Effects of infrastructure on the adoption of sustainable agricultural practices in sub-Saharan Africa

Supplementary material

Section S1: Infrastructure in Africa

The relevance of infrastructure is not new in both developed and developing economies. Aside from being a key driver of economic growth, improved infrastructure contributes to human development, and poverty reduction, and has the potential to achieve even more (Alhassan et al., 2023; Kotchofa et al., 2020). Yet infrastructure in most remote areas of Africa remained stagnant or worse after independence (Chamberlin & Jayne, 2013). It is probably for these reasons that efforts to focus on developing or improving existing infrastructure, especially, in Africa, have been gaining attention among think tanks and development organisations. These efforts are evidenced in several policy documents and programs concerning Africa. An example is the Programme for Infrastructure Development in Africa to facilitate infrastructural development in Africa (African Development Bank, 2019). However, all these efforts do not appear to go beyond declarations and documentation of intents to improve or develop infrastructure. Thus, the hopes of improved infrastructure in the continent are still low as the private deployment of capital for infrastructure continues to be slow in this part of the developing world (Mumin et al., 2023). Scaling up of infrastructure via increased investment could have helped curb the situation in the continent but investment looks sparse and discouraging despite the several calls and efforts. Currently, communication facilities - implied in trade in information and communication technology (ICT) in some parts of the region - are lower than in other regions of the globe. Whereas trade in ICT in sub-Saharan Africa is at 0.4-6.6% for exports, imports, and services, trade in ICT in Europe and Central Asia is at 5.1-16.1% for exports, imports, and services (The World Bank, 2022). Regarding electricity, current losses in electric power transmission and distribution are 11.7% of the total output in sub-Saharan Africa and higher than Europe's 6.2%,

and 5.4% in East Asia and the Pacific (ibid.). Although some areas of Africa have experienced rapid transformation, agricultural factor markets are still less functioning (Dillon & Barrett, 2017) and are challenged with variations in the trends of factor input prices (Abay et al., 2021; Kopper & Jayne, 2019). Roads are central to rural-urban linkages, transporting not less than 80% of goods, and 90% of commuters in Africa. However, such infrastructure remained neglected as 53% are still unpaved (*ibid*.). Also, the percentage of loss and waste in the food supply chain is high and thus, highlights the challenges still faced in accessing post-production infrastructures (Owusu-Addo et al., 2023). Irrigation has been particularly important in agricultural and economic growth yet investment in irrigation infrastructure remained poor. Available statistics showed that only 6% of the cultivated area is irrigated in the region while that of Asia and Latin America are approximately 37% and 14%, respectively (Turley & Uzsoki, 2018).

The challenge of low investment in infrastructure in Africa appears to affect use among her population. For instance, internet usage is still lower than other areas despite the increase from 18.6% in 2012 (African Development Bank, 2022) to 30% in 2022 (The World Bank, 2022). Road access among the African population is less than half of the population of Africa (*ibid*.). Of the world total, Africa's rail and air freight are less than 2% and 1%, respectively (*ibid.*), and reflect the lower number of passengers and goods carried as compared to other regions. Affordable housing is still a major problem for many African households (African Development Bank, 2022), and 78% of the people in the region lack electricity (SEforALL, 2021). Consumption per capita is 487.3 kWh in Africa and lower than 6,021.9 kWh in Europe and 3,665.1 kWh in East Asia and the Pacific (The World Bank, 2022). Current projections in the region even show that coverage in terms of electricity access will not exceed 70% by 2040 (African Development Bank, 2022).

Given that infrastructure is believed to have a strong role in structural transformation (Kodongo & Ojah, 2016), the low investment in Africa (Chinzara et al., 2023) is casting doubt on the potential role of infrastructure in structural transformation in Africa. The focus of this study is to answer the questions of the adoption effect of the use of irrigation and produce/product storage infrastructure in Africa.

Section S2: Infrastructure and Adoption of SAPs: Conceptual Links

The relationship between infrastructure and smallholder adoption of sustainable agricultural practices (SAPs) is conceptualized in Figure 1. The conceptual model also shows the various relationships that exist between the adoption of SAPs and some variables hypothesized to influence the adoption of SAPs. The model starts with an introduction of government policies including taxes, subsidies, liberalization, and price control which may directly or indirectly affect infrastructure and SAP adoption as shown with a loop from government policies to infrastructure. For example, through the cost of construction, maintenance, and operation, tax may serve as an incentive for investment in agricultural infrastructure such as irrigation systems, or storage facilities. Consequently, private sector participation, availability, and use of infrastructure in rural areas may be enhanced. Subsidies can reduce the financial burden on farmers and incentivize the adoption of water-saving technologies. Additionally, subsidies for storage facilities can improve market access and reduce post-harvest losses, thereby enhancing the utilization of infrastructure by farmers. Liberalization of trade and investment regulations may attract private capital into infrastructure projects, such as storage facilities or processing plants, leading to improved access to markets and value-added services for farmers. However, liberalization can also pose challenges, such as uneven distribution of infrastructure benefits and risks of market concentration. Further, price controls on agricultural inputs or outputs may distort market signals and affect farmers' willingness to invest in infrastructure-intensive production

systems. Conversely, price controls that ensure fair prices for agricultural products may stimulate investment in infrastructure, as farmers have greater confidence in the returns on their investments.

Regarding SAP adoption, taxes on environmentally harmful inputs, such as chemical fertilizers and pesticides, can incentivize farmers to adopt more sustainable practices. Such taxes may also raise the prices of agricultural products, causing a disincentive to production. Conversely, providing subsidies for sustainable agricultural inputs, such as organic fertilizers, crop rotation systems, or agroecological practices, can lower the costs of adopting these methods. Subsidies make sustainable practices more economically viable for farmers, thereby increasing their adoption rates. In a liberalized framework, reducing trade barriers and promoting market competition, can affect the adoption of sustainable practices in several ways. Increased market access can expose farmers to international standards and consumer preferences for sustainably produced goods, incentivizing them to adopt practices that meet these requirements. Additionally, liberalization may facilitate the diffusion of knowledge and technology related to sustainable agriculture through trade and investment flows. Further, price controls, including price floors or ceilings for agricultural products, can influence farmers' decisions regarding production and resource use. When prices for environmentally friendly products are supported through price floors or premium pricing mechanisms, farmers are more likely to adopt sustainable practices that enhance product quality or meet certification standards. Conversely, if prices for unsustainable inputs are artificially low due to subsidies or price ceilings, farmers may have less incentive to adopt alternatives that are more environmentally friendly but comparatively expensive. These relationships are shown by an arrow from government policies to SAPs. However, the adoption of SAPs is influenced by a complex interplay of several factors, including

farmer/household characteristics, agroecological/locational characteristics, institutional characteristics, and infrastructure use. Such relationships are also shown by arrows from farmer/household characteristics, agroecological/locational characteristics, institutional characteristics, and infrastructure used for SAPs in Figure 1. In the next section, we model these dynamics under the theory of random utility (Greene, 2002).

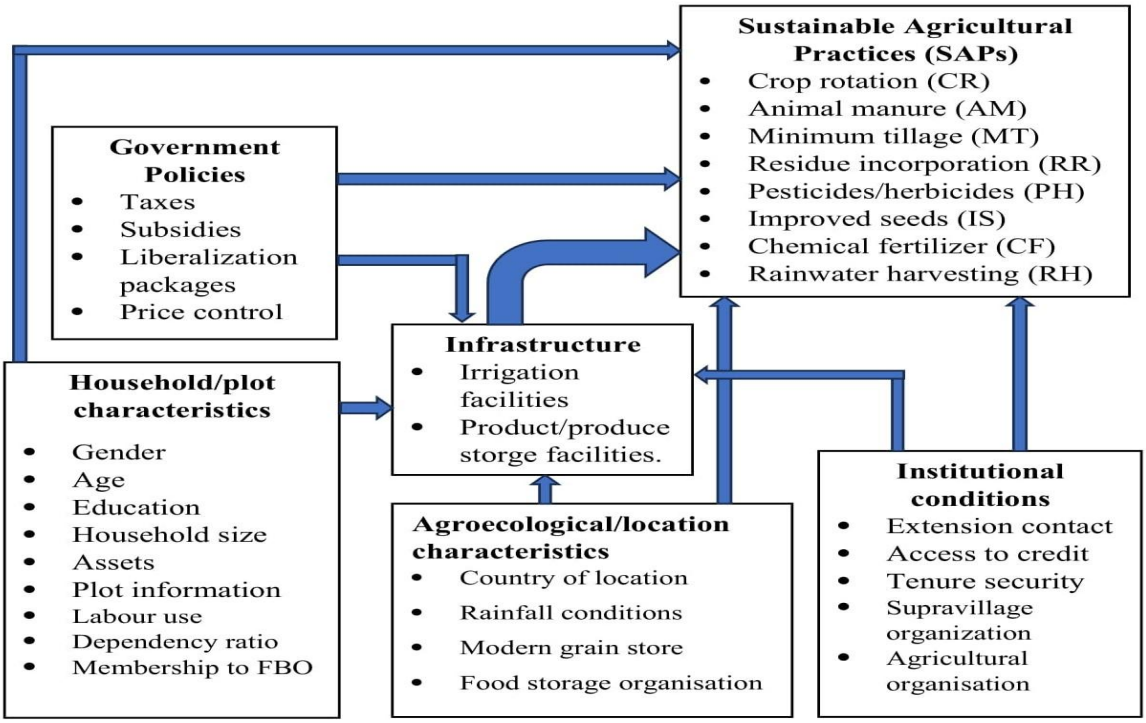

Figure 1: Conceptual framework linking infrastructure to SAP adoption.