecosystems for climate change mitigation and adaptation. A recent international study identified a set of agricultural practices with strong potential to deliver both mitigation and adaptation benefits in agricultural landscapes, including: restoration of degraded or fragile lands; establishment of agroforestry and silvopastoral systems; sustainable intensification; land-use planning for a mosaic of agricultural land and natural habitat; rehabilitation of degraded lands; and conservation and restoration of forests, riparian areas, wetlands, and peatlands, among others (Harvey et al., 2013). Climate-related benefits can also accrue at the landscape scale through broad adoption of farm- or plot-level activities such as sustainable land management in upland farms to control downstream flooding, restoration of riparian areas to improve water provision, use of windbreaks to protect crops and animals from wind stress, and farmer-managed natural regeneration.

While achieving both mitigation and adaptation benefits is important, agricultural systems and landscapes in Africa generally have higher potential to deliver adaptation benefits due to the relatively low GHG emissions from African cropping and livestock systems. For example, business-as-usual agricultural GHG emissions for four East African countries (Ethiopia, Kenya, Tanzania, and Uganda) and five West African countries (Burkina Faso, Ghana, Mali, Niger, and Senegal) were estimated to be 129 million tons CO_2e/year—a small fraction of global emissions—with significant contribution by livestock production (Brown et al., 2012). For these nine countries, potential mitigation through change in agricultural practices was estimated to be 6-22 tons CO_2e/hectare/year with greatest potential shown for sequestration through agroforestry and avoided conversion of marginal lands to agricultural use. Unlike agricultural systems in other regions that use high rates of nitrogen fertilizer, little opportunity was seen for reducing agricultural nitrous oxide emissions; instead targeted increases in nitrogen application could achieve mitigation through improved productivity and "land sparing" (e.g. preventing remaining forests from being cleared for agricultural production).

The Fifth Assessment report of the Intergovernmental Panel on Climate Change (IPCC) finds that African agricultural systems will be affected by increasing water stress, higher temperatures, and precipitation changes that are very likely to reduce productivity of cereal crops and livestock and to negatively affect food security (IPCC, 2014). Conservation agriculture, agroforestry and farmer-assisted tree regeneration, participatory research, and multi-objective management are leading adaptation efforts in the region. The United Nations Environment Programme report (2013) on "Africa's Adaptation Gap" identifies a number of promising agricultural adaptation

strategies, such as rainwater harvesting, crop irrigation, agricultural diversification, and protection of freshwater fish habitat. The IPCC reports that most African governments are working to mainstream adaptation into sectoral planning, but notes that improved institutional frameworks are needed to coordinate across the range of adaptation initiatives (i.e. disaster risk management, social protection, poverty alleviation, technologies, infrastructure, ecosystem-based approaches, conservation agriculture, and livelihood diversification).

Benefits of Agrobiodiversity

Agricultural production systems rely fundamentally on agricultural biodiversity ("agrobiodiversity")—the variety and variability of animals, plants, and micro-organisms in farm fields and homegardens, as well as in non-cultivated parts of agricultural and pastoral landscapes—in order to effectively adapt to external and internal drivers (Munang et al., 2013). Many types of farm practices, land use change, and landscape 'homogenization' threaten this agrobiodiversity-based resilience. For example, ecological services provided by pollinators are threatened as African agroecosystems transition to high-input farming systems (Gemmill-Herren et al., 2014). A recent study in three long-term agrobiodiversity conservation areas in Kenya, Nepal, and Bolivia documented ways in which farmers cope with and recover from weather extremes by taking advantage of landscape heterogeneity and crop diversity (e.g. by maintaining multiple farms in different micro-agroecological zones) (Mijatovic et al., in submission). The importance of local networks and institutions that support cooperation and benefit-sharing to prevent degradation of land and ecosystems and associated agrobiodiversity was emphasized by surveys that measured community perceptions of how different landscape characteristics confer resilience.

Research Gaps

There are a number of important scientific gaps that restrict integrated landscape management in Africa and globally.

- Enhanced quantification of the full set of benefits (e.g. agricultural yields, climate change mitigation and adaptation, food security, human wellbeing, sustainability of ecosystem services, and biodiversity) and costs accruing from different management practices in different agricultural landscapes is needed to plan and implement effective agricultural transitions at both the farm and landscape level (Harvey et al., 2013; Munang et al., 2013). This should include data mining from theses and other publications.

- Improved capacity for linking farm-scale data to landscape-scale effects is needed to understand how the effects of agricultural diversification, ecological restoration, land rehabilitation, forest conservation and restoration, and other interventions compare with business-as-usual agricultural practices. This requires directing research toward spatially explicit studies to understand how different landscape elements interact and contribute to multifunctionality, including information on synergies and tradeoffs across different objectives and approaches (Mijatovic et al., in submission; Garbach et al., in submission).

- Agreement by a broad consortium of research institutions on a set of multi-scale landscape metrics is needed in order to monitor outcomes under different agricultural development scenarios (Harvey et al., 2013). This should be complemented by improved mechanisms and incentives for sharing equipment and data among African researchers.

Consensus actions

There are two major strategies for building scientific knowledge and capacity for integrated landscape management in Africa.

Tackle highest priority research needs

- Document pathways, risks, and mitigation strategies for key threats to African agriculture such as climate change, soil degradation, invasive species, decline in pollinators, food loss and waste, and energy demand. For example, with estimated climate change adaptation costs of USD 7-15B by 2020 (growing by 7% annually thereafter), strategies to anticipate and respond to severe weather, sea level rise, and associated threats to communities, agriculture, and economies represent high priority arenas for African research (UNEP, 2013). This should emphasize cost-effective, ecosystem-based adaptation options for smallholder farm households (Vignola et al, in submission).

- Reframe research towards a holistic understanding of multifunctionality and the interactions and complexity of agricultural landscape components and characteristics. Systematic assessment of the yield, income, human wellbeing, ecosystem services, and biodiversity outcomes of different suites of agricultural practices in different socio-ecological contexts at multiple scales is important for developing targeted recommendations and technologies for sustainable agricultural production (Garbach et al., in submission; Rosegrant et al., 2014).

- Investigate a wide array of agricultural management regimes, in different regions, focused on agroecological intensification that draws upon 'hard' and 'soft' innovations and capitalizes on synergies (e.g. land restoration and increased yield; adaptation and mitigation). Researchers should address widespread challenges such as reducing soil nutrient deficits and imbalances that significantly constrain agricultural productivity (Van der Velde, 2014), increasing agrobiodiversity and resource use efficiency in landscapes, improving plant and animal genetic adaptation to current and emerging stresses (SDSN, 2013), and managing ecosystems for multiple benefits (Munang et al., 2013).

- Engage policy makers and practitioners in early phases of agricultural research design to ensure that findings are demand-driven and relevant to multi-stakeholder landscape management. Bring attention to governance issues including power relations in landscapes (e.g. corruption, unequal access to resources, social marginalization) and institutional arrangements for multi-sector coordination. Combining socio-economic, biophysical, and climate change models through multi-stakeholder scenario processes offers promise for identifying high-impact intervention strategies (Thornton and Lipper, 2014).

- Undertake transformative landscape-scale research that looks beyond business-as-usual (e.g. economic development strongly coupled with environmental degradation) and immediate conditions (e.g. prevalence of smallholder agriculture) and explicitly recognizes interactions across highland-lowland and rural-urban gradients and transboundary resources. Establishment of long-term landscape 'observatories' (e.g. linked to CGIAR sentinel landscapes and other existing research platforms) could facilitate a new model of action research in which communities' information needs are met through multi-disciplinary inventories of local knowledge and regional studies.

Build Networked Agroecological Research Systems that Effectively Manage Multi-Stakeholder Dynamics

- Each national government should have a strategy for ensuring the necessary scientific foundation for sustainable management of its agricultural landscapes (e.g. shrinking yield gaps, increasing resilience, enhancing ecosystem services and biodiversity) that leverages domestic resources, global donor support, private sector resources, access to global knowledge repositories, and regional and global research communities, and balances investment in research infrastructure and human capacity, including women and youth (FARA, 2013; SDSN, 2013).

- Regional research consortia should assess the specific strengths of governmental and scientific institutions, broker meaningful engagement and appropriate expectations among field and laboratory researchers across a broad set of scientific disciplines, and encourage specialization within coordinated, committed research networks including shared ownership of equipment and databases supported by transparent, equitable joint financing (FARA, 2013).

- International research organizations with relevant experience in stakeholder-driven action research should collaborate with national and regional research platforms to expand and refine this model of scientific inquiry to ensure that the innovative capacity of farmers and communities contributes to transformative science (FARA, 2013). This will require widely accepted, easily replicated protocols for participatory research activities such as conducting baseline landscape assessments, selecting methodologies that accommodate iterative co-learning, enabling data quality control, and ensuring broad access to innovations.

- Global donors with significant investments in African development should contribute to robust, long-term monitoring systems that generate data to support research, innovation, and evaluation needs as well as continually re-evaluating the costs and benefits of highly variable funding allocations across African countries (FARA, 2013; Harvey, 2013).

- Multi-institutional and public-private partnerships should build a business case for shared investment in essential scientific capacity and knowledge systems such as seasonal forecasting and GHG emissions estimation (Brown et al., 2012; Thornton and Lipper, 2014). Improved documentation of the impact of research outputs and communication about progress made in specific landscapes can inculcate a sense of success. Innovative communications (e.g. simple graphs and images) developed for policy makers and practitioners can help research recommendations make economic sense to ministries,

communities, and companies, result in increased R&D investments, and help to ensure broader adoption of effective practices by farmers.

"Springboards for Action"

In Africa, there are a number of initiatives and platforms that can support collaborative action toward improved research capacity in integrated landscape management and translate research findings into action in policy and practice.

- *National- and Regional-Scale.* National Agricultural Research Systems are foundational platforms for research on domestic agricultural priorities, which can improve training and retention of scientists by more effectively engaging with international research centers and higher education institutions. The Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) and other regional academic consortia can facilitate improved training and research standards (FARA, 2013). Regional centers for excellence, such as the Biosciences eastern and central Africa International Livestock Research Institute Hub, enable sharing of high-quality research facilities (FARA, 2013).

- *Africa-Scale.* The Comprehensive Africa Agriculture Development Programme provides important convening functions focused on increasing agricultural productivity. The Forum for Agricultural Research in Africa (FARA), the African Union's Science, Technology and Information Strategy for Africa 2024 (STISA-2024), and other continent-wide platforms are important vehicles for harmonizing African priorities and representing pan-African perspectives in global research dialogues. The Africa Soil Information Service is filling a critical data gap that will serve multiple information needs. Launched in Africa, the Vital Signs program provides near real-time data and diagnostic tools to inform agricultural decisions and monitor their outcomes at household to global scales.

- *Bi-Lateral Engagement.* Advanced research institutes in developed countries and major emerging economies such as Brazil, China, India, and Argentina represent key partners for strengthening the capacities of African research institutions.

- *'Boundary Organizations.'* Groups like AfricaAdapt can accelerate collaborative research by facilitating information flow among researchers and decision makers. Platforms such as the African Fertilizer and Agribusiness Partnership (AFAP) can build on research findings to re-shape agricultural value chains. The array of NGOs working in specific landscapes can translate guidelines, practitioner tools, standards, and other research outputs into local languages for communities and extension officers.

- *Global-Scale.* The CGIAR research centers, such as the World Agroforestry Center (ICRAF), the International Institute of Tropical Agriculture (IITA), and Africa Rice, and the set of collaborative research programs (CRPs) engaged in wide array of 'research for development' partnerships relevant to integrated landscape management and multi-stakeholder engagement in setting research agendas (CGIAR, 2014). Entities such as the United Nations Economic Commission for Africa (UNECA) can provide mandates to regional centers for excellence to lead transformative landscape research. United Nations programs led by the Food and Agriculture Organization (e.g. Sustainability Assessment of Food and Agriculture, SAFA, systems), United Nations Development Programme (e.g.

Africa Human Development Report), and United Nations Environment Programme (e.g. Ecosystem-based Adaptation, EbA) are important partners for research and extension in Africa.

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