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Towards a Holistic Agricultural Transformation Index for Africa: A Universal Framework with Insights from Zambia

Mrs Comfort Laraba Ahmed

College of Education Akwanga Nasarawa State

benvivian52@gmail.com

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Abstract

The Holistic and Inclusive Agricultural Transformation Index (HIATI) for Africa aims to assess agricultural transformation in Africa, focusing on productivity, policy, and institutional effectiveness. The index categorizes countries into early, emerging, transitioning, and advanced stages based on overall scores. The study shows significant changes in African countries' agricultural development stages from 2000 to 2020. 21 countries were at an early stage of transformation, while 46 were emerging. Countries transitioning from subsistence-based systems to market-driven economies saw the highest HIATI scores. Namibia, Liberia, Gambia, Equatorial Guinea, and Zimbabwe stagnated in this category. The study reveals that agricultural transformation is primarily driven by "Agricultural Productivity and Efficiency" and "Rural Infrastructure and Financial Services." However, some emerging countries have stagnated and reduced HIATI scores due to low scores in climate resilience and structural economic shifts. Zambia's HIATI score increased from 28 in 2000 to 34 in 2020, driven by structural economic shifts, policy and institutional effectiveness, and market integration.

Keywords: Agricultural Transformation Index, Africa, Zambia

1. INTRODUCTION

Improving the efficiency and performance of agriculture is critical for many developing countries. Agriculture serves as the backbone of most economies and facilitates the structural transformation of the economy from an agriculture-based one to one that is driven by secondary economic sectors (Bruce F & Soren T, 1966). In order to effectively support economic diversification, the sector must undergo a complete agricultural transformation.

Agricultural transformation can be broadly defined as the gradual shift from low-productivity, subsistence-orientated farming to one that is more commercially orientated and technologically advanced (AFDB, 2017). Several studies have identified the core elements of an agricultural transformation, including:

Improvement in agricultural productivity. This improvement is the first indicator of progress in the transformation ladder when farmers record an increase in farm yields through mechanisation, improved seeds and better farming practices (Raian & Dederica, 2016). These improvements lead to increased output per unit of labour, which contributes to food security and economic growth. As agriculture becomes more efficient, labour and resources are gradually reallocated to more productive sectors such as manufacturing and services (Sara, Nicolas, & Sunil, 2017).

A gradual shift from subsistence to market-orientated farming (Raian & Dederica, 2016). This shift entails farmers engaging more actively with markets as they sell the surplus produce and become more integrated into

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value chains (IFPRI, 2016).
Reducing share of agriculture in GDP and employment as the broader economy diversifies (Timmer, 1988). A notable implication of improved efficiency is the decreasing proportion of agriculture in GDP because investments move towards industries and services. As a country's economy grows, sectors such as industry and services expand more rapidly than agriculture, leading to a relative decline in agriculture's share in GDP (Annermarie, 2015).

A notable growth of agro-industries and food processing sectors (Laborde, Lallemant, Kieran, Smaller, & Traore, 2019).

As noted above, agricultural transformation is a multi-dimensional process that goes beyond productivity growth. While some regions like Asia and Latin America have experienced successful agricultural transitions, the African continent faces challenges that require a more holistic and tailored approach (Audrey & Amadou, 2017). This paper explores how existing measures of agricultural transformation can be enhanced to develop a more holistic and contextually relevant Agricultural Transformation Index for Africa. Such an index would more accurately capture the status of transformation to inform policy and agriculture investment decisions by governments and development partners.

2. AGRICULTURAL TRANSFORMATION AND THE STRUCTURAL TRANSFORMATION OF THE ECONOMY

Structural economic transformation refers to the long-term shift in a country's economic activity and labour movement from low-productivity agriculture to high-productivity sectors like manufacturing and services (Lukas & Andy, 2020). This understanding is a central feature of economic development as outlined in classical economic models like the Lewis Model of Economic Development (1954) and Timmer's model of Agricultural Transformation (1988). Lewis (1954) describes the shift from agriculture to industry as labour migrates from low-productivity rural areas to high urban wage sectors. Furthermore, Johnson and Mellor (1956) highlighted the role of agricultural surplus in financing industrial growth. Timmer (1988) defined agricultural transformation as a four-stage process involving productivity growth, industrial linkages and declining agricultural employment (Anwar et al., 2017).

Most countries in Asia and Latin America went through a successful agricultural transformation during the Green Revolution from the 1960s to the 1980s. During this time, countries in these regions recorded increases in agricultural productivity, labour migration, industrialisation, economic diversification and a demographic transition. This pattern is in line with traditional economic theory where agricultural transformation leads to rapid industrial expansion, urbanisation and economic diversification (Sharma et al., 2011). However, African agricultural transformation has faced different challenges, and several studies highlight the need to relook at our approaches for tracking agricultural transformation in Africa (Fantu N, Guush, Bart, & Alemayehu S, 2018).

Failure to achieve agricultural transformation has far-reaching consequences for the structural transformation of the economy. For instance, a large proportion of the economy would be engaged in low-efficiency farming, which could limit their income, savings and investments. Incomplete agricultural transformation would result in a stunted industrial sector and an economy that struggles to move beyond primary production. (Sharma et al., 2011).

3. THEORETICAL FRAMEWORK

3.1 Lewis Model

The Lewis model is one of the key theories explaining agricultural transformation in the context of dual economies for poor countries. According to Lewis, a poor/developing country consists of two sectors, including 1) a small capitalist sector and 2) a large traditional agricultural sector. Lewis argues that employers in the capitalist sector take up labour to make money, while those in the traditional sector are not profit-orientated and therefore hire too many people, leading to low productivity (Lewis W. A., 1979).

Based on this, Lewis argues that one way to catalyse development in poor countries is to move labour to manufacturing where it is more productive. He argues that

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capitalists save out of their profits and use these savings to expand, which leads to growth. Lewis assumed that workers in agriculture save nothing and that the only way to save was through the capitalists in manufacturing. Lewis used this model to explain the pattern of growth in poor countries, outlining different growth stages based on a country's income level. In poor countries, growth is slow because of a small or non-existent manufacturing sector. Middle-income countries record higher growth because the manufacturing sector is pulling workers out of agriculture. At the high-income level, growth slows as the gains from diverting labour out of agriculture are almost fully realised (Lewis W.A., 1979).

Lewis further argued that poor countries engaged in trade would get little benefit from increasing their exports; the benefits would go to consumers in richer countries. He recommended that poor countries should instead focus on food production rather than exports (Lewis W. A., 1979).

3.2 Mellor's Model on Agricultural Transformation

Mellor divided the agricultural development process into three phases: 1) traditional agriculture, 2) technologically dynamic agriculture and 3) high-capital agriculture. According to Mellor, the traditional phase is comprised of small family farms with low productivity. At this stage, farming is mainly subsistence-orientated, labour-intensive and farm-centred. The transition to the second phase requires institutional and educational reforms to enable farmers to adopt better and more efficient farming methods, such as the use of improved seeds, fertiliser and irrigation. The third phase involves high-capital agriculture, utilising mechanisation and larger farm sizes, supported by a developed non-farm sector (MELLOR, 1969).

Mellor's model is key in that it emphasises the critical role of institutional and educational reforms to transition from phase one to phase 2. Failure to achieve these reforms would result in a premature shift to phase three, which could lead to structural issues, as the country's institutional capacity may not support specialised agriculture effectively (MELLOR, 1969).

4. CONCEPTUAL FRAMEWORK

The agricultural transformation process typically follows a trend in which agricultural productivity improves and labour and resources are freed up for more productive non-agricultural sectors (Dong, Chunlai, & Christopher, 2023). As the sector transitions over time, each stage requires specific , deliberate policy interventions, investment and structural support. The transformation process can be broadly categorised into three broad phases as follows:

4.1 Increased productivity leading to surplus

The first phase of the agricultural transformation process is marked by improvements in productivity per unit of land and labour. These improvements are achieved through the adoption of improved seed varieties, mechanisation, better soil management practices and improved access to extension services. Agricultural output expands as productivity increases, which leads to surplus production beyond subsistence needs (Douglas, 2021).

During this phase, farmers transition from traditional, low-yield farming methods to more efficient and market-responsive practices. However, it is crucial to note that sustained productivity growth requires investments in infrastructure such as rural roads, irrigation systems and post-harvest storage facilities. Without such investments, productivity gains may be short-lived due to input inefficiencies, post-harvest losses and market failures.

4.2 Surplus Utilization

During the second phase, countries use the surplus agricultural output from stage one, which creates opportunities for reinvestment in the economy. The surplus can be utilised in several ways, including 1) through increased household food security, improved nutrition and income, which in turn can stimulate local demand of goods and services. 2) through taxation,

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government interventions or investments in public goods such as rural electrification and market development. 3) through value addition, agro-processing and integration into supply chains (Timmer, 1988).

4.3 Integration with the broader economy

The third phase involves the deeper integration of agriculture into the national and global economies. Such integration can only be achieved with operational agricultural markets, financial services and policy frameworks that support competitive agribusiness development.
5.

4.4 Stages of Agricultural Transformation

Based on the above analysis, this study will measure agricultural transformation into four stages as depicted in Figure 1:
1. Advanced Transformation: Highly mechanised, market integrated and diversified economy
2. Transitioning: Strong productivity with structural shifts, but challenges still remain
3. Emerging: Partial Transformation but lacking infrastructure or policy support
4. Early Stage: Predominantly subsistence agriculture, weak institutions

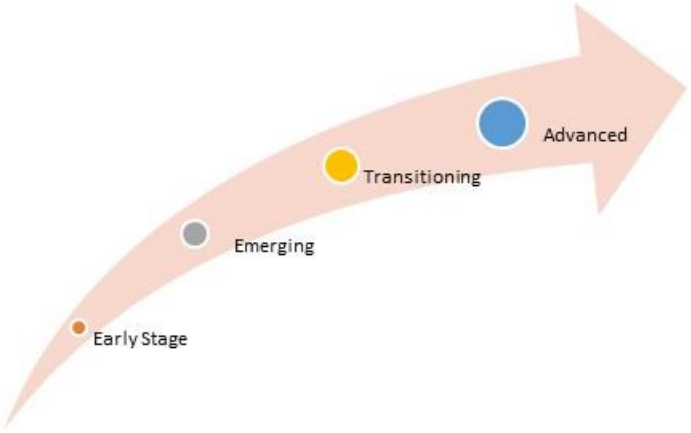

Figure 1: Stages of Agriculture Transformation

In assessing countries over time, it is important to consider the context and dynamics surrounding it. The critical development question remains: how long should agricultural transformation last? Various studies have shown that many developing countries have experienced prolonged or incomplete agricultural transformations, which continue to hamper their broader economic development.

5. Challenges with Africa's Agricultural Transformation

Compared to Asia, Africa's agricultural transformation has not led to the expected structural changes and economic growth. Instead, several studies indicate that it has taken an atypical and slower trajectory with distinct challenges, including:

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5.1 Limited Productivity growth

According to the African Development Bank, crop yields remain three times lower than in Asia despite efforts to introduce improved seeds and fertilisers in Africa (Adamon N, Andinet D, Adeleke O, & Simpasa, 2017). Further, mechanisation remains low, with over 60% of farming in sub-Saharan Africa still rainfed (Dong, Chunlai, & Christopher, 2023).

5.2 Labour shifts from low-productive services instead of industry.

Unlike in Asia, Africa's labour migration from agriculture is not fuelling growth in the manufacturing sector. Instead, many workers move into low-productivity urban services and informal employment (AFDB, 2017). As noted byAbedullah, Shujaat, & Farah (2023), this results in "urbanisation without industrialisation", where cities grow without corresponding increases in high-value economic activity**.**

5.3 Rural Urban Transitions Lags behind other Regions

A study by Dong, Chunlai, & Christopher (2023) notes that Africa's demographic transition is slower because rural populations continue to grow, creating pressure on land and food systems. Furthermore, Abedullah, Shujaat, & Farah (2023) note that many African countries still have over 50% of their population engaged in agriculture compared to 10 to 20% in industrialised Asian economies.

5.4 Market Access and Agribusiness Still Remain Weak

Several studies have shown that limited rural infrastructure such as roads and electricity prevents market integration and value addition (World Bank, 2019). Unlike in Asia, where agricultural transformation created a dynamic agribusiness sector, Africa's agribusiness sector remains underdeveloped (AFDB, 2017).

5.5 Climate and Environmental Constraints

There is increasing evidence that shows that Africa is more severely affected by climate risks such as droughts, floods and land degradation than Asia and other regions (Abedullah, Shujaat, & Farah, 2023). Other studies indicate that Africa has been slower in adopting climate-smart agriculture, which is necessary to sustain long-term productivity growth.

6. Objectives of the Study

1. To develop a holistic and globally applicable Agricultural Transformation Index (ATI)
2. To conduct cross country analysis and categorise transformation levels
3. To provide actionable recommendations for accelerating agricultural transformation in Zambia.

7. Literature Review of Existing Measures of Agricultural Transformation

In the past 30 years, several measures and indices have been developed to track agricultural transformation across different regions and economic contexts. These approaches usually focus on productivity, structural changes and commercialisation. Africa's agricultural transformation faces unique challenges, so we need to develop a more holistic measure that also considers informal market structures, climate vulnerability, and rural employment shifts.

In proposing the enhanced agricultural transformation measure, the paper will first review the existing measures, including their key features and limitations.

7.1 The Agricultural Transformation Index (ATI)–IFPRI

Developed by the International Food and Policy Institute (IFPRI), the Agricultural Transformation Index (ATI) is one of the most widely used indices for measuring progress in agricultural transformation across

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countries (International Food Policy and Research Institute (IFPRI), 2024).

The IFPRI's ATI measures productivity growth by assessing agricultural output per worker, land productivity, and total factor productivity. It further measures market integration by capturing commercialisation and the proportion of produce sold in markets. It tracks structural transitions by measuring the declining share of agriculture in GDP and employment, as well as the movement of labour to non-farm sectors. In terms of policy and institutional support, the index considers investments in rural infrastructure, access to credit and policy effectiveness (International Food Policy and Research Institute (IFPRI), 2024).

Limitations

In view of the unique challenges affected by the African continent, the IFPRI ATI lacks indicators to track climate resilience, land degradation and biodiversity loss. Furthermore, the index fails to capture the rural non-farm economy, which is crucial in understanding transformation in the context of the African continent.

7.2 The International Institute for Sustainable Development (IISD) Classification of Agricultural Transformation

The IISD proposed a measure of agricultural transformation which categorises transformation into six distinct phases ranging from subsistence farming to full industrialisation. Building on Timmer's (1988) framework, the classification is based on 45 years of empirical data from 45 countries. One of the key findings from the model is that transformation is nonlinear, and countries progress at different speeds depending on policy priorities, investments, and economic linkages (Laborde, Lallemant, Kieran, Smaller, & Traore, 2019).

The framework categorised countries into six phases reflecting different levels of agricultural transformation as follows:

1. Subsistence agriculture
2. Getting agriculture moving
3. Moving labour out of agriculture
4. Agriculture as a contributor to growth
5. Agriculture integrated into the macro economy
6. Industrialised economies

Indicators used to measure agricultural transformation include, agricultural productivity, labour transitions, market integration, public investments and infrastructure and policy and institutional reforms.

Limitations

While the IISD framework provides a structured classification of agricultural transformation, its methodology does not fully capture the unique challenges of African agriculture particularly climate vulnerability, informal market structures and demographic pressures.

7.3 Total Factor Productivity (TFP) Analysis

A recent study by (Meimei, Libang, & Haojian, 2020) utilised TFP to assess the agricultural transformation stages in Gansu Province in China. They employed the DEA-Malmquist index model to measure TFP for 87 countries from 1988 to 2017. The study identified three distinct stages of agricultural transformation including:

1. **Traditional Agriculture (1988 – 1998).** The study established that this period was characterised by low technology efficiency and minimal technological efficiency.
2. **Low-capacity technology agriculture (1999 - 2011).** This period was marked by gradual improvements in technology adoption and efficiency.
3. **High-capacity technology agriculture (2012 – 2017).** This period was defined by significant technological advancements and increased productivity.

7.4 Micro-Level Indicators of Agricultural Transformation

More recently, (Mulubrhan, Priyanka, & Trung, 2023) conducted a comparative analysis between Southeast Asia (SEA) and Sub-Saharan Africa (SSA) to identify

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micro level indicators of agricultural transformation. The study examined how the changes in agricultural income influenced various factors including:

- **Non-farm Income Share** which is the proportion of household income from non-farm activities.
- **Livestock Income Share** which is the percentage of agricultural income from livestock farming
- **Agricultural Machinery** covering investments in farm mechanisation and equipment

The study established that increases in agricultural income in SEA were associated with higher non-farm income and more investment in mechanisation. This indicated a complementary relationship between farm and non-farm sectors. In contract, SSA exhibited a substitute effect, where increased agricultural income led to reduced non-farm income suggesting differing pathways of transformation between the regions.

8. Towards a Holistic and Inclusive Agricultural Transformation Index for Africa

Building on existing frameworks and indices of agricultural transformation, this section presents a more comprehensive and context-specific approach to measure agricultural transformation in Africa. It is a Holistic and Inclusive Agricultural Transformation Index (HAITI) that takes into account Africa's unique transformation challenges such as climate vulnerability and rural employment dynamics.

Accordingly, the HIATI comprises six dimensions, each including multiple indicators that measure key aspects of agricultural transformation, including (i) (i) (i) (i) (i) agricultural productivity and efficiency, (ii) market integration and value addition, (iii) structural economic shifts, (iv) rural infrastructure and financial services, (v) climate resilience and sustainability and (vi) policy and institutional effectiveness.

8.1 Computational Methodology

The index is computed by normalising the values of each dimension to a uniform scale in a given year. Each normalised score is then multiplied by a predetermined weight relative to its importance (25% for agricultural productivity and efficiency, 20% for market integration and value addition, 15% for structural economic shifts, 15% for rural infrastructure and financial services, 15% for climate resilience and sustainability and 10% for policy and institutional effectiveness), and the weighted scores are summed to produce the overall HIATI score.

8.1.1 Limitations and remedial measures taken

A major limitation in developing the High-Level Agricultural Transformation Index (HIATI) has been the lack of publicly available, agriculture-specific data across African countries. To address this challenge and ensure cross-country comparability, the index draws primarily from the World Bank Development Indicators and other internationally recognised sources. While this approach ensures consistency and replicability, it has necessitated the use of proxy indicators in some dimensions, particularly where more granular or sector-specific data (e.g., on technology adoption, extension reach, or climate-smart practices) are not readily available.

Despite these limitations, the HIATI presents a robust conceptual and analytical framework for assessing agricultural transformation in Africa. It provides valuable insights into the key drivers of transformation, including productivity, market integration, structural shifts, infrastructure, sustainability, and policy effectiveness. As more detailed and disaggregated data become available over time, the index can be further refined, enhancing its diagnostic power and relevance for decision-makers.

8.2 Rationale for the Selection of Dimensions and Their Indicators

8.2.1 Agricultural Productivity

Agricultural productivity is a foundational driver of transformation. According to neoclassical growth theory (Solow, 1956), increases in total factor productivity (TFP) raise output per unit of input, which is essential for economic expansion. The Lewis dual-sector model (Lewis W. , 1954) also emphasised the release of

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surplus labour from agriculture into higher-productivity sectors as a mechanism for structural transformation.

(Gollin, Hansen, & Wingender, The impact of the Green Revolution, 2021) shows that in low-income countries, agricultural productivity remains significantly lower than in other sectors, constraining national income growth. BThe agricultural productivity gap enables higher rural incomes, reduces poverty, and catalyses labour mobility (Gollin, Lagakos, & Waugh, 2014). However,wever,wever,r, the nature of technological change matters: labour-saving technologies may displace workers unless complemented by rural non-farm employment (Bustos, Caprettini, & Ponticelli, 2016).

Direct indicators such as crop yields and livestock productivity and proxy indicators such as technology adoption rates help capture both system efficiency and innovation uptake.

Ideal Indicators

- Agriculture output per hectare
- Efficiency of water use
- Agriculture labour productivity

Direct and Proxy Indicators used

1. Agriculture, forestry and fishing value added (% of GDP) - to measure the economic contribution of agriculture, relative to the overall economy.
2. Cereal yield (kg per hectare) - to assess productivity in staple crop production.
3. Fertilizer Consumption (kg per hectare of arable land) - indicates input efficiency, which is crucial for assessing technological adoption in agriculture.
4. Agricultural irrigated land (% of total agricultural land) - shows the extent of land under improved agricultural practices.

8.2.2 Market Integration and Value Addition

This dimension tracks the extent to which agriculture is integrated into domestic and international markets and contributes to value-adding processes such as agro-processing, packaging, and commercialization. Market integration and value addition are key features of agricultural transformation, enabling a shift from subsistence to a **market-driven agricultural system** that is productive, competitive, and profitable.

From the lens of **transaction cost economics** (Williamson, The economic institutions of capitalism: Firms, markets, relational contracting, 1985), effective integration into markets reduces information asymmetries and coordination failures, thereby incentivizing producers to specialize and invest. In a transforming system, farmers are not only producers but also participants in **value chains** that link them to input suppliers, processors, distributors, and final consumers.

Empirical studies reinforce this importance. Marwa et al. (2017), in a study of rice markets in Indonesia, show that integrated markets lead to more stable prices and efficient resource allocation. Similarly, initiatives like the **AfDB's AMVAT project in South Sudan** demonstrate how support to agro-processing and export development can strengthen food systems, boost employment, and enhance value retention in rural areas (Marwa, Abdelraouf, & Abuarab, 2017).

Agricultural transformation also entails **vertical and horizontal integration**: farmers increasingly engage in contractual relationships, aggregation models, and structured markets. These arrangements improve market access, reduce post-harvest losses, and allow for product differentiation—steps that are essential for upgrading within regional and global value chains.

Ideal Indicators

- Degree of agricultural Produce processing
- Agricultural export diversity
- Domestic Market Integration

Direct and Proxy Indicators used

1. Food exports (% of merchandise export) – to measures the economic importance of agricultural products in national exports.
2. Crop Production Index (2014 – 2016 = 100)

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3. Livestock Production Index (2014 – 2016 = 100) – to reflect the output and growth in crop and livestock sectors respectively, indicative of market integration and production scaling.

8.2.3 Structural Economic Shifts

A defining feature of agricultural transformation is its contribution to broader **structural economic change**, wherein labor and resources shift from low-productivity agriculture to higher-productivity sectors like manufacturing and services. However, transformation does not imply the abandonment of agriculture. Rather, it involves the **modernization of agriculture**, improved labor productivity, and **efficient reallocation** of labor and capital across the economy.

The theoretical basis for this transition is rooted in the **Lewis dual-sector model** (Lewis W. , 1954), which posits that the movement of surplus labor from traditional agriculture to the modern sector underpins early industrial growth. **Kuznets** emphasized that such a shift is accompanied by urbanization, income growth, and changing consumption patterns (Kuznets, 1957). Later, **Johnston and Mellor (1961)** argued that a productive agricultural sector provides essential capital and food to fuel urban development and economic diversification.

Empirically, countries such as **Vietnam** and **Ethiopia** have demonstrated how rising agricultural productivity and urban demand lead to diversification of both rural and urban economies, supporting off-farm employment, food system modernization, and reduced poverty (Christiaensen & Martin, 2018). Yet, if labor exits agriculture without accompanying productivity gains, the result may be “distress-driven” migration, persistent underemployment, and urban informality—a challenge documented across parts of sub-Saharan Africa (McMillan, Rodrik, & Sepúlveda, 2017).

As such, this dimension of the ATI captures the **scale and direction of labor and demographic shifts**, providing insight into whether a country’s transformation path is sustainable, inclusive, and productivity led.

Ideal Indicators

- Shifts of labour from Agriculture to other sectors
- Agriculture contribution to GDP
- Urbanisation as a factor of agricultural demand

Direct and Proxy Indicators used

1. Employment in agriculture (% of total employment) – provides insights into labour allocation.
2. Rural population (% of total population) – helps analyse demographic shifts impacting agricultural practices
3. Urban Population (% of total population) – same as above.

8.2.4 Rural Infrastructure and Financial Services

The availability and quality of rural infrastructure and financial services are essential enablers of agricultural transformation. These services reduce transaction costs, improve productivity, and enable farmers to access markets, technologies, and capital. Without investments in rural infrastructure—such as roads, irrigation, and electricity and inclusive financial systems, agriculture remains trapped in subsistence and low-value production.

According to endogenous growth theory (Romer, 1990), public goods such as infrastructure increase the returns on private investment and contribute to long-term economic growth. In agriculture, these investments are especially crucial for enabling scale, commercial viability, and resilience. Transaction cost theory (Williamson, 1985) also highlights how the lack of physical and financial infrastructure increases barriers to market entry and reduces the efficiency of input-output systems.

Empirical studies show that feeder roads and irrigation are strongly correlated with increased farm productivity and income. For instance, (Dercon, Gilligan, Hoddinott, & Woldehanna, 2009) found that rural road development in Ethiopia significantly improved consumption growth and poverty reduction. Access to electricity enables agro-processing and cold storage, reducing post-harvest losses and supporting value chains. On the financial side, studies by Arias et al. (2019) and IFPRI (2016) highlight the transformative role of

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agricultural credit and insurance in enhancing technology adoption, risk management, and commercialization.

Thus, this dimension evaluates the extent to which enabling infrastructure and financial systems are in place to support farmers' transition from subsistence to a commercially viable and modern agriculture.

Ideal Indicators

- Access to agricultural credit
- Quality and extent of rural roads
- Water management infrastructure

Direct and Proxy Indicators used

1. Access to electricity (% of population) – to measure access to electricity including in rural areas.
2. Domestic credit to private sector (% of GDP) proxy to show the financial environment's support for private sector growth, including agriculture.

8.2.5 Climate Resilience and Sustainability

This dimension addresses the extent to which agricultural systems are equipped to manage environmental risks and contribute to long-term ecological sustainability. As agricultural transformation progresses, systems must not only become more productive and market-oriented but also resilient to climate variability and environmentally sustainable. Failure to embed climate resilience and resource conservation can reverse gains and expose livelihoods to shocks.

The relevance of this dimension is underscored by environmental production theory, which extends the neoclassical production function to include environmental assets as both inputs and outputs (Barrett, Ortiz-Bobea, & Pham, 2021). Moreover, the sustainable livelihoods framework (DFID, 1999) highlights environmental stewardship as a key form of capital, alongside human, social, and economic resources.

Climate change disproportionately affects smallholder-dominated systems through erratic rainfall, droughts, and temperature extremes, particularly in rainfed regions of sub-Saharan Africa and South Asia. Ortiz-Bobea et al. (2020) found that climate change has already reduced global agricultural total factor productivity (TFP) by up to 20% since 1961. Simultaneously, agriculture contributes significantly to climate change through emissions, land degradation, and water use—necessitating a dual focus on adaptation and mitigation (Ortiz-Bobea, Ault, Carrillo, Chambers, & Lobell, 2021).

Sustainable transformation requires widespread adoption of climate-smart practices (e.g., conservation agriculture, drought-resistant varieties, rotational grazing), supported by policies and investments that encourage low-emission development pathways.

Ideal Indicators

- Adaptation to climate variability
- Sustainable water and land management practices
- Carbon foot print of agricultural practices

Direct and Proxy indicators used

1. Agricultural methane emissions (kt of CO2 equivalent)
2. Forest area (% of land area)
3. Renewable internal freshwater resources per capita (cubic meters)

8.2.6 Policy and Institutional Effectiveness

Government commitment and institutional quality are among the most decisive factors in determining the success or failure of agricultural transformation. Policies set the strategic direction, while institutions implement reforms, regulate markets, and coordinate investments. This dimension evaluates the **strength, coherence, and effectiveness of agricultural policy frameworks and institutional systems**, which are essential for fostering a stable, enabling environment for transformation.

Empirical evidence shows that **policy consistency, decentralization, and inclusive governance** significantly influence transformation outcomes. For

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instance, the experience of **Bangladesh** demonstrates how long-term agricultural strategies, extension reforms, and public-private coordination enabled sustained productivity and commercialization gains. Conversely, fragmented policies and weak enforcement have been key constraints in countries where transformation has stalled (Moin & Salam, 2021).

Strong institutional support also matters for cross-sectoral coordination (e.g., between ministries of agriculture, finance, environment, and trade), local implementation, and monitoring. In the face of growing complexity, from climate change to nutrition and youth employment, agriculture requires agile, adaptive institutions that are politically and technically empowered.

Ideal Indicators

- Effectiveness of agricultural Policies
- Regulatory environment for agriculture
- Institutional support for agricultural initiatives

Direct and Proxy Indicators used

1. Government effectiveness (CC.GOV.EFF.XQ)
2. Strength of legal rights (0=weak to 12=strong) (IC.LGL.CRED.XQ)

8.3 Data Selections and Standardization

8.3.1 Data Sources

To ensure comparability, the ATI will be computed using publicly available datasets from the World Bank Development Indicators.

8.3.2 Standardisation Indicators

Given that countries report agricultural data in different units and scales, indicators must be normalised. The min-max scaling will be used to ensure comparability:

$$X' = \frac{X - X_{min}}{X_{max} - X_{min}} \times 100$$

Where :

- X'= Normalised value of an indicator
- X = Actual value of the indicator
- Xmin, Xmax = Minimum and Maximum values of the indicator across all countries in the data set

**This transformation scales all indicators to a 0 – 100 range ensuring consistent aggregation across different metrics.*

8.3.3 Weighting scheme

The HIATI dimensions will be weighted based on their importance in driving agricultural transformation as follows:

1. Agricultural Productivity and Efficiency – 25%
2. Market Integration and Value Addition – 20%
3. Structural Economic Shifts – 15%
4. Rural Infrastructure and Financial Services – 15%
5. Climate Resilience and Sustainability – 15%
6. Policy and Institutional Effectiveness – 10%

In line with economic theory and other studies, the weights reflect prioritisation of productivity and market factors but also recognise the role of sustainability and policy support (Paula, Bruno, & Jacopo, 2016). The weighting scheme reflects Conesus in development economics that improvements in productivity and market linkages are foundational to agricultural transformation aligning with the structural transformation theory. The theory emphasizes the gradual shift from subsistence to commercial agriculture as the economy grows and diversifies.

8.3.3 Robustness and comparison with indexes

To assess the robustness of the HIATI and validate its insights, a comparative review was conducted with other well-established indices and conceptual frameworks on agricultural transformation. This includes IFPRI's Agricultural Transformation Index (ATI) developed by Diao et al. (2024), Timmer's foundational work on agricultural transformation (1988), and the IISD's sustainability-based indicators (Čičkušić, Domuz, Topalović, & Bećirović, 2012).

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The IFPRI ATI provides a compelling point of comparison due to its similar structure and focus on composite measurement. Built around four core indicators staple crop productivity, diversification, labor productivity, and food system expansion IFPRI's ATI is methodologically aligned with HIATI in tracking system-wide change. However, HIATI introduces two additional dimensions (infrastructure and financial inclusion, and policy/institutional effectiveness), offering a more comprehensive lens tailored to the African context. While IFPRI's index draws strongly on macroeconomic and welfare correlations, HIATI places greater emphasis on integrating climate resilience, governance, and institutional effectiveness, which are particularly critical for Africa's agricultural transformation.

Timmer's (1988) framework remains a gold standard in understanding the stages of agricultural transformation. His emphasis on "getting agriculture moving," followed by integration into the macroeconomy, is reflected in HIATI's structure particularly in dimensions such as productivity, structural change, and market integration. Where HIATI advances this narrative is by operationalizing these theoretical constructs into measurable indicators that allow for comparative analysis across African countries, grounded in recent data and reflecting present-day development priorities such as sustainability and policy alignment.

The International Institute for Sustainable Development (IISD) approach emphasizes systems thinking and sustainability, focusing on interlinkages between agriculture, environment, and social well-being. While IISD's framework is broader and not agriculture-specific, it reinforces the importance of including climate and institutional dimensions, a principle that HIATI adopts explicitly. HIATI's inclusion of environmental indicators such as methane emissions and forest coverage echoes IISD's emphasis on the environmental footprint of development processes.

8.4 HIAT Calculation

The HIATI score for each country will be computed as:

$$HIATI = \sum (Wi \times X'i)$$

Where:
Wi = Weight assigned to dimension i
X'i = Normalised score of dimension i

8.5 Interpretation of HIATI Scores

6. HIATI > 80 – Advanced Transformation: Highly mechanised, market integrated and diversified economy
7. HIATI 60 – 79 – Transitioning: Strong productivity with structural shifts, but challenges still remain
8. HIATI 31 – 59 – Emerging: Partial Transformation but lacking infrastructure or policy support
9. HIATI < 30 – Early Stage: Predominantly subsistence agriculture, weak institutions

9. FINDINGS AND DISCUSSION

As presented in the computational methodology in the previous section, the HIATI was calculated using publicly available data from the World Bank Development Indicators.

9.1 HIATI Scores for Africa

The HIATI scores were generated at three time periods (2000, 2010, 2020) in order assess the trends over time. The study reveals some notable changes in the agricultural development stages of African countries. As shown in Figure 2, 21 countries were classified as being at an "early stage" of transformation in 2000. By 2020, this number had decreased to only 7 including South Sudan, Congo Dem. Rep. Somalia, Djibouti, Lesotho, Libya and Burkina Faso. Meanwhile, the number of countries identified as "emerging" increased from 30 in 2000 to 46 in 2020 (Figure 2 and 3) showing a gradual shift from subsistence based agricultural systems to more structured and market driven economies.

Among the 16 Countries that transitioned from early

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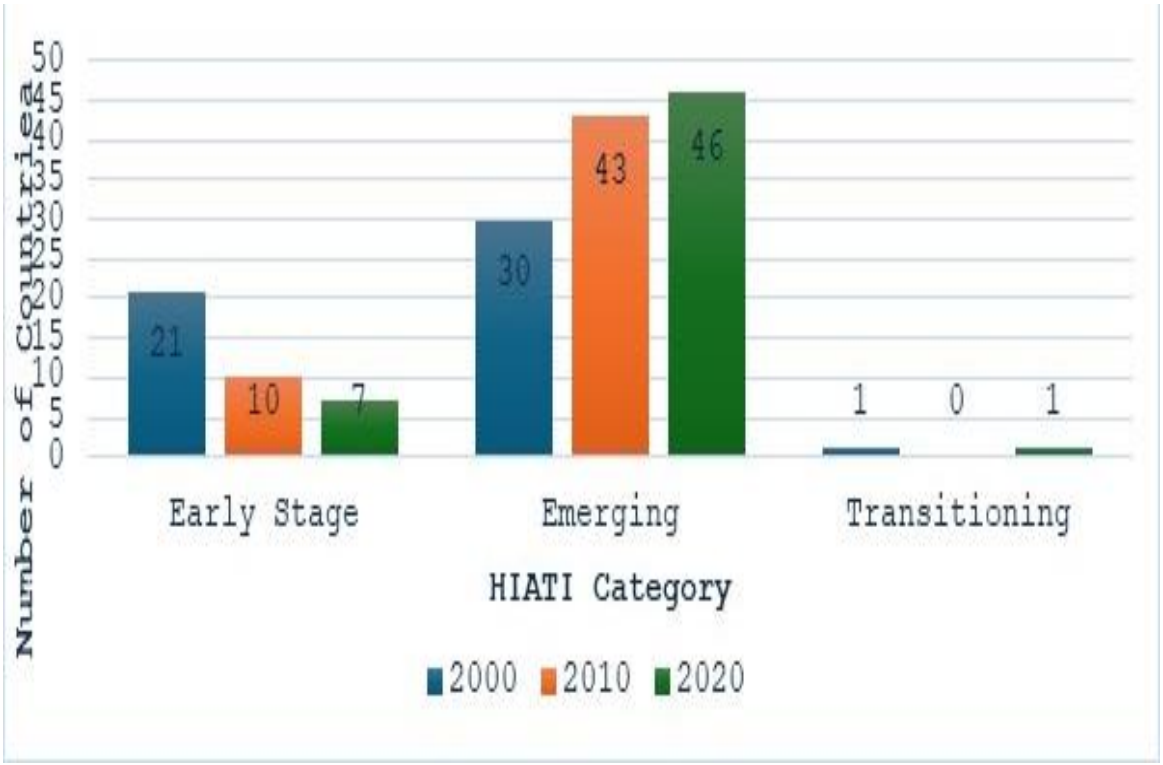

Figure 2: Number of Countries Per Category 2000, 2010, 2020

stage to emerging, Mali, Ethiopia, Guinea and Kenya were among the countries that recorded the highest HIATI scores. During the 20-year period, only one country was categorized as transitioning and none as advanced.

The findings are similar to the findings of the other indices and frameworks including the IFPRI Agricultural Transformation Index and Timmer's theoretical stages of transformation. For instance, countries such as Ethiopia, Ghana, Rwanda, and Malawi appear across all three frameworks as experiencing significant progress in agricultural transformation. For instance, in HIATI, Ethiopia's score rose from 31 (early stage) in 2000 to 47 (emerging) in 2020, signaling strong gains in productivity and market integration. This aligns with IFPRI ATI findings, where Ethiopia recorded one of the highest score increases among Feed the Future countries.

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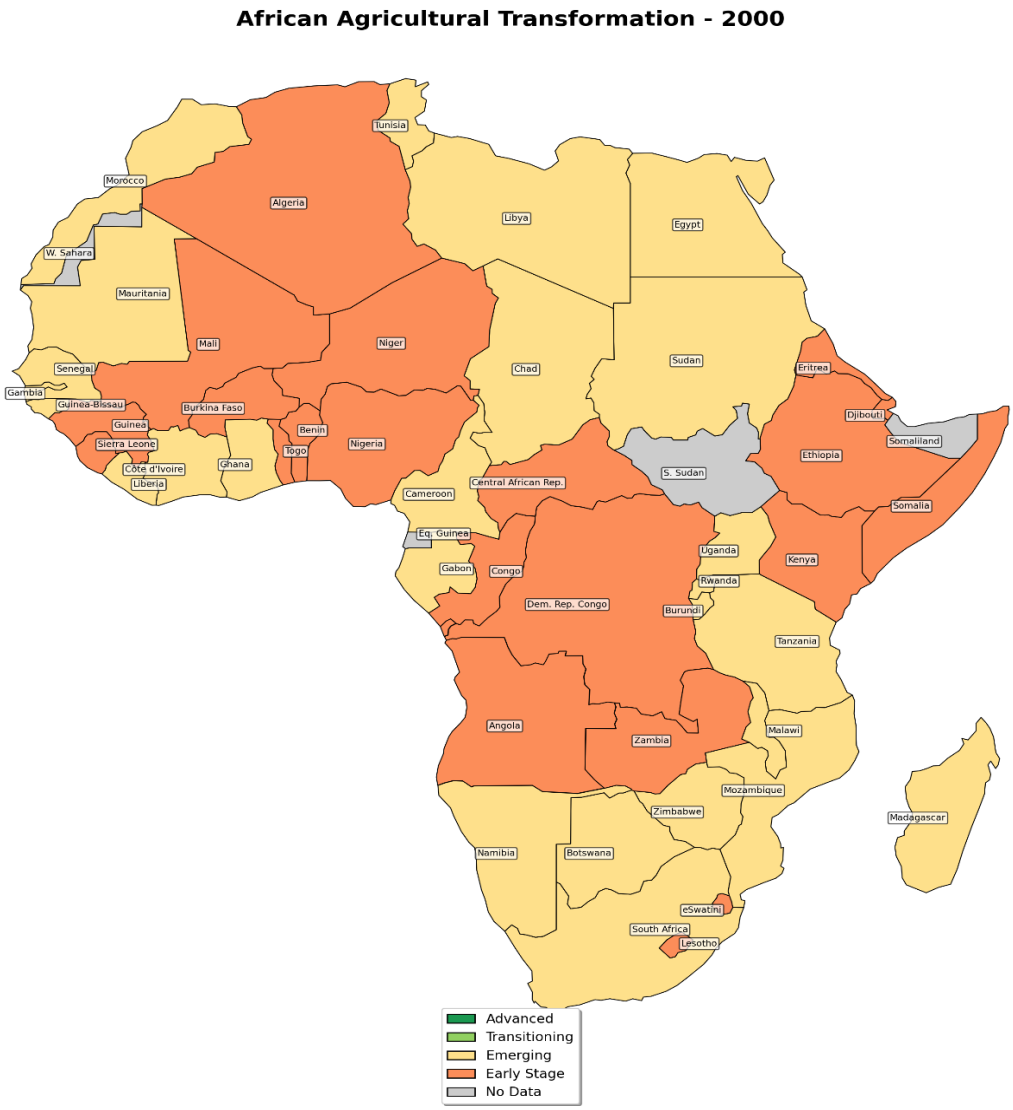

Figure 3: African Agricultural Transformation map - 2000

Similarly, Ghana and Rwanda are shown to have sustained improvements in both indices. Ghana maintained an emerging transformation status in HIATI with a consistent score rise from 37 to 43 between 2000 and 2020. Rwanda also showed upward momentum, rising from 32 to 40 during the same period. The IFPRI ATI supports this trend, noting
Rwanda's gains exceeding 0.30 points over two decades driven primarily by improvements in food system expansion and labor productivity

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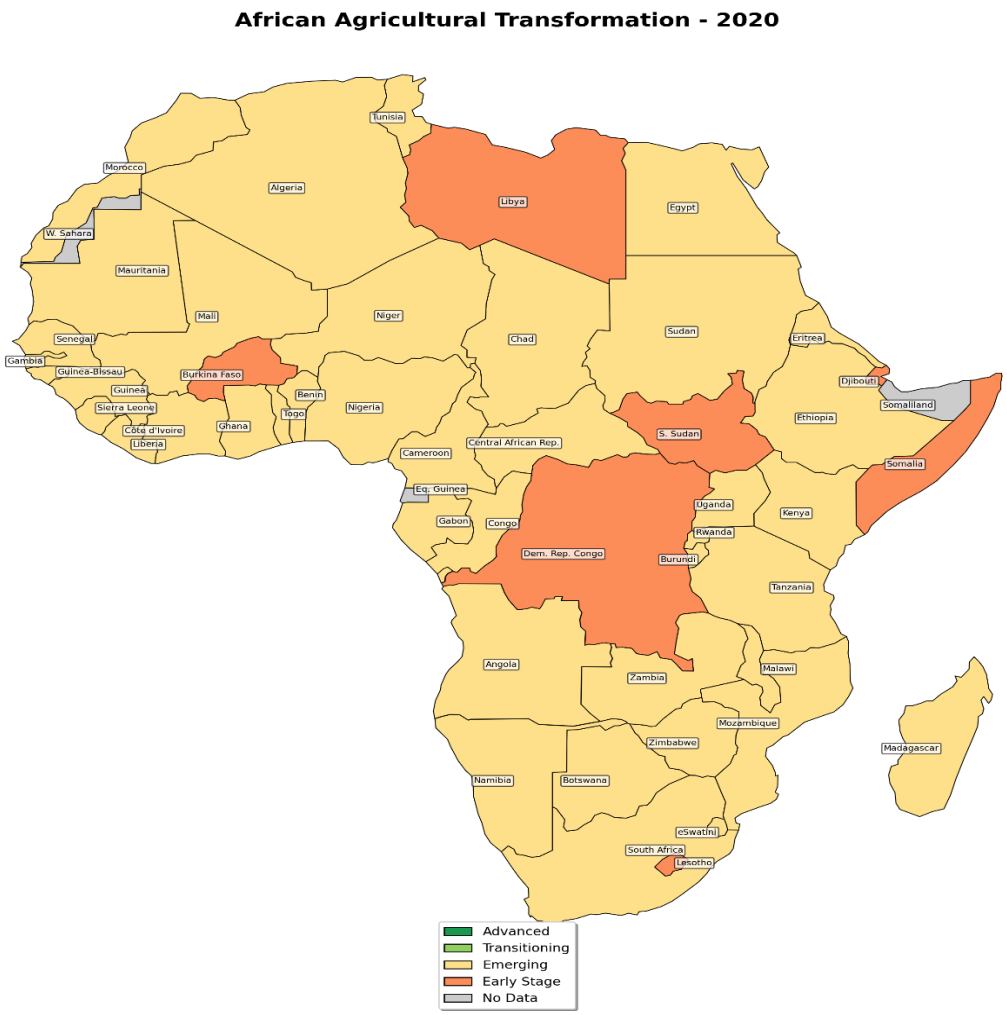

Figure 4; Africa Agricultural Transformation Map - 2020

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Table 1: Country Categorisation 2000, 2010 and 2020

Country Name	2000 Score	Category	2010 Score	Category	2020 Score	2020 Category
Algeria	27	Early Stage	31	Emerging	35	Emerging
Angola	28	Early Stage	31	Early Stage	31	Emerging
Benin	31	Early Stage	36	Emerging	36	Emerging
Botswana	32	Emerging	37	Emerging	39	Emerging
Burkina Faso	25	Early Stage	29	Early Stage	29	Early Stage
Burundi	32	Emerging	35	Emerging	35	Emerging
Cabo Verde			45	Emerging	45	Emerging
Cameroon	31	Emerging	34	Emerging	40	Emerging
Central African Republic	25	Early Stage	31	Early Stage	32	Emerging
Chad	33	Emerging	32	Emerging	34	Emerging
Comoros	35	Emerging	35	Emerging	38	Emerging
Congo, Dem. Rep.	30	Early Stage	32	Emerging	27	Early Stage
Congo, Rep.	31	Early Stage	29	Early Stage	32	Emerging
Cote d'Ivoire	32	Emerging	32	Emerging	41	Emerging
Djibouti	30	Early Stage	29	Early Stage	30	Early Stage
Egypt, Arab Rep.	40	Emerging	43	Emerging	41	Emerging
Equatorial Guinea	45	Emerging	39	Emerging	40	Emerging
Eritrea	30	Early Stage	34	Emerging	36	Emerging
Eswatini	28	Early Stage	34	Emerging	35	Emerging
Ethiopia	31	Early Stage	41	Emerging	47	Emerging
Gabon	41	Emerging	41	Emerging	48	Emerging
Gambia, The	39	Emerging	43	Emerging	35	Emerging
Ghana	37	Emerging	37	Emerging	43	Emerging
Guinea	27	Early Stage	34	Emerging	39	Emerging
Guinea-Bissau	33	Emerging	36	Emerging	36	Emerging
Kenya	30	Early Stage	34	Emerging	42	Emerging
Lesotho	29	Early Stage	29	Early Stage	26	Early Stage
Liberia	36	Emerging	37	Emerging	34	Emerging
Libya	31	Emerging	29	Early Stage	24	Early Stage
Madagascar	34	Emerging	33	Emerging	35	Emerging
Malawi	35	Emerging	34	Emerging	41	Emerging

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Table 2 cont.

Mali	24	Early Stage	33	Emerging	43	Emerging
Mauritania	33	Emerging	27	Early Stage	34	Emerging
Mauritius	45	Emerging	54	Emerging	52	Emerging
Morocco	42	Emerging	44	Emerging	46	Emerging
Mozambique	34	Emerging	36	Emerging	38	Emerging
Namibia	39	Emerging	38	Emerging	38	Emerging
Niger	27	Early Stage	32	Emerging	33	Emerging
Nigeria	28	Early Stage	30	Early Stage	32	Emerging
Rwanda	32	Emerging	37	Emerging	40	Emerging
Sao Tome and Principe	56	Emerging	42	Emerging	41	Emerging
Senegal	36	Emerging	36	Emerging	44	Emerging
Seychelles	62	Transitioning	58	Emerging	71	Transitioning
Sierra Leone	25	Early Stage	36	Emerging	34	Emerging
Somalia	21	Early Stage	31	Emerging	27	Early Stage
South Africa	38	Emerging	44	Emerging	46	Emerging
South Sudan					24	Early Stage
Sudan	35	Emerging	37	Emerging	31	Emerging
Tanzania	34	Emerging	34	Emerging	39	Emerging
Togo	26	Early Stage	28	Early Stage	35	Emerging
Tunisia	38	Emerging	40	Emerging	45	Emerging
Uganda	36	Emerging	38	Emerging	38	Emerging
Zambia	28	Early Stage	32	Emerging	34	Emerging
Zimbabwe	38	Emerging	32	Emerging	32	Emerging

The HIATI scores for all countries are indicated in Table 1. The data shows a general trend of improvement over the 20-year period as follows:

- Number of countries categorized as “early stage” of agricultural transformation decreased from 21 in 2000 to 7 in 2020.
- The number of countries categorized as “emerging “increased from 30 in 2000 to 46 in 2020.

While the data points to a positive outlook, it is important to further interrogate the factors driving these changes. In particular, the study analyses the transformation drivers for countries that progressed from the early stage to the emerging category. The study also assesses if the countries within the emerging category have experienced regression and the dimensions of the index that account for the reduced growth. Finally, the study examines the countries that have experienced slow growth over the 20 years period.

Countries moving from Early Stage to Emerging (2000 – 2020)

A total of 16 Countries transitioned from “early stage” to “emerging” during the period 2000 and 2020. In this category, 13 countries recorded an increase in the HIATI score by more than 5 points with an average increase of 9.42.

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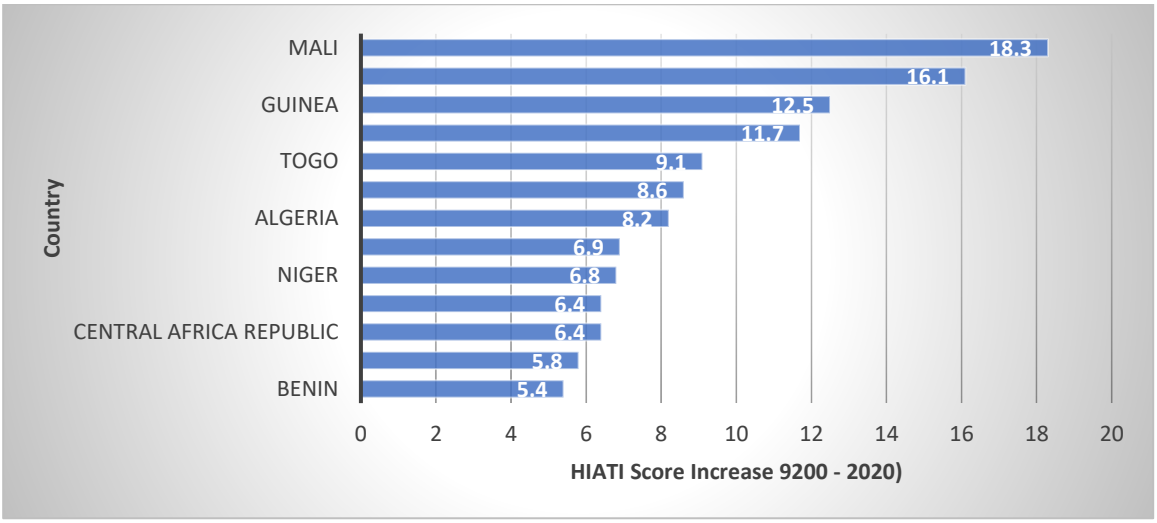

Figure 5: Countries Moving from Early Stage to Emerging with HIATI score >=5

As shown in Figure 5, Mali and Ethiopia recorded the highest increase in their HIATI scores with 18.3 and 16.1 points respectively. Three countries recorded an HIATI growth of less than 5 points with an average increase of 2.46 as illustrated in Figure 6.

Angola and Congo Rep. recorded the least improvements in their HIATI scores by 2.8 and 0.9 points respectively

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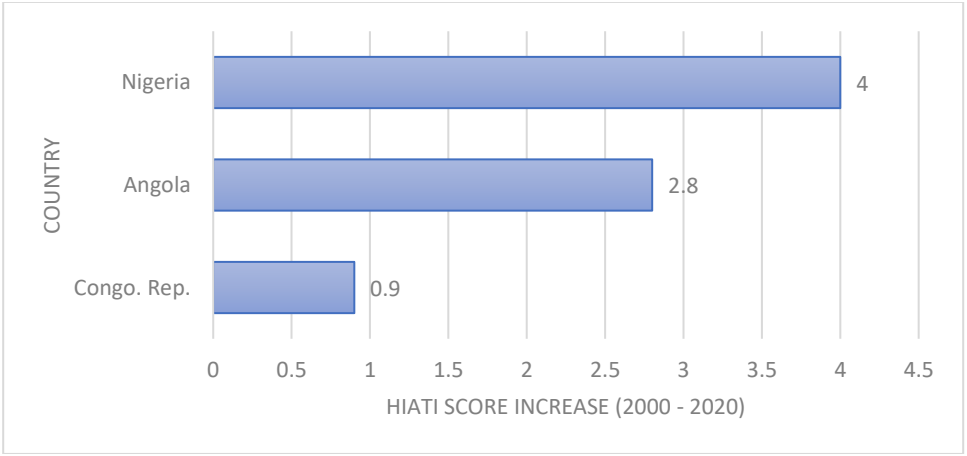

Figure 6: Countries Moving from Early stage to Emerging with an HIATI Score of <= 5

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9.2 Drivers of Agriculture Transformation in countries that moved from early stage to emerging

To assess the drivers of transformation for countries that moved from early stage to emerging, countries were assessed against six dimensions of transformation ranging from agricultural productivity to structural economic shifts. Figure 7 depicts which dimensions accounted for transformation for countries that moved from early stage to emerging category.

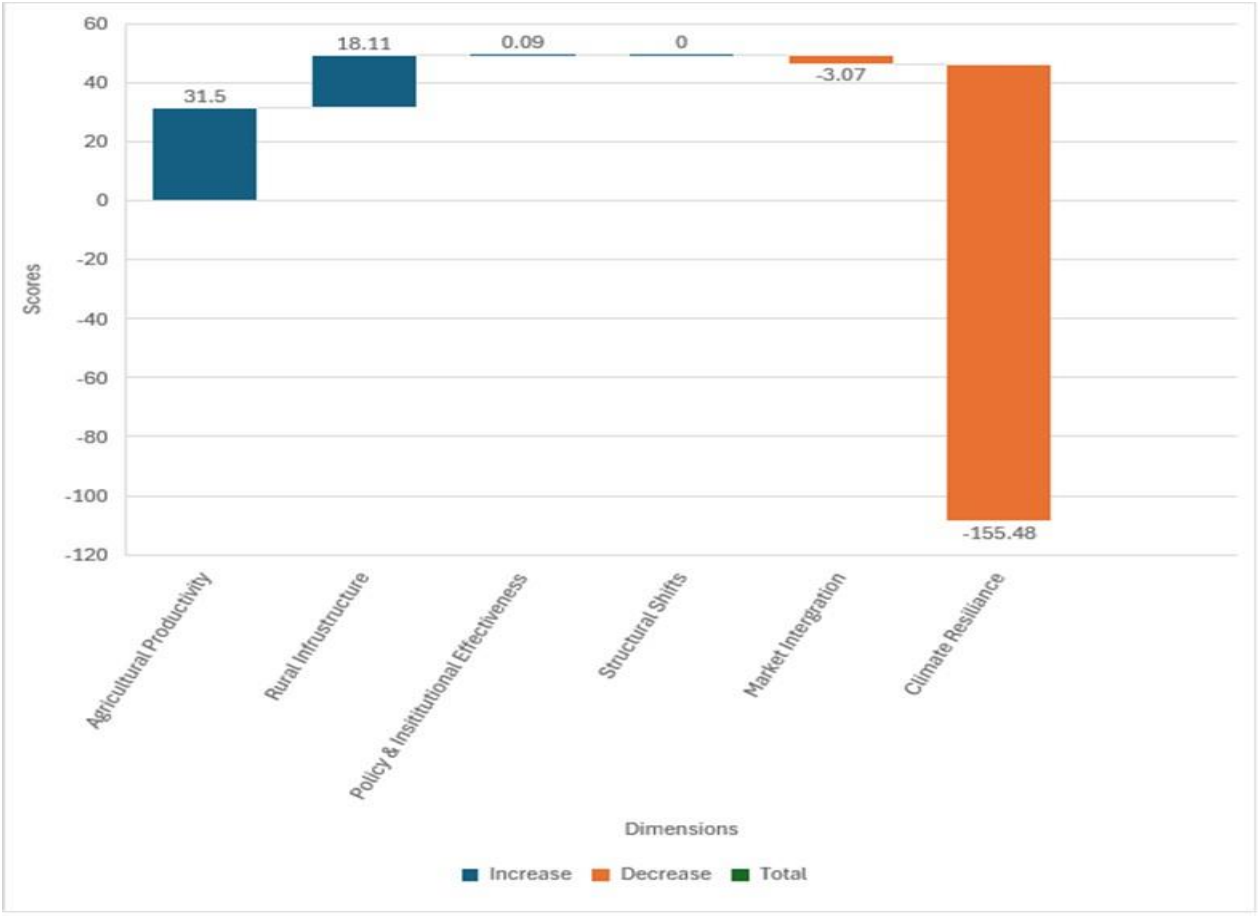

Figure 7: Dimension Scores for countries that moved from early stage to emerging

The analysis shows that “Agricultural Productivity and Efficiency” and “Rural Infrastructure and Financial Services” are the two top dimensions contributing to agricultural transformation accounting for 31.5 points and 18.1 points respectively. This shows that advancements in agricultural productivity through enhancements in crops yields, improvements in farming techniques and adoption of new technologies plays an important role in driving

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agricultural transformation. Furthermore, improved rural infrastructure such better road network, irrigation systems and better access to financial services have facilitated access to markets and easier access to capital for farmers.

Despite these improvements, the findings also indicate that agricultural progress was not uniform. For instance, some countries within the emerging category stagnated and recorded reduced HIATI scores.

9.3 Countries experiencing reduced HIATI scores within the same category

As shown in Figure 8, Equatorial Guinea, Gambia, Liberia, Namibia, Sao Tome, Sudan and Zimbabwe experienced a decline in their HAITI scores within the emerging category.

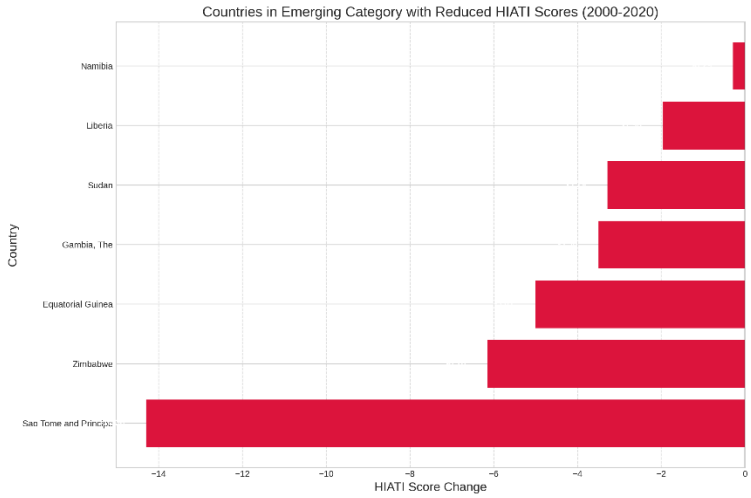

Figure 8: Countries in Emerging Category with reduced HIATI scores 2000 - 2020

Sao Tome recorded the most decline (-14.30 points), followed by Zimbabwe (-6.16 points) and Equatorial Guinea (-5.01 points). These findings are consistent with IPFRIs index. Both HIATI and IFPRI highlight countries that have stagnated or regressed, such as Liberia and Mali. HIATI places them among the group whose transformation scores plateaued, while IFPRI attributes this to declining crop diversification and staples productivity, particularly in Mali, Liberia, and Uganda. These shared insights underscore the fragility of transformation when diversification and environmental resilience are not sustained.

Moreover, Timmer's framework suggests that countries early in their development should exhibit gains through "getting agriculture moving"—typically through input use and basic infrastructure. This maps well onto HIATI results where countries like Kenya, Guinea, and Mali recorded some of the highest score jumps, moving from early-stage to emerging transformation largely due to improvements in productivity and institutional support, echoing Timmer's early transformation phase

9.4 Factors contributing to reduced HIATI Scores

In order to establish the dimensions that influence the HIATI scores, a correlation heatmap was used. The results indicate varying degrees of correlation between different dimensions of the HIATI scores:

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- Structural Economic Shifts accounted for the strongest negative correlation (-0.82) implying that countries with improvements in this area had small reductions in their overall HIATI scores.
- Climate Resilience and Sustainability also showed a negative correlation (-0.39) suggesting that improvements in climate resilience are linked to better agricultural transformation.
- Market integration and value addition showed a weak negative correlation (-0.24) indicating a minor influence on agricultural transformation

As demonstrated in Figure 9, these findings underscore the complexity of factors influencing agricultural transformation in Africa. The slow structural transformation of the economy shows the low efficiency of the primary sectors in catalysing the growth of secondary economic sectors including labour movements from agriculture to other non-agricultural sectors. Additionally, climate related challenges such as extreme weather events and water scarcity have exacerbated vulnerabilities leading to reduced agricultural productivity in some regions. This indicates that while agriculture transformation is progressing in certain parts of Africa, it remains fragile in the absence of climate adaptation measures.

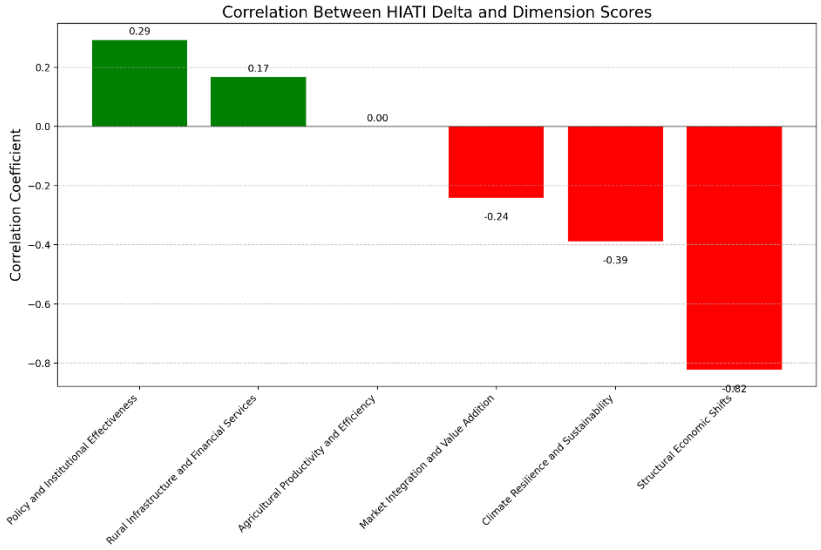

Figure 9: Correlation Between HIATI Delta and Dimension Scores

Rural Infrastructure and Financial Services showed a weak positive correlation of (0.17), which suggest a slight positive impact on agricultural transformation. Agricultural Productivity and Efficiency showed no correlation implying that changes in this dimension did not significantly affect the HIATI scores.

10. Computation of Zambia's HIATI

Given the way the HIATI is computed, it possible to get insights at the country level in terms of the drivers of transformation and the areas that need more attention. For this purpose, the study delves into the agricultural

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transformation status and trends for Zambia with a view of identifying the drivers and challenges of agricultural transformation.

10.1 Overview of Agriculture in Zambia

While Zambia has recorded some progress in the agriculture sector since independence, the agriculture sector has not transformed to the levels required to catalyse structural change. The country's agriculture sector is heavily dependent on rain with limited agricultural mechanisation, low efficiency, and inadequate market integration. These challenges slow the rate of agricultural transformation and restrict the sector's potential to drive economic growth.

10.2 HIATI Scores for Zambia

The study findings show that Zambia's HIATI scores have increased from 28 in 2000 to 34 in 2020 reflecting a gradual improvement as depicted in Figure 10 below;

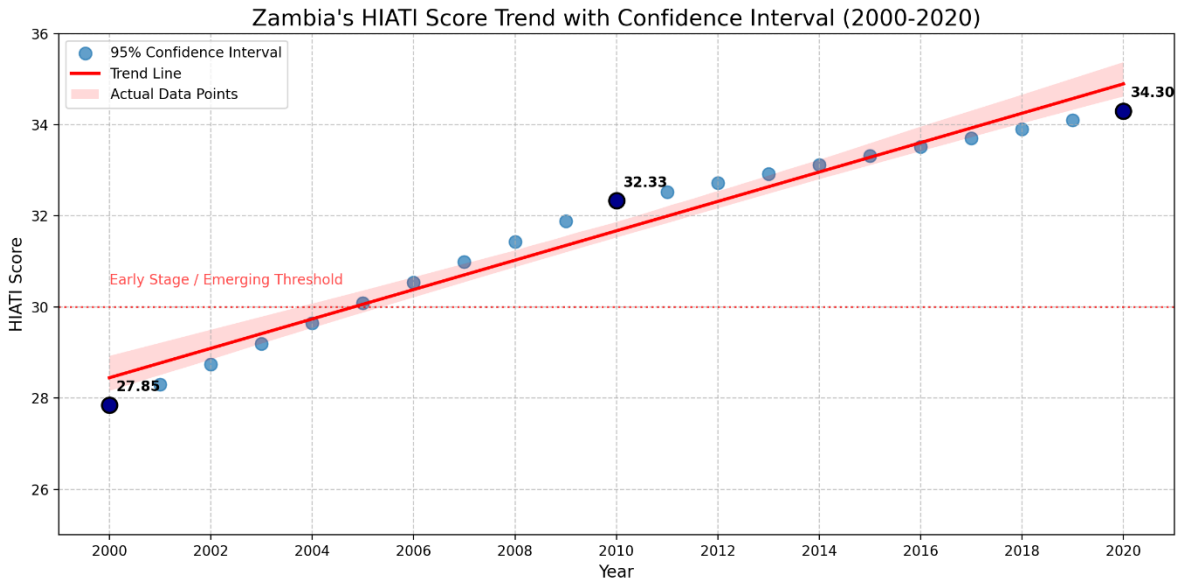

Figure 10: Zambia's HIATI Score Trend with Confidence Interval 2000 - 2020

The study shows that structural economic shifts and Policy and Institutional Effectives were the main drivers behind this improvement. This was followed by Market integration and value addition contributing about 16.77. These results align with insights from **IAPRI (2009, 2020)** and other studies, which have long pointed to Zambia's strong macro-policy frameworks, such as the Second National Agricultural Policy (NAP II) and recent reforms under the Comprehensive Agricultural Transformation Support Programme (CATSP) (Mason, Jayne, Chapoto, & Weber, 2009). These policy shifts emphasize public-private partnerships, enabling environments for irrigation,

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and development of agro-industrial corridors (Chapoto, Mulenga, Kabisa, & Muyobela, 2020).

Despite these improvements, the country recorded low scores on some other critical dimensions of transformation such Agricultural Productivity and Efficiency (12.32) and Rural Infrastructure and Financial Services (15.86).

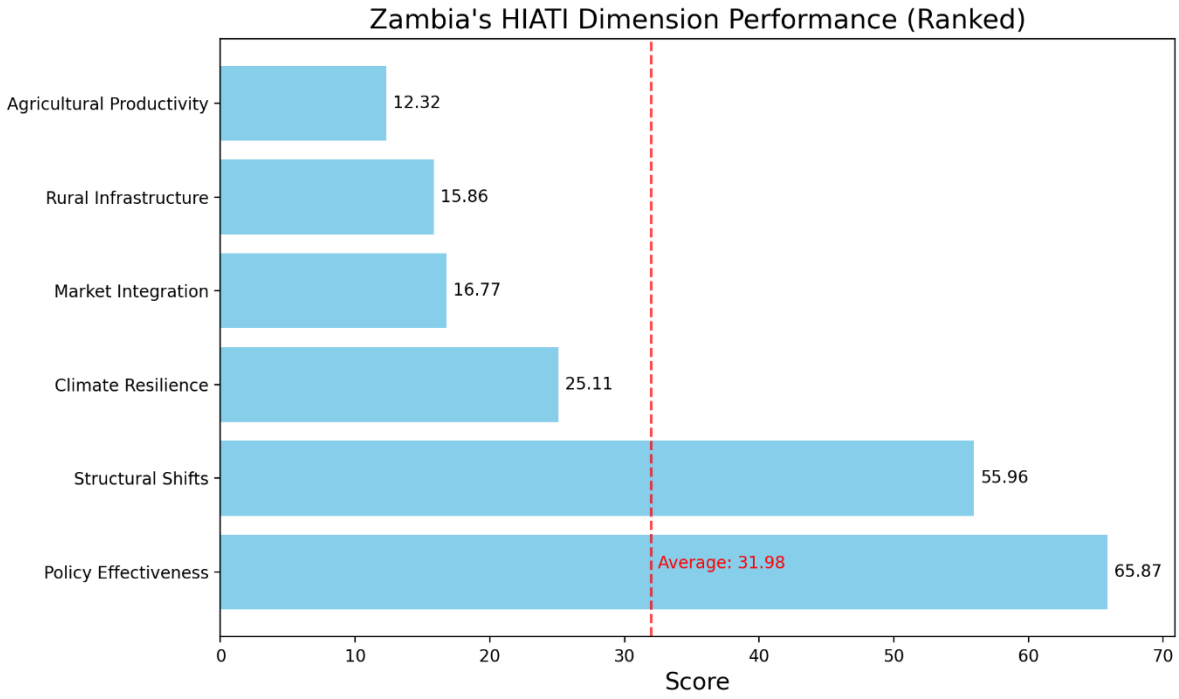

Figure 11: Zambia's HIATI Dimension Performance (Ranked)

These findings are consistent with conclusions from Food Security Research Project (FSRP, 2011) and the AFRICAP participatory scenario planning report (GCRF-AFRICAP, 2019). Both sources highlight low mechanisation, rain-fed dependency, limited irrigation (only 156,000 ha irrigated out of 2.75 million ha potential), and low maize yields (~2 t/ha vs. a 3 t/ha target). This is also echoed in Zulu et al. (2000) who note stagnation in smallholder maize production and weak market orientation, which corroborates the HIATI findings of poor performance in productivity and infrastructure dimensions (Zulu, ayne, & Beaver, 2000).

,,,,,,These results highlight the need for immediate action to improve agriculture productivity and rural infrastructure and financial services. As shown in Figure 12, Zambia lags behind the regional average on a number of indictors including Market Integration, Rural Infrastructure and Climate Resilience.

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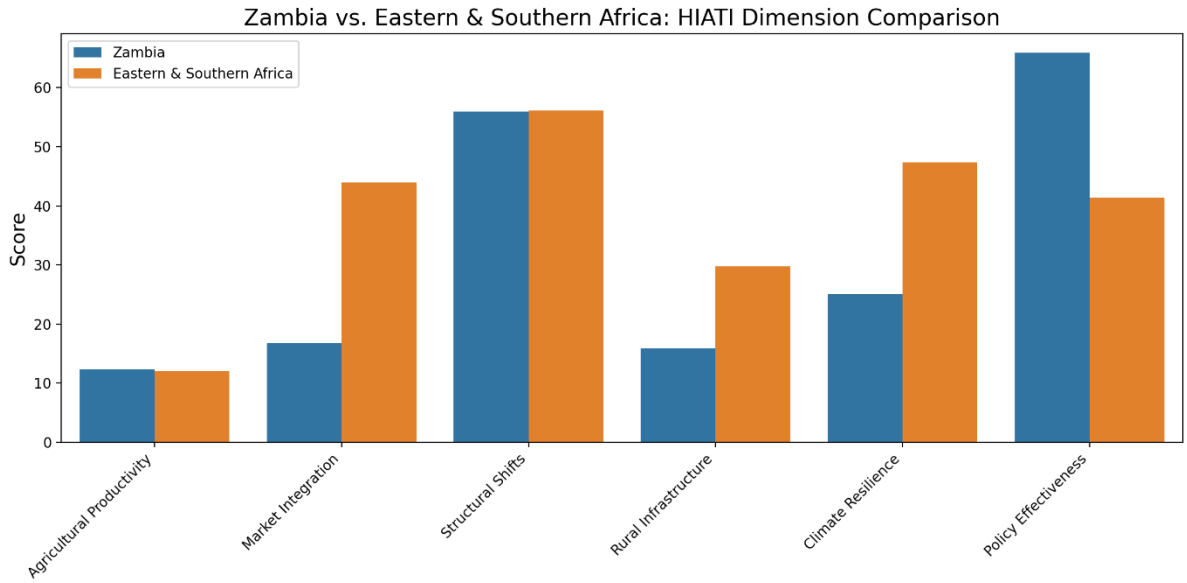

Figure 12: Zambia vs. Eastern and Southern Africa: HIATI Dimension Comparision

Market integration, while improving slightly in HIATI (contributing 16.77% to Zambia's score), is another area of partial alignment. Studies have shown that while Zambia has expanded export markets (e.g., soybean, cotton, horticulture), marketing inefficiencies and inadequate infrastructure continue to constrain full integration. For example, Tembo and Jayne (2009) and (Tschirley & Jayne, 2010) note that better-performing smallholders tend to dominate markets, but the majority remain disengaged due to lack of infrastructure and support services (Tembo, 2010).

10.3 Conclusion and Recommendations

The HIATI has provided good insights into the status and trends of agricultural transformation in Africa during the period 2000 to 2020. The findings show a significant shift from subsistence based agricultural systems to more structured and market driven economies signalling a continent-wide progression towards improved agricultural transformation and economic integration. The analysis shows that "Agricultural Productivity and Efficiency" and "Rural Infrastructure and Financial Services" are the two top dimensions contributing to agricultural transformation.

Despite these improvements, the findings also indicate that agricultural progress was not uniform. For instance, some countries within the emerging category stagnated and recorded reduced HIATI scores. The reduced performance is due to the low scores for 2 dimensions including (i) Climate Resilience and (ii) Structural Economic Shifts. This indicates that while agriculture transformation is progressing in certain parts of Africa, it remains fragile in the absence of climate adaptation measures.

For Zambia, the index indicates a gradual but positive trend in agricultural transformation with high scores in policy and institutional effectiveness and structural economic shifts. Despite the gains, the country scores low on critical drivers of transformation including agricultural productivity and rural infrastructure.

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Policy Implications – Continental Level

1. Given that Rural Infrastructure and Financial Services and Agricultural Productivity and Efficiency are identified as the main drivers of agricultural transformation, there is need to maintain and strengthen investments in these areas.
2. Governments and development partners should prioritise policies that support access to improved farming inputs such as fertilizers, improved seeds and mechanisation. Expanding access to rural financial services also remains critical in maintaining and catalysing transformation.
3. Facilitating market linkages through better infrastructure and digital agriculture platforms will contribute to more resilient agricultural systems.
4. Given the low performance of climate resilience, countries should strengthen their efforts to integrate climate adaptation strategies such as climate smart agriculture, disaster risk reduction and sustainable land management in agriculture development plans and prioritise policies that incentivize farmers to adopt climate resilient practices.

Policy implications Zambia

1. Prioritise investments aimed at improving agricultural productivity and rural infrastructure: The focus should be on addressing persistent productivity constraints by investing in agricultural research and extension, irrigation expansion, and mechanization services, especially for smallholder farmers.
2. Invest in climate resilience building initiatives: Given Zambia's high vulnerability to climate shocks and the HIATI's low climate resilience scores, the government should scale up climate-smart agriculture (CSA) practices, including conservation agriculture, agroforestry, drought-resistant seed systems, and water harvesting technologies.
3. Enhance implementation capacity of agricultural policies and programmes: While Zambia performs well on policy and institutional frameworks (as reflected in the HIATI score), implementation remains uneven. Strengthening institutional capacity at both national and subnational levels—including better coordination among ministries and increased agricultural budget execution—will be essential. Monitoring mechanisms should be institutionalized to track performance of flagship programmes like FISP and CATSP, and ensure alignment with farmer needs and emerging development priorities.

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