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Agroecological Food Systems Transition Architecture (AFSTA): From Evidence Synthesis to Modelling Transboundary Climate Risks and Food-System Transition Pathways in Africa

Solomon M. Nzioka

nzioka_sm@yahoo.com

Phoenix Climate and Health Impact Experts

Patrick K. Ketiem

Kenya Agricultural and Livestock Research Organization

Alice W. Murage

Kenya Agricultural and Livestock Research Organization

George W. Wanjala

Kenya Industrial Research and Development Institute

Moustapha Guèye

Institut Sénégalais de Recherches Agricoles

Júlio Manjate

Instituto de Investigação Agrária de Moçambique

Kelvin Namukhasi Khisa

Kenya Industrial Research and Development Institute

Robert Kilonzo

Phoenix Climate and Health Impact Experts

Lolem Lokolile Bosco

Ministry of Health

Duba Golicha

Kenya Agricultural and Livestock Research Organization

Godwin Macharia

Kenya Agricultural and Livestock Research Organization

Systematic Review

Keywords: climate risk, food systems, agroecology, transition pathways, food-trade networks, transboundary risk

Posted Date: October 13th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11131918/v1

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Additional Declarations: No competing interests reported.

Abstract

Climate-related risks to food systems can extend beyond the location of a climatic hazard through changes in production, resource availability, markets, trade and other interdependencies. Existing approaches provide methods for analysing climate impacts, food-system transformation, agroecological transition, resilience and network transmission, but these processes are often examined separately. We develop the Agroecological Food Systems Transition Architecture (AFSTA) as an evidence-derived architecture for subsequent modelling of transboundary climate risks and food-system transition pathways in Africa. A structured narrative synthesis was organised around six domains: climate hazards and food-system shocks; production and resource responses; trade, markets and network transmission; cross-border and cascading risks; sustainable and agroecological transition pathways; and trade-offs, synergies and resilience outcomes. The synthesis identifies the relationships required to connect climate forcing with production responses, network-mediated transmission, transboundary effects, transition pathways and multidimensional outcomes, with comparative application to Kenya, Mozambique and Senegal. AFSTA treats transition pathways as changes in food-system and network configuration that can modify subsequent risk transmission. The study defines the system boundary and modelling requirements for formalisation, parameterisation, calibration and validation. AFSTA is not an executable model and does not present model-generated pathway results.

1. Introduction

Climate change affects food systems through changes in temperature, precipitation, drought, flooding and other extremes. These hazards affect agricultural production and the water and other resources required for production, with consequences for food availability, prices and livelihoods [1, 2]. Effects can extend beyond the location of the initiating hazard when changes in production alter food supply, trade and markets in connected locations [3]. Climate risk in food systems therefore includes direct effects as well as indirect and cascading effects transmitted through connected systems [1, 3].

Africa is exposed to substantial climate-related agricultural risk, with effects varying across regions, crops and production systems [4]. Anthropogenic climate change has already affected agricultural productivity, with heterogeneous effects across locations and production systems [5]. The IPCC identifies significant risks to African food production, water resources and food security [6]. Trade can buffer local production losses by providing alternative supplies, but dependence on particular suppliers can also transmit shocks between countries [7]. Network structure, reserves and connectivity influence the extent to which disturbances are absorbed or redistributed [8, 9].

Food-system transition introduces further interactions. Agroecological approaches address ecological processes, diversity, resource use and interactions among production, environmental and social dimensions [10, 11]. Sustainable food-system transition can involve changes in production practices, resource management, markets, knowledge systems, institutions and governance [10–13]. These

changes can affect productivity, environmental performance, resource requirements, livelihoods and resilience, creating trade-offs among objectives [12–14].

Several modelling traditions address parts of this problem. Climate and crop models estimate agricultural responses to climatic conditions [15]. Economic and food-system models represent production, demand, prices and trade [16]. Network models represent interdependence and shock transmission [7–9], while scenario and pathway approaches examine alternative food-system configurations [16–18]. These approaches provide established capabilities but do not consistently connect climate forcing, production responses, network transmission, transition and transboundary outcomes within one analytical structure [15–18].

The modelling problem addressed here is therefore one of connection rather than replacement. AFSTA specifies relationships among six domains: climate hazards and food-system shocks; food production and resource responses; trade, markets and network transmission; cross-border and cascading climate risks; sustainable and agroecological transition pathways; and trade-offs, synergies and resilience outcomes. The architecture provides the analytical basis for subsequent formal modelling. It does not constitute an executable model or present model-generated pathway results.

2. Results

2.1 Evidence synthesis and six analytical domains

The evidence synthesis identifies six connected domains that together define the AFSTA modelling problem. The domains are analytically distinct but linked through causal, network and feedback relationships.

Climate hazards and food-system shocks. Climate hazards enter food systems through temperature, precipitation, drought, flooding and other extremes. Their effects depend on timing, duration, intensity, spatial distribution and the characteristics of the affected production system [1, 4–6]. African evidence shows heterogeneous responses across crops, locations and production systems, while extreme events can generate losses that differ from responses to changes in climatic means [4, 5, 19, 20].

AFSTA therefore distinguishes climate forcing from the food-system shock generated by that forcing. The hazard is the initiating disturbance; the shock is the resulting change in production or other food-system conditions. This distinction permits a common climatic event to generate different shocks under different exposure and system conditions [5, 6, 19–21].

Food production and resource responses. Production responses are mediated by water, land, soil, inputs, management and adaptive capacity. Evidence from African systems shows that drought, heat and flooding affect agricultural productivity differently across production environments and that adaptation can reduce losses, although effectiveness and adoption vary [19–22]. Adaptation is also subject to constraints related to finance, infrastructure, technology, institutions and information [6, 21]. AFSTA

therefore treats production response as an intermediate mechanism between climate disturbance and production shock. The required sequence is climate disturbance → resource conditions → production response → production shock.

Trade, markets and network transmission. Production shocks can become transboundary risks through trade and market relationships. Trade may provide alternative supplies and buffer local shortages, while supplier dependence can transmit disturbances [7–9]. Network studies show that position within food-trade networks affects exposure to supply shocks and that trade, reserves and network structure influence transmission and buffering [7, 9, 23–26]. Climate-induced changes in production can also alter trade flows and redistribute effects across countries [24, 25]. AFSTA therefore treats markets and trade as a transmission layer whose structure can change with production and transition conditions rather than as a fixed background network.

Cross-border and cascading climate risks. Transboundary effects arise through trade, commodity substitution, price transmission, input dependence and other connections [1, 3, 7, 24–26]. Direct effects occur in systems exposed to the initiating hazard; indirect effects arise through external connections; cascading effects arise when transmitted disturbances interact with subsequent production, market, resource or institutional responses. Concurrent hazards can interact across connected systems [1, 7, 26]. AFSTA consequently traces the sequence from initiating hazard to production shock, transmission pathway, receiving-system effect, secondary response and cascading outcome. The system boundary is functional: external countries, markets or commodities enter where they form material transmission pathways.

Sustainable and agroecological transition pathways. Transition involves changes across production, resource use, markets, institutions, investment and, where relevant, consumption [10–13]. Agroecology is treated as one transition approach within the broader sustainable food-system transition landscape [10–12]. Evidence indicates that changes in crop diversity, soil management, water use, input dependence and production organisation can alter climate sensitivity while also affecting labour, costs, yields, market access and resource demand [11–13, 21, 22]. AFSTA therefore represents a transition pathway as a system configuration rather than a single intervention coefficient. A pathway can alter production, resource conditions, market relationships and network dependence, thereby changing the conditions under which subsequent climate shocks are absorbed and transmitted [16–18, 26].

Trade-offs, synergies and resilience outcomes. Transition pathways can affect several objectives simultaneously. Changes may improve resilience or environmental performance while increasing resource demand, costs or dependence on external suppliers [10–14]. Diversification and improved resource management can produce synergies, while changes in production or sourcing can redistribute risk between countries or system components [7–14, 24–26]. Resilience is treated as the capacity to absorb, adjust to and recover from disturbance while maintaining critical functions [14]. AFSTA therefore retains food security and nutrition, production, livelihoods, equity, environmental performance, economic conditions, resilience and transboundary risk as separate outcome dimensions. Trade-offs, synergies

and risk redistribution are assessed across spatial and temporal scales before any higher-order interpretation.

Together, these domains define the principal modelling sequence: climate forcing → food-system shock → production and resource response → trade and network transmission → transboundary and cascading effects → transition pathway → multiple outcomes. The sequence is not strictly linear because market conditions can affect production, transition can alter trade dependence, and repeated disturbances can change system state over time [7–9, 16–18, 24–26].

2.2 From evidence synthesis to AFSTA architecture

Existing approaches provide complementary representations of the food-system risk and transition problem. Climate-risk frameworks address exposure, vulnerability and adaptation [1, 4]. Food-system and agroecological frameworks address production, resources, nutrition, environment, livelihoods, ecological processes and governance [10–13, 15]. Resilience frameworks address absorption, adjustment, adaptation and recovery [14]. Trade and network models represent connectivity and shock propagation [7–9, 23–26], while economic and pathway models represent production, demand, prices, trade and alternative system configurations [16–18].

The evidence synthesis identifies a persistent connection problem. Climate and production models can represent biophysical responses without subsequent trade transmission; network models can propagate shocks through established structures without necessarily representing how transition changes those structures; and food-system models vary in their treatment of interactions and uncertainty [16–18, 24–26]. The unresolved sequence is therefore climate forcing → production/resource response → food-trade transmission → transboundary risk → transition pathways → multidimensional outcomes.

AFSTA addresses this by organising the relationships rather than replacing the component methods. Climate hazards generate differentiated food-system shocks. Production and resource conditions mediate the response. Markets and networks transmit or buffer the resulting disturbances. Transboundary and cascading effects are traced through receiving systems. Transition pathways modify production, resource, market, institutional and network conditions. Outcomes remain separately represented to preserve trade-offs, synergies and redistribution across locations and time. The resulting architecture provides the basis for formal model specification, while parameterisation, calibration and validation remain subsequent tasks.

Table 1
Comparative assessment of existing approaches and relevance to AFSTA

Approach	Principal representation	AFSTA modelling requirement
Climate-risk frameworks	Exposure, vulnerability, adaptation and transboundary risk [1, 4]	Connect climate risk with food-system and transition dynamics.
Food-system transformation frameworks	Production, consumption, nutrition, environment and livelihoods [10, 11, 15]	Connect food-system change with climate and network transmission.
Agroecological transition frameworks	Ecological processes, diversity, resource use, knowledge and governance [10–12]	Represent transition within connected food systems.
Resilience frameworks	Absorption, adjustment, adaptation and recovery [14]	Extend resilience assessment across connected systems and outcomes.
Trade and network models	Connectivity, shock transmission, diversification and buffering [7–9, 23–26]	Allow transition to modify network exposure and transmission.
Economic/equilibrium models	Production, demand, prices, trade and policy scenarios [16–18]	Connect economic adjustment with climate-risk transmission.
Scenario/pathway models	Alternative future configurations and transition options [16–18]	Link pathway configuration with propagation and outcome assessment.
AFSTA	Climate risk, production/resources, networks, transboundary risk, transition and multidimensional outcomes	Provides the common architecture for subsequent formalisation and testing.

The comparison shows that the component approaches are complementary. AFSTA addresses the connection among their relevant processes without requiring a single computational method.

Table 2
Evidence-derived modelling requirements and AFSTA response

Evidence domain	Modelling requirement	AFSTA response
Climate hazards and food-system shocks	Distinguish climate forcing from the food-system shock it generates.	Represent hazards as initiating disturbances producing differentiated shocks [1–6, 19–23].
Production and resource responses	Represent resource conditions and production response as mediating mechanisms.	Explicitly represent water, land, soil, inputs, management and adaptive capacity [19–23].
Trade, markets and networks	Allow network transmission to respond to shocks and system configuration.	Represent market adjustment, connectivity, supplier dependence and buffering [7–9, 23–26].
Cross-border and cascading risks	Distinguish direct, transmitted and cascading effects.	Trace effects across originating and receiving systems [1, 3, 7, 23–26].
Transition pathways	Allow pathways to change conditions under which later shocks occur.	Represent changes in production, resources, markets, institutions and networks [10–13, 16–18, 26].
Trade-offs, synergies and resilience	Retain outcome dimensions across spatial and temporal scales.	Represent production, food security, resources, environment, resilience and transboundary risk separately [10–14, 16–18, 26].

2.3 Comparative application: Kenya, Mozambique and Senegal

The initial comparative application uses Kenya, Mozambique and Senegal as differentiated national configurations within the same AFSTA architecture. The comparison retains common analytical relationships and scenario definitions while allowing climate exposure, production systems, resource conditions, institutions, data systems and market connections to vary by country.

Table 3
Comparative country configuration for AFSTA implementation

Comparative dimension	Kenya	Mozambique	Senegal
Regional network setting	East African setting, including EAC and wider international commodity connections.	Southern African setting, including SADC and wider international commodity connections.	West African setting, including ECOWAS and wider international commodity connections.
Climate-risk configuration	Heterogeneous climatic and production environments, with drought, heat and rainfall variability; KMD and NDMA provide relevant climate and drought-risk inputs.	Exposure to drought, floods and cyclones; INAM provides national climate and weather information.	Climate variability and drought- and rainfall-related agricultural stress; ANACIM provides national climate information.
Production structure	Diversified crop and livestock systems, supported by KALRO, KIRDI and AFA across research, innovation and value-chain development.	Predominantly smallholder systems undergoing modernisation, with IIAM providing agricultural research capacity.	Mixed crop–livestock systems supported by ISRA and ANCAR through research and advisory functions.
Resource constraints	Variable water, land, soil, input and technology conditions across production and agroecological systems.	Water, land, soil, infrastructure and input constraints interacting with smallholder production and modernisation.	Water, land, soil and other production-resource constraints interacting with crop–livestock systems and agricultural management.
Market/network position	EAC and international commodity connections provide pathways for supply buffering and shock transmission.	SADC and international connections provide pathways for production shocks, external supply dependence and market adjustment.	ECOWAS and international connections provide pathways for regional trade, supply adjustment and shock transmission.
External shock pathways	Imports, exports, supplier dependence and commodity flows connect domestic systems to regional and international markets.	Imports, exports, supplier dependence and commodity flows connect domestic systems to regional and international markets.	Imports, exports, supplier dependence and commodity flows connect domestic systems to regional and international markets.
Transition configuration	Production diversification, resource management, agro-industrial innovation, technology adoption and value addition, supported by national and county	Smallholder modernisation, climate-smart and agroecological practices, resource management and institutional change,	Crop–livestock integration, resource management, agricultural research and advisory systems, and production and market reorganisation,

Comparative dimension	Kenya	Mozambique	Senegal
	systems and institutions including KALRO and KIRDI.	supported by IIAM and SETSAN.	supported by ISRA, ANCAR and MASAE.
Institutional implementation conditions	National and devolved governance through the Ministry of Agriculture and Livestock Development, county governments and Council of Governors, alongside KALRO, KIRDI, KMD, NDMA, KNBS and RCMRD.	National coordination through the Ministry of Agriculture, Environment and Fisheries, IIAM, SETSAN, INAM and INE, with provincial and district administrations.	National coordination through MASAE, ISRA, ANCAR, ANACIM, ANSD, DAPSA and CSE.
Trade-offs, synergies and resilience outcomes	Production, food security and nutrition, livelihoods, environmental and economic outcomes, and resilience can be assessed alongside market dependence and risk redistribution.	Production resilience, smallholder livelihoods, resource use, food security, environmental and economic outcomes can be assessed alongside regional transmission.	Production, food security and nutrition, livelihoods, resource and environmental conditions, economic outcomes and resilience can be assessed alongside regional transmission.

The three countries provide differentiated settings rather than a closed three-country network. External countries, commodities and markets can enter where they provide material pathways for transmission, buffering or risk redistribution [3, 7–9, 23–26]. The same climate forcing or transition pathway can therefore be examined under different national starting conditions without assuming identical responses. Parameterisation, calibration and validation remain subsequent stages.

3. From AFSTA architecture to formal modelling

AFSTA defines five computational layers: climate forcing; production and resource response; trade and network transmission; transition pathways; and outcome assessment. Cross-border and cascading risk is represented through transmission pathways and outcome assessment rather than as a separate computational layer.

Climate forcing represents the timing, magnitude, duration and spatial distribution of relevant hazards. Production and resource response translates these disturbances into heterogeneous system effects conditioned by production systems, resources, management and adaptive capacity [5, 19–23]. Trade and network transmission represents domestic supply, prices, storage, imports, exports, commodity flows, supplier dependence and network structure [7–9, 23–26]. Transition pathways modify production, resource, market, institutional and investment conditions [10–13, 16–18, 26]. Outcome assessment retains food security and nutrition, production, livelihoods, equity, environmental performance, economic conditions, resilience and transboundary risk as distinct outputs.

The formal specification must distinguish direct, transmitted and cascading effects. Direct effects occur in systems exposed to the initiating hazard. Transmitted effects arise through trade and other network connections. Cascading effects arise when transmitted disturbances interact with subsequent production, market, resource or institutional responses, including concurrent shocks [1, 3, 7, 24–26]. The corresponding sequence is initiating hazard → direct effect → transmission pathway → receiving-system effect → secondary response → cascading effect.

Transition pathways should be represented as changes in system configuration rather than fixed intervention coefficients. A pathway may alter production diversity, resource efficiency, input dependence, market structure, infrastructure, governance or investment. These changes can modify import requirements, supplier dependence, production response and future shock transmission [10–13, 16–18, 26]. The same pathway can therefore be assessed across Kenya, Mozambique and Senegal without imposing a uniform response.

Uncertainty must be retained across climate forcing, production response, resource constraints, network structure, supplier dependence, transition assumptions and feedbacks. Sensitivity analysis should assess the influence of these parameters and assumptions, while structural analysis should examine alternative defensible representations of production response, trade adjustment, network propagation and transition effects [26]. Candidate computational approaches include climate–production functions, economic or equilibrium models, network propagation, system dynamics and hybrid formulations [5, 16–18, 23–26]. The architecture does not select one method in advance; the implementation should follow the relationships to be represented, available evidence, required spatial and temporal resolution, and calibration and validation requirements.

4. Discussion

AFSTA addresses a modelling problem that arises from the interaction of processes usually represented through different analytical traditions. The evidence base does not indicate an absence of methods for climate impacts, production, trade, networks or transition. It indicates the need to specify how these processes interact when climate disturbances propagate through interconnected food systems and when transition changes the configuration through which subsequent disturbances are transmitted [15–18, 23–26].

The principal analytical implication is that transboundary food-system risk cannot be specified from climate exposure or production loss alone. A production shock becomes a transboundary risk through relationships with other systems. Trade may buffer a local disturbance or transmit it through supplier dependence, while concurrent hazards can alter the capacity of networks to compensate for individual losses [7–9, 23–26]. AFSTA therefore treats network structure as part of the state of the food system rather than as a fixed external condition.

A second implication concerns transition. Transition pathways are commonly represented as scenarios or interventions applied to a food system. AFSTA instead requires the pathway to change the production,

resource, market, institutional and network configuration through which later disturbances operate. This permits analysis of pathways that reduce risk in one component while increasing dependence, resource pressure or exposure elsewhere [10–13, 16–18, 26]. The approach also accommodates feedbacks in which market conditions influence production decisions and changes in production alter future trade relationships.

A third implication concerns outcome assessment. Food security, nutrition, production, livelihoods, environmental conditions, economic performance and resilience may respond differently to the same pathway. A pathway may reduce domestic exposure while increasing external dependence, or improve production stability while increasing resource demand. Treating these dimensions separately before interpretation preserves the possibility of identifying trade-offs, synergies and risk redistribution [10–14]. This is particularly relevant to transboundary analysis because a change beneficial within one national system may alter conditions in connected systems.

The comparative application to Kenya, Mozambique and Senegal provides differentiated national configurations through which these relationships can subsequently be formalised. Kenya combines heterogeneous production environments with a devolved institutional structure and extensive regional and international market connections. Mozambique provides a predominantly smallholder setting with exposure to drought, floods and cyclones and distinct agricultural, climate and food-security institutions. Senegal provides a West African setting with mixed crop–livestock systems and different agricultural, advisory, climate and statistical institutions. These differences are not treated as separate AFSTA models; they are the country-specific conditions under which the common architecture operates.

The study has several limitations. The evidence is heterogeneous in spatial and temporal resolution, commodities, production systems, outcome definitions and analytical methods, and African evidence is uneven across countries and food-system components. The synthesis therefore does not assign common effect sizes or response functions across African food systems. The relationships identified require empirical parameterisation using variables and data appropriate to each component and country. Trade and network structures also vary by period, commodity and market, so alternative network specifications may produce different transmission patterns [7–9, 23–26].

AFSTA is consequently an architecture for formal model development, not a completed predictive model. It has no empirical parameterisation, calibration or validation and produces no model-generated pathway results. Subsequent work must translate the architecture into reproducible variable definitions, functional relationships, network representations and transition scenarios, followed by parameterisation, calibration, validation, sensitivity analysis and assessment of alternative model structures. The three-country comparison provides the initial empirical setting for that work, while the architecture remains applicable to other interconnected African food systems.

Methods

The study used a structured narrative evidence synthesis organised around six analytical domains: climate hazards and food-system shocks; food production and resource responses; trade, markets and network transmission; cross-border and cascading climate risks; sustainable and agroecological transition pathways; and trade-offs, synergies and resilience outcomes. Evidence was considered when it contributed empirical findings, established conceptual relationships or modelling approaches relevant to one or more domains and to the transboundary food-system problem.

Three evidence types were distinguished. Foundational evidence established concepts and relationships underlying climate risk, food systems, resilience, agroecology, transition and network connectivity [1, 3, 10–14]. Empirical evidence was used to examine observed relationships, with emphasis on African food systems and evidence relevant to Kenya, Mozambique and Senegal [4–6, 19–22]. Modelling and methodological evidence was used to assess how climate, production, economic, network, scenario and pathway relationships have been represented [7–9, 15–18, 23–26].

The synthesis used structured narrative comparison rather than statistical aggregation of all available effect estimates. Evidence was assigned to one or more analytical domains according to its substantive contribution, and cross-domain synthesis was then used to identify established relationships, missing connections, alternative assumptions and requirements for subsequent modelling. Targeted quantitative synthesis was considered only where studies addressing a defined question used sufficiently comparable populations, exposures, outcomes and effect measures to support meaningful pooling; no pooled estimate is reported in the present study.

The geographical emphasis was Africa. Evidence from other regions was included selectively where it established mechanisms or modelling approaches relevant to African food systems. Kenya, Mozambique and Senegal were selected as the comparative application settings because they provide differentiated climatic, production, institutional and regional-network conditions. The AFSTA system boundary is functional rather than exclusively geographical and may therefore include external countries, markets or commodity relationships where they constitute material transmission pathways [3, 7–9, 23–26].

The architecture was derived by first identifying established relationships within each domain and then examining cross-domain connections. These included climate-to-production effects, production-to-supply relationships, supply-to-trade transmission, trade-mediated cross-border effects, transition-to-system-configuration changes and outcome interactions. The resulting relationships were translated into modelling requirements concerning variables, functional relationships, network representation, transition scenarios and outcomes. Parameterisation, calibration, validation and sensitivity analysis were treated as subsequent stages rather than completed components of the present study.

AI use in manuscript preparation. AI tools were used only for limited language editing, structural review and drafting support. All scientific content, interpretation, methodological decisions, citations and conclusions were developed, reviewed and verified by the authors. No AI tool was used to generate, analyse or interpret scientific results.

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Declarations

Additional Information

Competing interests.

The authors declare no competing interests.

Ethics, Consent to Participate, and Consent to Publish declarations

not applicable.

Funding.

The authors received no direct or indirect funding to support development of this manuscript.

AI use declaration. The authors used artificial intelligence tools during manuscript preparation for limited language editing, structural review and drafting support. All scientific content, interpretation of the evidence, modelling concepts, methodological decisions, citations and conclusions were developed, reviewed and verified by the authors. The authors take responsibility for the accuracy, originality and integrity of the manuscript. No artificial intelligence tool was used to generate, analyse or interpret scientific results presented in this study.

Author Contribution

Author Paper-specific contributionSolomon M. Nzioka Lead Author and Corresponding Author. Conceived the study and defined the central modelling problem; developed the Agroecological Food Systems Transition Architecture (AFSTA) for modelling transboundary climate risks and food-system transition pathways; led the structured narrative evidence synthesis and integration of the six analytical domains; developed the analytical architecture linking climate forcing, food-system shocks, production and resource responses, trade and network transmission, transboundary and cascading risks, transition pathways, and multidimensional outcomes; coordinated the comparative framing of Kenya, Mozambique and Senegal; and led manuscript preparation, revision and final integration.Patrick K. Ketiem Contributed strategic and scientific expertise on African agricultural systems, agricultural research, climate resilience and institutional transformation; supported interpretation of how production systems, agricultural

research capacity and institutional conditions shape climate-risk responses and transition pathways; contributed to the African agrifood-system framing; and critically reviewed and revised the manuscript.Alice W. Murage Contributed expertise in agricultural economics and food-system analysis, including socioeconomic dimensions of transition, food-system foresight, scenario and pathway considerations, and assessment of transition trade-offs; supported interpretation of how economic and socioeconomic conditions interact with production, markets and transition choices; and critically reviewed and revised the manuscript.George W. Wanjala Contributed Kenya-specific food-system evidence and expertise in food technology, agro-processing, innovation systems and value-chain transformation; supported interpretation of production, processing, market and value-chain mechanisms relevant to climate-shock transmission and food-system transition; and critically reviewed and revised the manuscript.Moustapha Guèye Contributed Senegal-specific agricultural-system evidence and institutional context, including interpretation of national food-system conditions and transition pathways within the West African setting; supported the comparative grounding of AFSTA in Senegal; and critically reviewed and revised the manuscript.Júlio Manjate Contributed Mozambique-specific agricultural research-system evidence and institutional context, including agricultural research coordination and interpretation of national food-system transition pathways; supported the comparative grounding of AFSTA in Mozambique; and critically reviewed and revised the manuscript.Kelvin Namukhasi Khisa Contributed expertise in environmental policy, resource efficiency, and green and circular economy approaches, including the institutional and environmental perspectives relevant to KIRDI; supported interpretation of resource conditions, environmental pressures, policy responses and transition mechanisms within the AFSTA architecture; and critically reviewed and revised the manuscript.Robert Kilonzo Contributed expertise at the food safety, food quality and public-health interface; supported interpretation of food-system outcomes and the relationships between food-system conditions, food safety and public-health considerations within the broader transboundary risk and transition analysis; and critically reviewed and revised the manuscript.Lolem Lokolile Bosco Contributed expertise in environmental health and climate–health and public-health dimensions; supported interpretation of the health implications of climate-related food-system disturbances and transboundary effects; contributed the Ministry of Health perspective to the assessment of food-system resilience and outcomes; and critically reviewed and revised the manuscript.Duba Golicha Contributed KALRO evidence and expertise in sustainable agriculture, soil and resource management, and dryland agricultural systems; supported interpretation of production and resource responses to climate stress and the implications of sustainable and agroecological transition pathways; and critically reviewed and revised the manuscript.Godwin Macharia Contributed crop-science and plant-breeding expertise, including evidence concerning food-crop production and climate-related production-system responses; supported interpretation of crop and production mechanisms within the food-system risk pathway and their relevance to transition options; and critically reviewed and revised the manuscript.

Data availability

No new datasets were generated or analysed for this study. The study synthesises published literature and publicly available documentary evidence.

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Figures

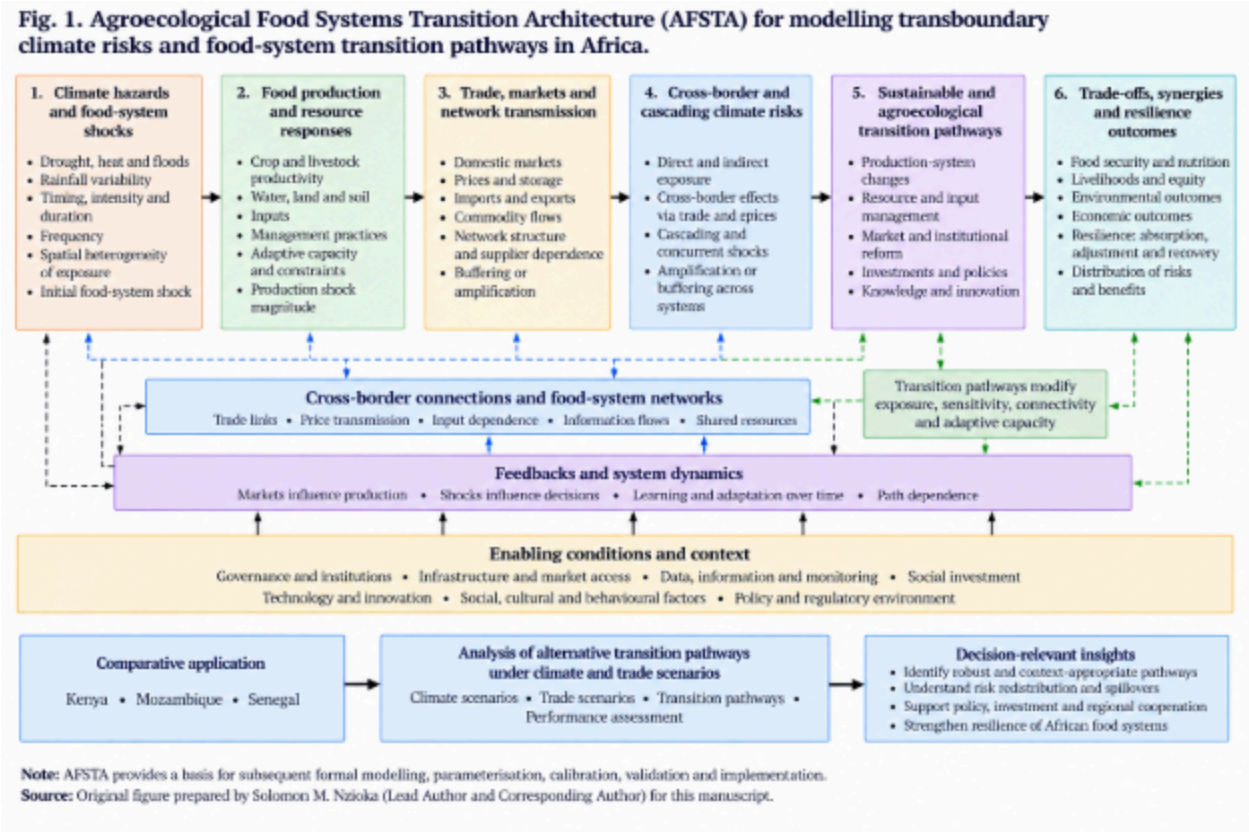


Figure 1

Agroecological Food Systems Transition Architecture (AFSTA) for modelling transboundary climate risks and food-system transition pathways in Africa. AFSTA comprises six interconnected domains: climate hazards and food-system shocks; food production and resource responses; trade, markets and network transmission; cross-border and cascading climate risks; sustainable and agroecological food-system transition pathways; and trade-offs, synergies and resilience outcomes. Cross-border connections and food-system networks provide transmission pathways, while feedbacks represent interactions among production, markets, transition and repeated disturbances. Enabling conditions and context influence these processes. The comparative application to Kenya, Mozambique and Senegal provides differentiated national settings for examining alternative transition pathways under climate and trade scenarios. The architecture provides the basis for subsequent formal modelling, parameterisation, calibration, validation and implementation; it is not an executable model and does not present model-generated pathway results.