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NESTLER

NESTLER oNe hEalth SusTainabiLity partnership between EU-AFRICA for food sEcuRity

Deliverable D1.2
EU - AFRICA Food Security Roadmap

Authors	Dr Rabbi (IITA)
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Abstract	The report outlines the food security priorities of key African countries (i.e. Nigeria, Ethiopia, Uganda, Rwanda, Kenya, and Cameroon) and aligns them with the broader goals of the One-Health initiative. These priorities include improving agricultural productivity, promoting climate resilience, addressing malnutrition, and enhancing sustainable livestock management. Based on them, the report proposes a EU-Africa Food Security Roadmap. Moreover, it also documents collaborative activities between the EU and African countries, focusing on initiatives that promote One-Health sustainability. As an annex the report provides a comprehensive framework for evaluating and guiding the development of the NESTLER platform, with a focus on addressing critical food security challenges through a One-Health approach.

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Date	Reviewer's name	Affiliation
24/10/2024	Odedeyi Temitope	UCL
25/10/2024	Stavroula Bourou	Synelixis
23/10/2024	Domenica Casciano	Z&P
24/10/2024	Georgia Pantelide	eBOS

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Definitions, Acronyms and Abbreviations

ADLI	Agricultural Development Led Industrialization
AfCFTA	African Continental Free Trade Area
AI	Artificial Intelligence
ARC	African Risk Capacity
ASAL	Arid and Semi-arid Land
AU	Africa Union
CAADP	Comprehensive Africa Agriculture Development Program
CDC	Centres for Disease Control and Prevention
EDCTP	European & Developing Countries Clinical Trials Partnership
EU	European Union
FAO	Food and Agriculture Organization
FEWS NET	Famine Early Warning Systems Network
FNSSA	Partnership on Food and Nutrition Security and Sustainable Agriculture
GIS	Geospatial Information System
GTP	Growth & Transformation Plan
IoT	Internet of Things
IPM	Integrated Pest Management
IWRM	Integrated Water Resources Management
JAES	Joint Africa-EU Strategy
KPIs	Key Performance Indicators
NNP	National Nutrition Programme
RARDB	Rwanda Agriculture & Animal Board
SDG	Sustainable Development Goals
UAT	User Acceptance Testing
UN	United Nations
WCAG	Web Content Accessibility Guidelines
WFP	World Food Programme
WP	Work Package

Executive Summary

The Deliverable D1.2 outlines the food security priorities of key African countries (*i.e.* Nigeria, Ethiopia, Uganda, Rwanda, Kenya, and Cameroon) and aligns them with the broader goals of the One-Health initiative. These priorities include improving agricultural productivity, promoting climate resilience, addressing malnutrition, and enhancing sustainable livestock management.

Based on them, the report proposes an EU-Africa Food Security Roadmap. Moreover, it also documents collaborative activities between the EU and African countries, focusing on initiatives that promote One-Health sustainability. Key activities include joint research projects, stakeholder engagements, innovative pilot projects, and policy proposals aimed at integrating human, animal, and environmental health into food security strategies.

As an annex the report provides a comprehensive framework for evaluating and guiding the development of the NESTLER platform, with a focus on addressing critical food security challenges through a One-Health approach. The report outlines the key methodologies, priorities, and collaborative efforts necessary to ensure the platform effectively supports cross-border agricultural and health challenges.

1 Introduction

Food security remains one of the most critical challenges in both the European Union (EU) and Africa, exacerbated by climate change, socio-political instability, and disruptions in global supply chains. The NESTLER project, funded by the EU Horizon Europe R&I Programme, aims to address these challenges through a multidisciplinary approach that integrates advanced technologies, stakeholder engagement, and strategic planning.

Deliverable D1.2 is a key component of Work Package 1 (WP1), focusing on:

1. **Challenges and priorities in Food Security.** The deliverable highlights the key challenges and priorities in Au and Africa Food security. Moreover, it focuses on key African countries (*i.e.* Nigeria, Ethiopia, Uganda, Rwanda, Kenya, and Cameroon) and aligns them with the broader goals of the One-Health initiative. These priorities include improving agricultural productivity, promoting climate resilience, addressing malnutrition, and enhancing sustainable livestock management.
2. **Development of the EU-African Food Security Roadmap:** This roadmap is designed to guide policymakers, researchers, and agricultural stakeholders in implementing strategies that enhance food security across the EU and Africa. It draws on historical case studies, stakeholder input, technology, and databased predictive modelling to offer actionable insights and recommendations.
3. **Collaboration Report on EU-Africa Activities for Promoting One-Health Programme Initiatives:** The deliverable is centred around documenting and analysing joint efforts between the European Union (EU) and African nations to promote the One-Health approach. The One-Health concept integrates human, animal, and environmental health, recognizing that these sectors are interconnected and must be addressed collectively to tackle global health challenges like zoonotic diseases spread and ensuring food safety in the supply chain.
4. **Assessment of the NESTLER Platform:** Based o the Description of Action, this deliverable also establishes a methodology for its evaluation. This includes the development of Key Performance Indicators (KPIs) that will be used to measure the platform's performance, reliability, and user satisfaction. In order to avoid distracting the reader, we provide the assessment methodology as an Annex.

In summary, deliverable D1.2 aim to create a robust framework that not only addresses immediate food security concerns but also supports the sustainable development of agricultural practices and resilience in both regions. The deliverable builds on the foundation laid by D1.1 and expands it by focusing on practical implementation and continuous improvement through a data-driven approach.

2 Challenges and priorities in Food Security

Based on the 1996 World Food Summit [1], ***food security is defined when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life***. Despite recent economic growth and development efforts, food security remains one of the most pressing challenges in Africa. Millions across the continent still face chronic food insecurity due to a variety of factors, including climate change, conflict, and poor agricultural productivity.

We could consider the following four main dimensions of food security[2]:

- **Physical *availability* of food**: Food availability addresses the "supply side" of food security and is determined by the level of food production, stock levels and net trade.
- **Economic and physical *access* to food**: An adequate supply of food at the national or international level does not in itself guarantee household level food security. Concerns about insufficient food access have resulted in a greater policy focus on incomes, expenditure, markets and prices in achieving food security objectives.
- **Food *utilization***: Utilization is commonly understood as the way the body makes the most of various nutrients in the food. Sufficient energy and nutrient intake by individuals are the result of good care and feeding practices, food preparation, diversity of the diet and intra-household distribution of food. Combined with good biological utilization of food consumed, this determines the nutritional status of individuals.
- ***Stability* of the other three dimensions over time**: Even if your food intake is adequate today, you are still considered to be food insecure if you have inadequate access to food on a periodic basis, risking a deterioration of your nutritional status. Adverse weather conditions, political instability, or economic factors (unemployment, rising food prices) may have an impact on your food security status.

2.1 Food Security Roadmap methodology

To create a comprehensive EU-Africa food security roadmap, aligned with the One Health approach, we have defined a structured methodology that is iterative, evidence-based, and participatory. Each step outlined below provides a clear pathway to designing an actionable and impactful strategy. In detail, we have adopted the following steps:

Figure 1: Methodology for defining the EU-Africa Food Security Roadmap

2.1.1 Step 1: Situational Analysis

The first step in developing the roadmap has been to conduct a thorough situational analysis to understand the current state of food security, environmental health and One Health risks across the EU

and Africa. This involves collecting data on agricultural productivity, food supply chains, zoonotic disease prevalence, and climate impacts. The analysis also identified gaps and vulnerabilities in existing policies and practices. For instance, regions highly dependent on rain-fed agriculture might require greater emphasis on climate-resilient technologies. This phase also assessed socio-economic disparities, including the effects of poverty and inequality on access to nutritious food. By consolidating data from multiple sources, this step has provided a baseline for targeted interventions.

2.1.2 Step 2: Multi-Stakeholder engagement and Consultations

Engaging a diverse group of stakeholders has ensured that the roadmap reflects multiple perspectives and priorities. This step has involved organizing virtual and regional workshops in EU (i.e. Greece and Italy) and Africa (i.e. Ethiopia, Nigeria, Kenya and Rwanda), focus groups, and policy dialogues that bring together representatives from the private sector, civil society, and academia. These consultations foster collaboration and identify shared objectives. Special attention has been given to including smallholder farmers, indigenous communities, and women, who are disproportionately affected by food insecurity. In total more than 40 stakeholders have been actively engaged in the process.

2.1.3 Step 3: Integration of the One Health Framework

At the core of this methodology is the integration of the One Health framework, which emphasizes the interconnectedness of human, animal, and environmental health. This step ensures that food security strategies account for the risks posed by zoonotic diseases, environmental degradation, and antimicrobial resistance. Cross-sectoral linkages between agriculture, public health, and environmental protection are established during this phase. For example, NESTLER surveillance systems for monitoring livestock health also consider their implications for human disease outbreaks. By embedding One Health principles, the roadmap promotes holistic and sustainable solutions to food security challenges.

2.1.4 Step 4: Data Collection and Analysis

Robust decision-making requires reliable data and scientific evidence. This step involves analyzing data from NESTLER pilots, case studies, and modeling tools to forecast future scenarios. For instance, predictive modeling can estimate the impact of climate change on crop yields. Additionally, this step has identified best practices from EU and African contexts that can be scaled or adapted. This step will continue well after deliverable D1.2 and even beyond the project lifetime.

2.1.5 Step 5: Formulating Recommendations

Based on the findings from data analysis, actionable recommendations should be developed. These recommendations must address identified challenges while promoting sustainable practices that enhance food security and health outcomes. They should also consider the feasibility of implementation within different contexts across Africa and Europe. This step may continue well after deliverable D1.2 and even beyond the project lifetime with specific policies (in many cases specialized in each country).

2.1.6 Step 6: Monitoring and Evaluation Framework

A robust monitoring and evaluation framework is critical for assessing progress and ensuring accountability. This step involves developing measurable indicators for each objective. Regular reviews allow for adjustments based on changing circumstances or unforeseen challenges. Community-based monitoring, which involves local populations in tracking progress, enhances transparency and ensures that interventions remain responsive to grassroots needs. For instance, participatory monitoring can

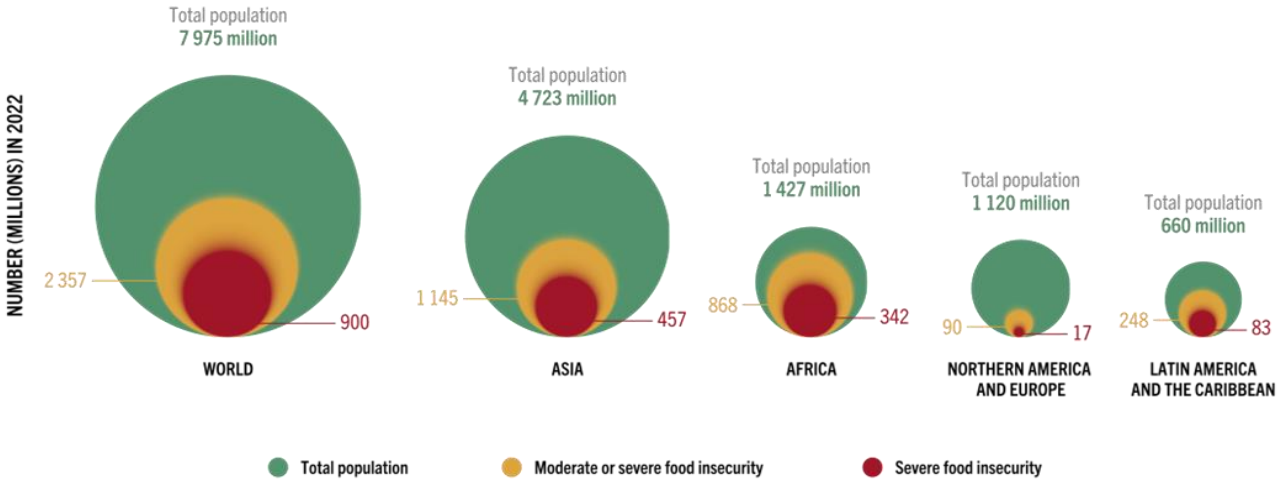
highlight gaps in service delivery, enabling timely corrective actions. This is a future step that goes beyond NESTLER lifetime.

2.2 Food Security Challenges in EU and Africa

Africa is the home to more than 25% of the world's population suffering from hunger, with the United Nations Food and Agriculture Organization (FAO) estimating that over 250 million people across the continent face food insecurity. There are several underlying issues have been identified to drive this crisis:

- **Climate Change and Environmental Pressures:** Extreme weather events, such as droughts, floods, and heatwaves, are becoming more frequent and severe, disrupting agricultural production. Climate variability affects crop yields and livestock, leading to regional imbalances in food availability. Additionally, soil degradation, water scarcity, and biodiversity loss further strain the EU's food production systems. Especially, Africa is highly vulnerable to climate change. Over 95% of agriculture in sub-Saharan Africa is rain-fed, making it especially susceptible to changes in weather patterns.
- **Conflicts and Geopolitical Instability:** Geopolitical tensions strain international trade agreements, disrupt exports, and increase reliance on less stable global markets. Conflicts near EU borders, such as the Russia-Ukraine war, directly impact food supply chains, particularly for grains and fertilizers. On the other hand, political instability, armed conflicts, and insurgencies in regions like the Sahel, Horn of Africa, and Central Africa exacerbate food insecurity. Millions of people have been displaced, disrupting farming and access to markets. Global trade dependencies make both EU and Africa vulnerable to external shocks, such as geopolitical conflicts and pandemics. Supply chain bottlenecks can result in higher food prices, reduced availability, and increased reliance on imports, compromising food sovereignty and security.
- **Economic Instability and Inequalities:** Rising food prices disproportionately affect low-income populations, exacerbating food insecurity. Inequalities within and across EU member states create disparities in access to nutritious and affordable food. Moreover, many African nations face economic challenges, including inflation, poor infrastructure, and limited access to financial services. These issues constrain agricultural productivity and make food systems fragile.
- **One Health Approach:** Recognizing the interconnection between human health, animal health, and environmental sustainability, there is a need to support resilience-building and sustainable development across EU's and Africa's food systems.

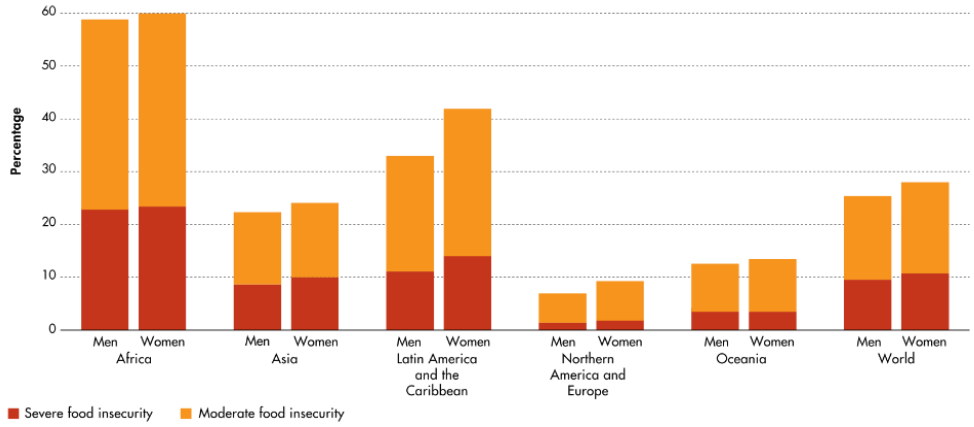
As shown in Figure 2, the concentration and distribution of food insecurity by severity differ greatly across the regions of the world. Africa follows Asia as far as total population is concern (4.7B people vs. 1.4B people), but the moderate or severe food insecurity is comparable and severe food insecurity directly comparable.



SOURCE: FAO. 2023. FAOSTAT: Suite of Food Security Indicators. In: *FAO*. [Cited 12 July 2023]. www.fao.org/faostat/en/#data/FS

Figure 2: The concentration and distribution of food insecurity by severity

As shown in Figure 3, Africa is by far the highest percentage of people on severe and moderate food insecurity as compared to any other location in the world. This insecurity is beyond gender.



Source: FAO. 2023. Suite of Food Security Indicators. In: *FAOSTAT*. Rome. [Cited October 2023]. https://www.fao.org/faostat/en/#data/FS
Download: https://doi.org/10.4060/cc8166en-fig50

Figure 3: Food Insecurity Levels by Region and Gender

2.3 Key priorities for Food Security in Africa

To address these challenges and achieve food security in Africa involves tackling interconnected challenges through strategic actions aligned with the United Nations Sustainable Development Goals (SDGs), particularly **SDG 2: Zero Hunger** [3]. In detail, key food security priorities within Africa and their alignment with SDG targets are summarized in the following:

1. **Enhancing Agricultural Productivity and Sustainability.** The number one priority to achieving food security is to enhance the agriculture productivity in Africa. On the other hand, especially the EU's agricultural sector faces pressures to balance productivity with sustainability. Overuse of pesticides, fertilizers, and intensive farming methods harm ecosystems. Thus, farmers must adapt to stricter environmental policies, such as the EU Green Deal, which aims to reduce emissions and promote

biodiversity. This includes the following sub-priorities:

- **Improved Farming Techniques:** Adopting sustainable practices such as conservation agriculture, crop rotation, and agroecology can significantly boost yields while preserving environmental health. These methods enhance soil fertility, reduce dependency on chemical inputs, and contribute to *SDG Target 2.4*, which focuses on ensuring sustainable food production systems [4].
- **Seed and Input Access:** High-quality seeds, fertilizers, and pest control tools are critical for increasing yields. Governments and NGOs can implement programs to subsidize these inputs and provide training. This aligns with *SDG Target 2.3*, which seeks to double small-scale agricultural productivity and incomes [5].
- **Pest outbreaks:** Crop and livestock diseases are major threats to food production. The roadmap emphasizes early warning systems, pest management techniques, and the use of biological controls to mitigate these threats. Integrated pest management practices will be supported by the NESTLER platform's data-driven insights
- **Extension Services:** Strengthening agricultural extension programs enables farmers to adopt best practices, access market information, and use climate-smart agriculture. This supports *SDG Target 2.A*, which emphasizes enhancing rural infrastructure and research.

2. **Climate-Resilient Agriculture.** Africa is extremely exposed to climate change conditions. The food security roadmap should address the increasing frequency and severity of extreme weather events such as droughts and floods, which negatively affect agricultural production. This is achieved through climate adaptation strategies like soil conservation, drought-resistant crops, and improved irrigation techniques. As such climate-resilient agriculture may contribute towards food sustainability. Most important parameters are:

   - **Drought and Flood Management:** Water conservation systems such as rainwater harvesting, irrigation, and flood barriers mitigate climate-related risks. These measures align with *SDG Target 13.1*, which emphasizes resilience to climate-related hazards [6].
   - **Climate-Smart Crops:** Promoting drought-resistant and early-maturing crops like millet and cassava helps farmers adapt to climate variability. These efforts support *SDG Target 2.4*, focusing on resilience in agricultural systems [4].
   - **Agroforestry:** Incorporating trees into agricultural systems enhances biodiversity, improves soil health, and provides alternative income sources. This approach aligns with *SDG Target 15.2*, emphasizing sustainable forest management [6].

3. **Infrastructure Development and supply chain assurance.** Access to efficient and state of the art infrastructure is also critical. The roadmap should highlight the importance of improving food supply chains to ensure the efficient transport, processing, and distribution of agricultural products. Strengthening supply chains is critical for reducing post-harvest losses, improving food availability, and ensuring that farmers have better market access. Africa needs to invest in:

   - **Irrigation Systems:** Irrigation infrastructure reduces reliance on unpredictable rainfall and stabilizes crop production. This supports *SDG Target 6.4*, which aims to improve water-use

efficiency [7].

- **Storage and Logistics:** Developing modern storage facilities and logistics systems minimizes post-harvest losses and improves market access, directly contributing to *SDG Target 12.3*, which seeks to halve global food waste.
- **Transport Networks:** Better rural roads and market linkages improve the flow of goods and services, enhancing economic opportunities. This aligns with *SDG Target 9.1*, emphasizing the development of resilient infrastructure.

4. **Dietary Shifts, Consumer Behaviour and Food Systems Transformation.** Changing consumer preferences, such as the rising demand for plant-based or organic foods, present challenges for traditional farming practices. At the same time, over-reliance on processed foods contributes to health issues and affects the demand-supply balance of essential nutrients. Addressing these challenges requires coordinated efforts in policy, innovation, and international collaboration to ensure resilient and sustainable food systems.
    - **Diversified Diets:** Promoting the production and consumption of diverse, nutritious foods addresses malnutrition and micronutrient deficiencies. This supports *SDG Target 2.2*, which aims to end all forms of malnutrition.
    - **Food Processing:** Investment in local food processing industries reduces dependency on imports, creates jobs, and adds value to agricultural products. This supports *SDG Target 8.2*, emphasizing higher levels of productivity through diversification.
    - **Waste Reduction:** Implementing food-saving technologies and policies throughout the supply chain contributes to both food security and environmental goals, supporting *SDG Target 12.3*.
5. **Policy and Governance.** Beyond the technical, technological and climate issues, Africa faces also policy and governance issues [5].
    - **Land Rights and Tenure Security:** Establishing equitable land tenure systems promotes investment and productivity, directly supporting *SDG Target 1.4*, which ensures equal rights to land ownership.
    - **Agricultural Financing:** Access to affordable credit and crop insurance enables smallholders to adopt modern practices and mitigate risks. This aligns with *SDG Target 2.A*, emphasizing investment in agriculture.
    - **Subsidies and Trade Policies:** Fair pricing mechanisms and trade policies stabilize markets and improve livelihoods. This supports *SDG Target 17.10*, promoting fair multilateral trading systems.
    - **Implementation of the Malabo Declaration**: Align national policies with the Malabo Declaration on Accelerated Agricultural Growth and Transformation, focusing on improving agricultural productivity and food security by 2025 [8]
6. **Technology and Innovation.** Promote the use of modern agricultural technologies and practices, including precision farming and climate-smart agriculture, to increase crop yields and resilience against climate variability [9].

- **Digital Platforms:** Mobile apps that provide weather updates, market prices, and agricultural tips enhance farmer decision-making. This aligns with *SDG Target 9.C*, which aims to expand access to ICT infrastructure.
- **Research and Development:** Investments in developing high-yield crop varieties and innovative pest management strategies are crucial for long-term sustainability. This supports *SDG Target 2.A*, focusing on research in agriculture.

7. Smallholder Farmers, young and gender Inclusion. Encouraging young people and women to pursue agriculture through training is important worldwide, including Africa.

- **Support for Smallholder Farmers**: Develop targeted support programs for smallholder farmers, who constitute a significant portion of the agricultural workforce. This includes access to credit, training, and resources to enhance productivity [10]
- **Youth Engagement:** Encouraging young people to pursue agriculture through training, incentives, and technology integration addresses the aging farming population. This aligns with *SDG Target 8.6*, reducing youth unemployment.
- **Empowering Women:** Equal access to resources and decision-making roles for women enhances productivity and food security. This supports *SDG Target 5.A*, ensuring reforms for women's economic rights.

8. Regional Cooperation. Regional cooperation is also important for

- **Cross-Border Initiatives**: Foster regional cooperation among African countries to share best practices, technologies, and resources aimed at improving food security across borders [10]
- **Trade Policies:** Strengthening regional trade agreements and infrastructure fosters equitable food distribution and price stability. Moreover, facilitate the movement of agricultural products within the continent, reducing reliance on food imports from outside Africa. This aligns with **SDG Target 17.11**, increasing exports from developing countries.
- **Knowledge Sharing:** Collaborative research and technology exchange between countries improve efficiency and innovation in agricultural practices.

9. Emergency Preparedness and Response. Emergency preparedness and response in food security in Africa is a critical area, given the region's vulnerability to various shocks, including climate events, conflicts, and economic disruptions. Here are key aspects to consider:

- **Food Reserves:** Improving storage infrastructure and creating food reserves are essential for emergency preparedness. Poor post-harvest storage leads to significant food losses in Africa, estimated at 20–30% of total production. Investments in modern silos and cold chains can help stabilize food availability during crises. Strategic grain reserves, like those managed by the African Union, play a vital role in addressing sudden shortages. Establishing grain reserves ensures food availability during crises, supporting *SDG Target 2.1*, which aims to end hunger.
- **Early Warning Systems:** African countries have implemented early warning systems to detect food security risks, such as droughts, locust infestations, and crop failures. Tools like the Famine Early Warning Systems Network (FEWS NET) [11] and satellite data are used to monitor weather patterns and agricultural conditions. However, gaps in infrastructure, data sharing, and funding

often limit their effectiveness. Predictive systems for droughts, pests, and diseases mitigate risks and enable proactive responses. This supports *SDG Target 13.3*, which focuses on improving climate resilience.

- **Crisis Response Mechanisms.** Humanitarian organizations, such as the World Food Programme (WFP) [12] and the Food and Agriculture Organization (FAO), collaborate with African governments to provide food aid during crises. Cash-based assistance is increasingly used to empower communities and support local markets. However, the scale and duration of some emergencies, such as protracted conflicts, strain these systems.

10. **Sustainable Resource Management.** Sustainable resource management in Africa is essential for ensuring food security, economic stability, and environmental conservation. However, the continent's rich natural resources face significant pressures from population growth, climate change, and unsustainable exploitation.

    - **Land Use and Soil Health:** Soil degradation affects over 65% of Africa's arable land due to overgrazing, deforestation, and unsustainable farming. Combatting soil degradation through sustainable land management enhances productivity, aligning with *SDG Target 15.3*, which promotes land restoration.
    - **Water Resources:** Protecting freshwater resources ensures their availability for agriculture, supporting *SDG Target 6.6*, which emphasizes the sustainable management of water ecosystems.
    - **Forest and Biodiversity Conservation:** Africa's forests, including the Congo Basin, are vital for global carbon storage and biodiversity but face deforestation from agriculture and logging.

It is also important to underline that improving food and nutrition security depends on increasing the productivity and resilience. However, as shown in Figure 4 progress in agriculture and food security in Africa remains modest. According to [8], only seven countries are in track to meet the Comprehensive Africa Agriculture Development Program (CAADP) goal of doubling agricultural productivity by 2025 and only 19 are on track to ensure resilience to climate-related risks.

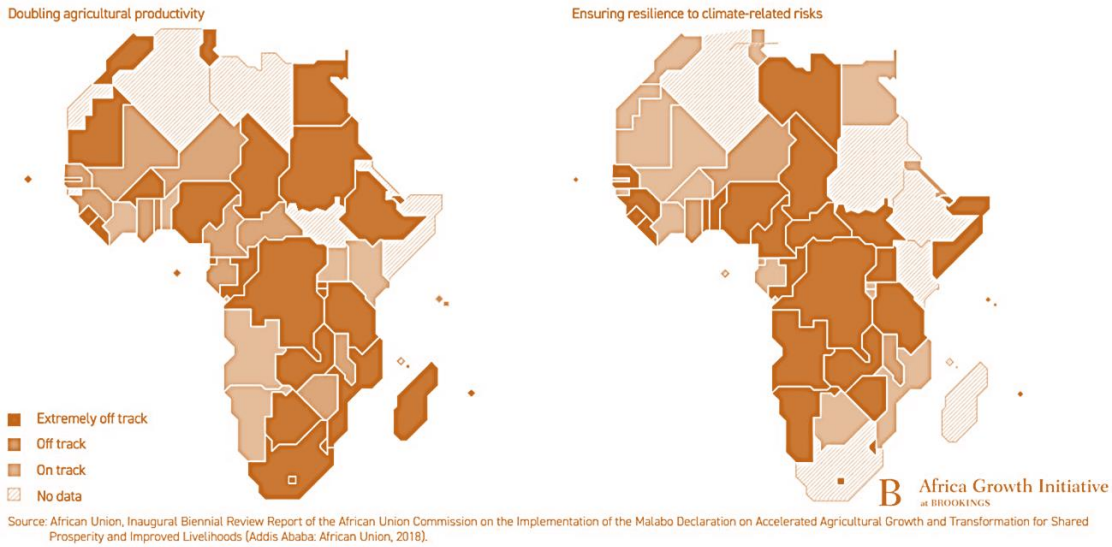


Figure 4: Improving food and nutrition security

2.4 National Priorities on Food Security Roadmap

The food security roadmap within the NESTLER framework aims to address National prioritiesfacing agricultural systems in both the EU and Africa. It focuses on three strategic areas:

- **Crop-based farming:** The roadmap emphasizes the need for increasing crop productivity, improving soil health, and promoting the adoption of climate-smart agriculture. It further addresses critical challenges like erratic rainfall, soil degradation, and pest outbreaks that threaten food production within the regions.
- **Livestock management:** This component focuses on improving the productivity and health of livestock systems. It seeks to tackle issues like disease control, genetic improvement, and feed optimization to ensure the efficient production of meat, dairy, and other livestock products. This is particularly vital in areas prone to drought and disease outbreaks.
- **Aquaculture:** Sustainable management of fisheries and aquaculture is another priority. The roadmap identifies aquaculture as a key source of nutrition and income for coastal and inland communities. Addressing issues like overfishing, water pollution, and disease management in fish populations are crucial for long-term food security.

This section highlights the food security priorities among the African nations and NESTLER possible Actions.

Table 1: Food Security Priorities in Cameroon and NESTLER Possible Actions

CAMEROON	Cameroon faces a multitude of challenges, ranging from protracted conflicts and climate shocks to underdeveloped agricultural practices. NESTLER platform's food security roadmap identifies strategic areas where it can enhance food security efforts.
Food Security Landscape	Cameroon, with over 26 million inhabitants, is classified as a lower-middle-income country but struggles with widespread poverty, particularly in rural areas. Over 55% of the population live in poverty, with a significant portion facing severe deprivation. The country's agricultural sector employs 62% of the labour force and contributes 15% of the GDP, yet it remains vulnerable to climate-related shocks, poor infrastructure, and low agricultural productivity.
Food Security Priorities	• ***Increase agricultural productivity:*** Focus on maize, rice, and horticulture, aiming to enhance productivity through drought-resistant varieties and improved market access. • ***Climate resilience:*** Address frequent flooding and drought by promoting climate-smart agriculture and supporting vulnerable households. • ***Improved food systems:*** Strengthen value chains and boost food safety and nutrition through programs such as home-grown school feeding and sanitation measures. • ***Inclusive development:*** Ensure participation from women, youths, and

	marginalized groups, and implement gender-sensitive policies in food security interventions.
Key Crops, Livestock, and Aquaculture	• ***Crops:*** Cocoa, maize, cassava, yams, and coffee are major crops, with cocoa being especially vital for export. • ***Livestock:*** Cattle, poultry, goats, and sheep. • ***Aquaculture:*** Tilapia and catfish farming have gained traction, offering an important food source and livelihood.
Actionable Insights for NESTLER	• ***Agricultural Resilience and Climate Adaptation:*** By integrating climate resilience data and offering tools for monitoring agricultural productivity, NESTLER can support Cameroon's transition to climate-smart agriculture. The platform can help smallholder farmers in vulnerable regions adopt climate-resilient crops and sustainable farming practices, improving yields and reducing post-harvest losses. • ***Addressing Malnutrition and Improving Health:*** NESTLER's ability to track nutritional outcomes and integrate health data can enhance Cameroon's efforts to combat malnutrition. By mapping regions with high malnutrition rates and linking these to food availability and access, the platform can help inform national policies and resource allocation to the most affected regions.
NESTLER Priorities	• Develop climate-resilient crops and implement pest and disease monitoring systems. • Promote food safety by integrating real-time surveillance systems into the NESTLER platform, particularly for cash crops like cocoa and coffee. • Support farmers through post-harvest management by product quality maintenance monitoring for enhancing nutritious food supply.
Roadmap	• ***Short-Term:*** Use satellite imagery and IoT sensors to monitor soil moisture and device to monitor crop quality to determine crop health in drought-prone regions. Also, develop early-warning systems within the platform to provide actionable insights to farmers before drought or pest outbreaks occur. • ***Long-Term:*** Scale these models to cover the entire country and integrate post-harvest management data to improve supply chain logistics and reduce food loss.

Table 2: Food Security Priorities in Ethiopia and NESTLER Possible Actions

ETHIOPIA	Ethiopia has made significant strides in economic development and poverty reduction over the last two decades, but food insecurity remains a significant challenge, exacerbated by conflict, drought, and population displacement.
Food Security Landscape	Ethiopia, a country with a rapidly growing population, faces severe food security challenges, particularly due to internal conflicts and climate-induced droughts. As of recent reports, around 20.1 million Ethiopians require food support, including internally displaced people (IDPs) who have fled from northern conflict areas or drought-affected Southern and South-eastern regions. While the government aims to move Ethiopia to middle-income status by 2025 through its Growth and Transformation Plan (GTP), achieving food security remains a critical part of this goal
Food Security Priorities	• ***Climate adaptation:*** Promote climate-resilient agriculture, particularly in drought-prone areas. The country focuses on early-warning systems for drought and pest control (e.g., locusts). • ***Nutrition-sensitive agriculture:*** Ethiopia integrates agriculture with nutrition to combat malnutrition, stunting, and undernutrition through the National Nutrition Programme (NNP). • ***Sustainable land management:*** Projects like hillside irrigation and soil conservation are helping to improve productivity and mitigate erosion, aiming to boost food security.
Key Crops, Livestock, and Aquaculture	• ***Crops:*** Teff (a staple grain), wheat, barley, sorghum, and maize are critical for both domestic consumption and export. • ***Livestock:*** Cattle, sheep, goats, and poultry are vital to the livelihoods of Ethiopia's rural population. • ***Aquaculture:*** While still in development, freshwater fish farming, particularly tilapia, is emerging as a key area of food production.
Actionable Insights for NESTLER:	• ***Agricultural Productivity and Data-Driven Insights:*** The NESTLER platform can provide data-driven tools to enhance Ethiopia's agricultural productivity. By leveraging geospatial data capabilities, Ethiopian farmers can better manage crop yields, monitor soil health, and optimize the use of climate-resilient seeds, all of which align with the Agricultural Development Led Industrialization (ADLI) strategy. • ***Environmental Sustainability and Resource Management:*** The platform can be used to monitor water resource management and reforestation efforts, key elements of Ethiopia's environmental rehabilitation strategy. Real-time data on soil erosion, water availability, and land degradation will allow policymakers to better allocate resources for sustainable

	farming and environmental conservation. • ***Addressing Malnutrition through Nutritional Data:*** NESTLER's ability to collect and analyse health and nutritional data can support Ethiopia's efforts to reduce stunting and improve the nutrition of women and children. By mapping malnutrition hotspots and linking them to agricultural production, the platform can help the government prioritize nutritional interventions and improve food distribution programs. • ***Climate Adaptation Tools:*** NESTLER's climate tools can help Ethiopian farmers predict droughts and manage their crops accordingly. The platform's early warning systems for climate-related shocks, combined with water conservation techniques, will support Ethiopia's broader strategy of climate adaptation in the agricultural sector.
NESTLER Priorities	• Develop climate adaptation strategies focusing on drought-prone regions, providing soil irrigation signals for improved production. • Integrate early warning systems for pests and diseases incidence on crops into the NESTLER platform towards mitigating food loss.
Roadmap	• ***Short-Term:*** Use drone, multispectral camera and sensors to monitor crop health and soil moisture in drought-prone regions. Develop early-warning systems within the platform to provide actionable insights to farmers before drought or pest outbreaks occur. • ***Long-Term:*** Expand these systems to integrate real-time nutritional data, allowing policymakers to tailor interventions that improve food distribution and nutritional outcomes in areas most affected by food insecurity.

Table 3: Food Security Priorities in Uganda and NESTLER Possible Actions

UGANDA	Uganda faces complex food security challenges, primarily driven by poverty, regional conflict, climate shocks, and malnutrition. Food security roadmap to support Uganda in achieving long-term sustainability and resilience.
Food Security Landscape	Despite significant progress in reducing poverty during the 1990s and early 2000s, Uganda has seen an increase in poverty since 2013, particularly in rural areas. Approximately 20.3% of the population now lives below the poverty line. Uganda faces food insecurity, driven by low agricultural productivity, the impact of climate change, and population displacement.
Food Security Priorities	• ***Pest and disease management:*** Locust outbreaks and livestock diseases like tick-borne illnesses remain key concerns. Uganda focuses on robust monitoring and early-warning systems. • ***Improving crop and livestock production:*** Uganda's food security strategy also emphasizes increasing production through the adoption of improved agricultural practices and disease control measures for livestock.
Key Crops, Livestock, and Aquaculture	• ***Crops:*** Uganda's agricultural sector is diverse, producing staple crops like maize, beans, bananas, cassava, and sorghum. The country also grows cash crops such as coffee, tea, and vegetable oil, which are vital for export. • ***Livestock:*** Cattle, goats, poultry, and sheep, particularly in the Karamoja sub-region and cattle corridor, are important for the livelihoods of many rural households. • ***Aquaculture***: Fish farming, especially tilapia and Nile perch, is a growing sector that supports both food security and export markets.
Actionable Insights for NESTLER	• ***Enhancing Agricultural Productivity and Climate Adaptation:*** NESTLER can provide tools to help smallholder farmers increase productivity by offering real-time insights into weather patterns, soil health, and pest outbreaks. By leveraging data analytics, the platform can assist farmers in adopting climate-smart practices, improving yield resilience to droughts, pests, and declining soil fertility. • ***Addressing Malnutrition through Targeted Nutritional Support:*** NESTLER can support nutritional data tracking to monitor malnutrition rates and link food security programs to high-risk populations. The platform's ability to identify hotspots of food insecurity and malnutrition can help inform resource allocation for school feeding programs and nutrition-sensitive agriculture initiatives that target children and women of reproductive age.

	• ***Livestock Health Monitoring and Disease Surveillance:*** NESTLER can provide real-time tracking of livestock health, helping Ugandan farmers manage diseases affecting poultry, cattle, and goats. By offering early warning systems for disease outbreaks and tools for water resource management, NESTLER can enhance livestock productivity, particularly in the drought-prone Karamoja sub-region. • ***Water Resource Management:*** NESTLER can enhance Integrated Water Resources Management (IWRM) by providing geospatial data on water availability and usage. This would allow farmers and policymakers to optimize water allocation for agriculture, particularly in water-scarce regions like Karamoja. The platform can also support the development of irrigation systems and help farmers adapt to rain-fed agriculture challenges.
NESTLER Priorities	• Achievable success in disease monitoring can be implemented in pest management systems focused on locust outbreaks and livestock disease surveillance. • Develop climate adaptation strategies focusing on drought-prone regions, providing soil irrigation signals for improved production. Adoption of crop quality monitoring tools for food security. • Strengthen cross-border disease surveillance and control mechanisms for zoonotic diseases, aligning with the One Health framework.
Roadmap	• ***Short-Term:*** Develop locust and livestock disease tracking systems through pilot projects using NESTLER. Collaborate with the Africa CDC and local health authorities to enhance zoonotic disease surveillance. Use drone, multispectral camera and sensors to monitor crop health and soil moisture in drought-prone regions. Develop early-warning systems within the platform to provide actionable insights to farmers before drought or pest outbreaks occur. • ***Long-Term:*** Scale these models for national implementation and collaboration with neighbouring countries, ensuring a holistic approach to pest and disease control that crosses borders and strengthens regional collaboration.

Table 4: Food Security Priorities in Rwanda and NESTLER Possible Actions

RWANDA	Rwanda has made notable progress in both the agricultural and socio-economic sectors, positioning agriculture as a key driver of economic growth. Yet, challenges related to food safety, malnutrition, and agricultural productivity persist.
Food Security Landscape	Agriculture is the backbone of Rwanda's economy, employing 70% of the labour force. The government has made significant investments in agriculture, increasing the share of the national budget allocated to the sector from 3% in 2006 to over 10% by 2015. Despite these gains, Rwanda continues to face low agricultural productivity, with high levels of malnutrition—38% of children under five are chronically malnourished.
Food Security Priorities	• ***Biodiversity and livestock management:*** Rwanda focuses on the sustainable management of livestock and biodiversity. The country implements measures to control zoonotic diseases and improve livestock productivity through vaccination programs. • ***Climate resilience:*** Initiatives such as hillside irrigation and soil conservation are key to Rwanda's agricultural strategy, aiming to enhance food security by controlling erosion and increasing crop yields.
Key Crops, Livestock, and Aquaculture	• ***Crops:*** Maize, beans, bananas, cassava, and coffee are key crops, with coffee being a major export commodity. • ***Livestock:*** Dairy cattle are central to Rwanda's food security, with programs focusing on milk production for both domestic consumption and export. • ***Aquaculture:*** Freshwater fish farming, particularly tilapia, is growing in importance, contributing to food security and providing an additional source of income for smallholder farmers.
Actionable Insights for NESTLER	• ***Food Safety Monitoring and Data Integration:*** The NESTLER platform can enhance food safety efforts in Rwanda by providing real-time data on pest and diseases on agricultural field contamination, so as to ensure maintenance of safety standards throughout production and the supply chain. This can help the government monitor food safety risks, particularly in rural areas, and reduce the incidence of foodborne diseases that contribute to malnutrition and economic losses. Integrating food safety monitoring into Rwanda's agricultural and nutrition programs will improve the overall health of the population. • ***Agricultural Productivity and Climate-Smart Technologies:*** NESTLER can support Rwanda's agricultural growth by providing data-driven insights into crop performance, soil health, and climate conditions. By monitoring the impact of climate shocks and advising on the adoption of climate-resilient

	crops, the platform can help increase productivity in key value chains such as maize, beans, and dairy. The platform can also support efforts to manage natural resources more effectively, helping farmers adapt to environmental changes and reduce losses due to climate variability. • ***Early Warning Systems:*** Use NESTLER's IoT-enabled devices and satellite imagery to monitor rainfall patterns, soil moisture levels, and river flow data. By integrating these data points into predictive models, the platform can send early flood warnings to farmers, policymakers, and communities in flood-prone areas, allowing for preventive measures to be taken. • ***Flood Risk Mapping:*** The NESTLER platform can use GIS tools and machine learning algorithms to create detailed flood risk maps based on historical rainfall and flood data. This provides stakeholders with visual insights into vulnerable areas, allowing them to plan accordingly. This allows for immediate response mechanisms, such as temporary relocation of livestock, redirection of water flows, or rapid evacuation in high-risk zones. • ***Crop and Livestock Adaptation Models:*** Use predictive analytics to model how floods might impact crop yields and livestock health. By factoring in flood risk, farmers can make data-driven decisions about crop planting, harvest timing, and livestock relocation to reduce losses.
NESTLER Priorities	• Strengthen livestock management systems to mitigate the spread of zoonotic diseases through the use of real-time monitoring tools integrated with NESTLER. • Use of weather data forecast from NESTLER platform to support planning for possible flooding, ensuring risk prevention and management from vulnerable farms and communities. • Promote biodiversity conservation through sustainable agricultural practices and habitat protection.
Roadmap	• ***Short-Term:*** Implement pilot projects for livestock monitoring and disease surveillance in collaboration with the Rwanda Agriculture and Animal Resources Development Board (RARDB). Deploying IoT sensors in flood-prone regions to monitor real-time water levels, rainfall, and soil conditions. Simultaneously, start using satellite imagery for flood risk mapping and establishing early warning systems in key regions. • ***Long-Term:*** Expand livestock monitoring and disease surveillance systems to integrate biodiversity data into the NESTLER platform, ensuring that agricultural productivity does not come at the expense of ecological health. Scale flood early warning system across all flood-prone regions, ensuring nationwide coverage. Utilize the NESTLER platform's predictive models to issue real-time alerts, preparing communities in advance of floods.

Table 5: Food Security Priorities in Kenya and NESTLER Possible Actions

KENYA	Kenya has made progress in addressing food security and nutrition challenges, enshrining the right to food in its Constitution and establishing the 2017 Food Security Act. Yet, it is on record that food insecurity, particularly in rural and arid regions, remains a significant challenge.
Food Security Landscape	Kenya's food security landscape is complex, with significant disparities between rural and urban areas. Despite achieving lower-middle-income status, over one-third of the population lives below the poverty line. The 2015/16 Kenya Household and Budget Survey indicated that 32% of Kenyans are food insecure, with rural areas experiencing a food poverty rate of 35.8%. Arid and semi-arid regions, which cover 80% of Kenya's land area, are particularly vulnerable to food insecurity, driven by factors such as rapid population growth, climate change, and inefficient food systems.
Food Security Priorities	• ***Focus Crops:*** Kenya places a significant emphasis on improving the productivity of maize, beans, sorghum, and horticultural crops. The country aims to increase crop yields through better seed varieties, mechanisation, and climate-smart agriculture. • ***Improved Irrigation Systems:*** Kenya seeks to boost agricultural productivity by increasing irrigation in arid and semi-arid lands (ASALs). The government is working on expanding irrigation systems to reduce the reliance on rain-fed agriculture and improve resilience against droughts. • ***Tackling Climate Change:*** With unpredictable rainfall and recurring droughts affecting 95% of rain-fed crops, Kenya prioritizes climate-resilient agricultural practices, including soil conservation, agroforestry, and improved water management to mitigate the adverse effects of climate change. • ***Promoting Sustainable Land Use:*** Programs like land rehabilitation, reforestation, and soil management are central to improving productivity in ASALs, which make up 80% of the country's land area. These areas are most vulnerable to climate change and food insecurity. • ***Food Safety and Nutrition:*** Kenya is committed to improving the nutritional status of its population by integrating food safety into its national strategies. Programs like the Food Safety Act of 2017 ensure access to safe and nutritious food, addressing public health issues related to malnutrition and foodborne diseases. • ***Combatting Malnutrition:*** Stunting affects 29% of children in rural areas, and vitamin and mineral deficiencies are widespread. Kenya's food security strategy includes increasing the availability of nutritious foods through homegrown school feeding programs and improving dietary diversity. • ***Private Sector Engagement:*** The government encourages private sector investment in agriculture, targeting the development of key value chains in the production of dairy, coffee, and tea. Strengthening these value chains is

	essential for enhancing food production, improving livelihoods, and promoting food security. • ***Market Infrastructure:*** Efforts are being made to rehabilitate rural feeder roads to improve access to markets, thereby facilitating better distribution of agricultural produce and reducing post-harvest losses.
Key Crops, Livestock, and Aquaculture	• ***Crops:*** Maize, beans, sorghum, and wheat are the main staples, while coffee and tea are significant export crops. • ***Livestock:*** Cattle, sheep, goats, and camels are crucial to the livelihoods of people in arid and semi-arid regions. • ***Aquaculture:*** Fish farming is a growing industry, providing an important source of nutrition and income, particularly in western Kenya.
Actionable Insights for NESTLER	• ***Agricultural Productivity and Climate Adaptation:*** NESTLER can support Kenya's agricultural productivity by providing climate-smart solutions and real-time data on weather patterns, crop health, and soil conditions. The platform can help farmers in drought-prone areas adopt improved farming techniques, diversify crops, and implement small-scale irrigation systems to reduce their dependence on rain-fed agriculture. These tools will be vital in building resilience against climate shocks and ensuring more consistent food supplies. • ***Enhancing Livestock and Market Access:*** NESTLER can improve livestock health monitoring by integrating data on diseases, pasture conditions, and water availability, particularly in the arid and semi-arid regions. This will help pastoralists and livestock farmers improve herd management, reducing losses due to drought and disease. By offering market data and supply chain insights, NESTLER can also support smallholder farmers and livestock herders in accessing markets more effectively, improving their incomes and food security.
NESTLER Priorities	• Address food insecurity in arid and semi-arid regions through climate-resilient agricultural practices and improved water management systems with soil moisture sensors. These regions, which make up 80% of the country's land area, are prone to drought and erratic rainfall, leading to poor agricultural performance and hunger. • Strengthen pest and disease management by deploying IoT sensors and drone technology to monitor agricultural health and predict pest outbreaks. Pest outbreaks, particularly the desert locust, have had devastating impacts on food security in Kenya.
Roadmap	• ***Short term:*** Use satellite imagery and IoT sensors to monitor soil moisture and crop health in drought-prone regions. Develop early-warning systems within the platform to provide actionable insights to farmers before drought or pest outbreaks occur. • ***Long-Term:*** Expand these systems to integrate real-time data beyond the pilots zones, allowing policymakers to tailor interventions that improve food security.

Table 6: Food Security Priorities in Nigeria and NESTLER Possible Actions

NIGERIA	With a population exceeding 220 million, Nigeria is the most populous country in Africa and faces significant challenges related to food security and nutrition.
Food Security Landscape	Despite being a major producer of crude oil and achieving lower-middle-income status in 2014, Nigeria faces widespread poverty, with 37% of its population (84 million people) living below the poverty line. Conflict, climate change, and economic challenges have contributed to an escalating food security crisis. As of 2024, 26.5 million Nigerians are projected to face acute hunger during the lean season, a sharp increase from 18.6 million at the end of 2023. Insecurity in the North East, where insurgent activities have displaced 2.2 million people, exacerbates the food crisis.
Food Security Priorities	• ***Increase agricultural productivity:*** Focus on cassava, maize, rice, and horticulture, aiming to enhance productivity through drought-resistant varieties and improved market access. • ***Climate resilience:*** Address frequent flooding and drought by promoting climate-smart agriculture and supporting vulnerable households. • ***Improved food systems:*** Strengthen value chains and boost food safety and nutrition through programs such as home-grown school feeding and sanitation measures. • ***Inclusive development:*** Ensure participation from women, youths, and marginalized groups, and implement gender-sensitive policies in food security interventions.
Key Crops, Livestock, and Aquaculture	• ***Crops:*** Maize, cassava, yams, rice, sorghum, and millet are staple crops, while cocoa, oil palm, and sesame are key export crops. • ***Livestock:*** Cattle, goats, sheep, and poultry play a significant role in the economy, particularly in northern Nigeria. • ***Aquaculture:*** Nigeria is the largest producer of catfish in Africa, and the fisheries sector is crucial for both food security and income generation.
Actionable Insights for NESTLER	• ***Data-Driven Solutions for Monitoring Food Security:*** The NESTLER platform can enhance food security in Nigeria by providing real-time data on high food production, malnutrition rates, and conflict-related displacement. This will allow policymakers to target interventions in areas like Borno, Adamawa, and Yobe, where food insecurity is most severe. The platform's ability to track food consumption patterns and nutritional outcomes can help the government prioritise resources for vulnerable populations. • ***Supporting Agricultural Productivity and Climate Resilience:*** NESTLER can support Nigeria's agricultural productivity by offering climate-smart solutions, such as real-time weather monitoring and crop health assessments. By integrating data on soil fertility and irrigation needs, the platform can help farmers adopt improved practices that increase yields and reduce vulnerability

	to droughts and floods. The platform can also assist in monitoring the expansion of irrigation systems, which is a key priority for improving agricultural resilience. ● ***Livestock Monitoring and Disease Control:*** NESTLER can assist in addressing Nigeria's livestock challenges by providing livestock health monitoring tools that track diseases and monitor pasture conditions. This will help livestock farmers in northern Nigeria manage their herds more effectively and reduce losses due to diseases and poor nutrition. The platform can also support the development of livestock value chains by providing market data and improving transportation and processing infrastructure.
NESTLER Priorities	● Develop climate adaptation strategies focusing on drought-prone regions, providing soil irrigation signals for improved production. ● Integrate early warning systems for pests and diseases into the NESTLER platform towards mitigating food loss. ● Provide support for farmers through post-harvest management by product quality maintenance monitoring for enhancing nutritious food supply.
Roadmap	● ***Short-Term:*** Use satellite imagery and IoT sensors to monitor soil moisture and crop health in drought-prone regions. Develop early-warning systems within the platform to provide actionable insights to farmers before drought or pest outbreaks occur. ● ***Long-Term:*** Expand these systems to integrate real-time nutritional data, allowing policymakers to tailor interventions that improve food distribution and nutritional outcomes in areas most affected by food insecurity.

3 EU-Africa Food Security Roadmap

Addressing food security in Africa requires a comprehensive and multi-faceted approach, given the continent's unique challenges, including climate change, conflict, and economic disparities. The following roadmap outlines strategic actions based on literature and existing frameworks to enhance food security across the region.

The roadmap for enhancing food security in Africa is a dynamic framework that requires continuous engagement from all stakeholders involved. By focusing on agricultural productivity, effective governance, climate resilience, nutrition enhancement, economic empowerment, and regional cooperation, Africa can work towards achieving sustainable food security for its population. The integration of these strategies will not only address immediate food needs but also lay the groundwork for long-term sustainability in the face of ongoing challenges.

Moreover, the One Health approach underscores the interdependence of human, animal, and environmental health, offering a comprehensive framework to address food security challenges. The EU and Africa, as partners, face shared and unique challenges in achieving food security, necessitating a collaborative strategy that incorporates sustainability, resilience, and innovation. This roadmap outlines key objectives and detailed action points aimed at achieving sustainable food systems in alignment with the One Health framework.

3.1 Strategic Action in EU-Africa Food Security Roadmap

The main directions in an EU-Africa food security roadmap are highlighted in the Figure 5 and analysed in the following sections:

Figure 5: Strategic Actions in EU-Africa Food Security Roadmap

3.1.1 Strategic Action 1: Enhance Sustainable Agricultural Practices

Objective: Promote resilient farming systems to mitigate climate impacts and ensure long-term productivity.

Sustainable agriculture is a cornerstone of food security. In Africa, agriculture is predominantly rain-fed, making it highly susceptible to climate variability. The EU can support Africa in adopting sustainable farming techniques such as agroecology, which enhance soil fertility, conserves water, and boosts biodiversity. Techniques like crop rotation, agroforestry, and conservation tillage can restore degraded lands and improve yields sustainably.

The transfer of climate-smart technologies, such as drought-resistant seed varieties and precision farming tools, can further bolster resilience. EU-Africa partnerships can facilitate knowledge exchange through joint research programs, field demonstrations, and farmer training. These efforts must prioritize small-holder farmers, who are critical to Africa's food production.

Summary of Action Points:

- Support agroecological practices, such as crop diversification, agroforestry, and conservation agriculture, to improve soil health and biodiversity [38][39] .
- Expand access to climate-smart technologies, including drought-resistant crops and precision agriculture tools.
- Establish EU-Africa knowledge-sharing platforms to disseminate sustainable farming practices and research outcomes.

Expected Outcomes: Increased agricultural resilience, reduced dependency on external inputs, and minimized environmental degradation.

3.1.2 Strategic Action 2: Strengthen One Health Surveillance Systems

Objective: Establish integrated surveillance systems to monitor zoonotic diseases, foodborne pathogens, and environmental risks.

Africa faces a high burden of zoonotic diseases, many of which have significant implications for food security. Establishing integrated surveillance systems across the EU and Africa is essential for early detection and response to such threats. Joint centres for disease surveillance can link human and veterinary health sectors, facilitating comprehensive monitoring [39].

Real-time data sharing, enhanced by modern technology such as GIS mapping and mobile apps, can improve response times. Training multidisciplinary teams to address threats within the One Health framework will be critical. The EU's experience in coordinating cross-border health responses can provide valuable insights for Africa's context.

Summary of Action Points:

- Develop joint EU-Africa centres for zoonotic disease surveillance, linking human and veterinary health networks.
- Promote data sharing and real-time monitoring of transboundary pests (e.g., locusts) and diseases.
- Train professionals across sectors to identify and manage risks under the One Health paradigm.

Expected Outcomes: Enhanced ability to predict and respond to health threats, reducing risks to food systems and public health.

3.1.3 Strategic Action 3: Invest in Sustainable Livestock and Aquaculture

Objective: Foster sustainable animal production systems that align with environmental and health standards.

The livestock sector in Africa plays a dual role in providing nutrition and livelihoods but is also a significant contributor to greenhouse gas emissions. Transitioning to low-emission livestock systems, such as optimized grazing practices and better manure management, is vital. Collaboration on research for feed alternatives, including insect-based feeds, can reduce the sector's carbon footprint.

In aquaculture, overfishing and habitat destruction remain pressing concerns. Promoting sustainable aquaculture practices that minimize environmental harm while enhancing fish productivity can address food security challenges. The EU's expertise in regulating sustainable fisheries can guide African nations in establishing robust governance frameworks.

Summary of Action Points:

- Transition to low-emission livestock systems, incorporating manure management and feed optimization [39].
- Develop sustainable aquaculture practices, reducing overfishing and environmental damage.
- Promote One Health-informed antimicrobial stewardship programs to reduce the overuse of antibiotics in agriculture.

***Expected Outcomes*:** Reduced greenhouse gas emissions, healthier ecosystems, and mitigated antimicrobial resistance.

3.1.4 Strategic Action 4: Enhance Nutrition Security

Objective: Address malnutrition through improved access to diverse and nutritious diets.

Malnutrition remains a critical challenge in Africa, with high prevalence rates of stunting, wasting, and micronutrient deficiencies. Biofortification of staple crops, such as vitamin A-enriched maize and iron-fortified beans, offers a cost-effective solution. These programs must be scaled up with EU support, leveraging its technical expertise and funding capacity.

School feeding programs, particularly those sourcing food locally, can simultaneously improve children's nutritional outcomes and support local economies. Public awareness campaigns promoting dietary diversification are equally important to address cultural and economic barriers to nutritious food consumption.

Summary of Action Points:

- Scale up biofortification programs for crops rich in essential nutrients (e.g., vitamin A-enriched maize).
- Strengthen school feeding programs using locally sourced, nutrient-dense foods.
- Promote dietary diversification campaigns that incorporate traditional African foods.

***Expected Outcomes*:** Improved nutritional outcomes, especially among vulnerable populations such as children and pregnant women.

3.1.5 Strategic Action 5: Build Resilient Food Supply Chains

Objective: Develop food systems that withstand disruptions and minimize waste.

Africa's food systems are highly vulnerable to shocks such as pandemics, conflicts, and climate events. Building resilience requires investments in post-harvest storage infrastructure, including silos, cold chains, and drying facilities, to reduce the estimated 30% post-harvest losses. Digital innovations like blockchain can enhance transparency and traceability in supply chains, fostering trust and efficiency.

EU-Africa trade agreements should prioritize policies that reduce dependency on imports while supporting local production. Developing regional value chains can reduce vulnerabilities to global market fluctuations.

Summary of Action Points:

- Invest in post-harvest storage infrastructure, such as cold chains and grain silos, to reduce food losses.
- Encourage EU-Africa trade agreements that prioritize local production while ensuring fair market access.
- Support digital solutions, such as blockchain, to enhance transparency and efficiency in supply chains.

***Expected Outcomes*:** Reduced food waste, stabilized markets, and improved food access during crises.

3.1.6 Strategic Action 6: Promote Policy Harmonization and Governance

Objective: Align policies between the EU and Africa to foster coherent food security strategies.

Effective governance is crucial for achieving food security goals. The EU and Africa must collaborate on harmonizing policies that integrate One Health principles into agriculture, health, and trade. Platforms like the African Continental Free Trade Area (AfCFTA) provide opportunities for coordinated regional food security initiatives.

Multilateral funding mechanisms, supported by both regions, can address cross-border food security challenges, such as regional droughts or pest outbreaks. Strengthened governance frameworks will enhance accountability and foster long-term investment in sustainable food systems.

Summary of Action Points:

- Establish joint policy frameworks integrating One Health principles into agriculture, health, and trade.
- Promote regional organizations like the African Union and the EU to coordinate investments in food security initiatives.
- Advocate for multilateral funding mechanisms to support cross-border projects, such as the African Continental Free Trade Area (AfCFTA).

***Expected Outcomes*:** Coherent policy implementation, increased investment, and strengthened regional food systems.

3.1.7 Strategic Action 7: Address Climate Change Impacts

Objective: Build adaptive capacity to address climate-induced challenges to food security.

Climate change poses significant threats to agriculture in Africa, including more frequent droughts, floods, and extreme heat. Collaborative efforts must focus on climate adaptation strategies, such as expanding the adoption of climate-smart agriculture. Projects like the Great Green Wall, which aims to combat desertification in the Sahel, can serve as models for ecosystem restoration.

Innovative insurance schemes, such as those provided by the African Risk Capacity (ARC), can protect farmers against climate shocks. EU funding and technical support can strengthen these initiatives.

Summary of Action Points:

- Collaborate on renewable energy projects to reduce reliance on fossil fuels in agriculture.
- Expand reforestation and ecosystem restoration initiatives, such as the Great Green Wall.
- Develop insurance schemes for farmers to buffer against climate shocks, leveraging tools like the African Risk Capacity (ARC).

***Expected Outcomes*:** Increased resilience to climate variability and reduced environmental degradation.

3.1.8 Strategic Action 8: Monitor and Evaluate the results

Objective: Track progress toward food security goals using evidence-based metrics.

Robust monitoring and evaluation mechanisms are critical for measuring the impact of food security interventions. Indicators should align with the Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger). Joint EU-Africa reviews of food security programs can provide valuable insights for policy adjustments.

Community-based monitoring approaches, which involve local populations in data collection and reporting, can enhance transparency and ensure that interventions are responsive to grassroots needs.

Summary of Action Points:

- Develop indicators aligned with the Sustainable Development Goals (SDGs), particularly SDG 2 (Zero Hunger) along with robust data collection mechanisms to monitor food security indicators across both regions. This should include metrics related to health outcomes, agricultural productivity, and environmental sustainability
- Implement frameworks for assessing the impact of policies and programs on food security, health outcomes, and environmental sustainability to ensure continuous improvement.
- Conduct joint annual reviews of EU-Africa food security initiatives.
- Encourage community-based monitoring to ensure grassroots participation and accountability.

***Expected Outcomes*:** Transparent assessment of progress and informed policy adjustments.

3.2 Additional Strategic Actions and Feasibility

The implementation of the above priorities and strategic actions require careful coordination among stakeholders, citizens, researchers, policy makers. The following section provide 10 additional Strategic Actions to support the realization of the roadmap priority:

1. **Strengthening Partnerships:** The collaboration between the EU and African Union (AU) should be further fostered via existing and new frameworks such as the Joint Africa-EU Strategy (JAES)[40] and the Partnership on Food and Nutrition Security and Sustainable Agriculture (FNSSA) [41] to align research and innovation efforts with food security goals12.
2. **One Health Integration:** Incorporate One Health principles into policy frameworks to ensure that agricultural practices consider human health, animal welfare, and environmental sustainability. This includes addressing zoonotic diseases that impact food systems and public health.
3. **Joint Research Initiatives:** Promote bi-regional research projects that focus on sustainable agricultural practices, food safety, and nutrition. This should include funding for initiatives that explore the links between agricultural productivity, health outcome, and environmental impacts.
4. **Capacity Building:** Invest in capacity-building programs for researchers and practitioners in both regions to enhance knowledge sharing on One Health practices and sustainable agriculture. Moreover, training programs for local stakeholders will be conducted to ensure they can effectively use the NESTLER platform to monitor agricultural trends, manage pests, and improve food security outcomes
5. **Food Safety Standards:** Develop harmonized food safety standards across the EU and Africa to facilitate trade while ensuring the safety of food products. This includes addressing mycotoxin contamination and improving food processing methods4.
6. **Public Awareness Campaigns:** Launch educational campaigns aimed at improving knowledge about nutrition, food safety, and the importance of a balanced diet, linking these concepts to local agricultural practices.
7. **Facilitate Smallholder Farmers Trading:** Enhance access to credit, markets, and technology for smallholder farmers who play a crucial role in food production. Empowering these farmers will improve local economies and contribute to food security. Moreover, strengthen intra-African trade through initiatives like the African Continental Free Trade Area (AfCFTA), which can enhance market access for agricultural products while promoting sustainable trade practices
8. **Pilot Testing and Data Collection:** Each country will initiate pilot programs using IoT devices, satellite imagery, and on-the-ground data collection. These pilots will test the platform's ability to integrate data from multiple sources and provide actionable insights.
9. **Scaling Up Predictive Models:** As the pilots demonstrate success, predictive models will be scaled up to cover more regions and integrate more data points, ensuring that the platform provides real-time insights for a larger portion of the population.
10. **Policy Integration:** The platform’s insights will be used to inform national and regional policies on food security, with an emphasis on integrating technology-driven solutions into existing agricultural and health frameworks.

3.3 Formulate Recommendations

EU-Africa collaborations within the One-Health framework are poised for growth and greater impact as both regions work to address pressing health, environmental, and agricultural challenges. To strengthen this partnership, short-term and long-term goals are outlined below:

3.3.1 Short-Term Goals:

The EU-Africa Food Security roadmap short-term goals include:

1. **Intensified Pilot Studies and Data Collection:** Building on existing pilot programs, the next phase involves expanding these studies to capture a wider range of data across regions with diverse climatic and agricultural conditions. Additional pilots will be launched to test the NESTLER platform's applicability in monitoring zoonotic disease risks, pest control, and crop health indicators.
2. **Capacity Building and Stakeholder Training:** Short-term actions will focus on strengthening local capacities in Africa by training stakeholders (farmers, researchers, and policymakers) on the functionalities and benefits of the NESTLER platform. This includes hands-on workshops, data interpretation training, and fostering partnerships with local organizations that can support sustained platform use.
3. **Policy Dialogues and Harmonization Workshops*:*** EU and African nations will conduct workshops and roundtables to harmonize regulatory standards on food safety such as insect for livestock feed initiative, zoonotic disease management, crop quality monitoring and climate resilience strategies. These collaborative policy dialogues are essential for ensuring the alignment of health and agricultural policies and for creating an integrated approach to the One-Health objectives.
4. **Refinement of Data Collection and Integration Processes:** Based on initial feedback, the next step involves enhancing the data integration mechanisms within the NESTLER platform. This refinement will improve the platform's ability to process IoT, satellite, and on-ground data, enabling more accurate and reliable predictive analytics. Technical teams will focus on harmonizing data formats and ensuring robust real-time analytics for all stakeholders.

3.3.2 Long-Term Goals

The EU-Africa Food Security roadmap long-term goals include:

1. **Scaling NESTLER Platform Deployment:** As pilot tests demonstrate effectiveness, the NESTLER platform will be scaled across more African countries and integrated into national and regional food security frameworks. The platform's deployment will target expanded predictive analytics capabilities, covering additional aspects such as soil health, crop resilience, and environmental risks.
2. **Expansion of Research Programs on Climate and Health Impacts:** A long-term objective involves establishing cross-border research initiatives aimed at understanding the interplay between climate change, food security, and health risks. Collaborative EU-Africa research networks will focus on developing sustainable agricultural practices, resilient crop varieties, and predictive models to mitigate climate-related challenges.

3. **Institutionalization of One-Health Policy Alignment:** To ensure the sustainability of One-Health initiatives, it is crucial to institutionalize collaborative policies at both the national and regional levels. Long-term policy coordination will aim to create standardized frameworks for disease surveillance, resource sharing, and emergency responses to cross-border health threats.
4. **Promotion of Technological Innovations and Localized Solutions:** The NESTLER project will continue to innovate with advanced technologies such as AI-driven data analysis, GIS mapping for precision agriculture, and IoT-enabled pest monitoring systems. Localized solutions tailored to each region's specific needs will be prioritized to ensure maximum impact and relevancy of the platform's functionalities.
5. **Creation of an EU-Africa Knowledge Exchange Hub:** A knowledge exchange hub will be established to promote continuous learning and innovation sharing between EU and African researchers, policymakers, and agricultural experts. This platform will facilitate the exchange of best practices, research findings, and technological advancements, strengthening the long-term success of One-Health partnerships.

4 EU-Africa Collaboration Activities for Promoting One-Health Initiatives

This chapter delves into a broader range of EU-Africa collaborative activities beyond the NESTLER project, aimed at promoting the One-Health approach. It covers joint research, capacity building, disease surveillance, and the integration of NESTLER outputs. These collaborations are integral to addressing shared challenges related to human, animal, and environmental health across continents. Together, they highlight a commitment to advancing food security, public health, and sustainable development.

4.1 Capacity Building and Technology Transfer

Empowering local communities through education, capacity building, and participatory resource management ensures that sustainable practices are culturally relevant and widely adopted. In this section we highlight a number of relevant capacity building initiatives.

4.1.1 Food and Nutrition Security and Sustainable Agriculture (LEAP-Agri)

LEAP-Agri is one of the most relevant initiatives, fostering sustainable food systems through a partnership between the EU and African research institutions. This program facilitates applied research on food and nutrition security, sustainable agriculture, and resilience against climate shocks. While LEAP-Agri emphasizes high-impact research projects, its output includes innovative techniques in sustainable agricultural practices and methodologies to boost crop and livestock resilience, both of which are central to NESTLER's goals.

For NESTLER, collaborating with LEAP-Agri on pilot projects could enhance predictive analytics for crop resilience by integrating climate-smart agricultural practices proven effective in other regions. Leveraging LEAP-Agri's extensive research outputs on sustainable farming can enrich NESTLER's datasets, informing predictive models that advise farmers on practices that mitigate environmental risks. For instance, insights from LEAP-Agri's trials on drought-resistant crop varieties and agroecological soil management can refine NESTLER's forecasting tools, providing data-driven guidance to farmers to adapt to changing climate conditions.

Actionable Steps:

- **Pilot Program for Climate-Resilient Crops:** Partner with LEAP-Agri to conduct joint field trials for drought-resistant crops in high-risk regions within NESTLER's operational scope. NESTLER can use LEAP-Agri's findings on these crops and integrate data from IoT sensors and satellite imagery to create predictive models tailored for Africa's diverse climatic zones.
- **Agroecological Practices Integration:** Utilize LEAP-Agri's insights on agroecological farming practices by incorporating these practices into NESTLER's recommendations for sustainable agriculture. Develop a module within NESTLER that suggests crop rotation and intercropping options based on LEAP-Agri's research, enabling farmers to diversify crops and improve soil health.
- **Data Exchange and Shared Dashboards:** Establish a data-sharing arrangement that allows NESTLER to access LEAP-Agri's agricultural research and datasets. Implement a shared dashboard accessible

to stakeholders in both programs, focusing on mapping soil quality, pest patterns, and water resources to aid in making adaptive farming recommendations.

- **Resource-Efficient Irrigation Practices:** Leverage LEAP-Agri's findings on efficient water usage to introduce drip irrigation and other water-saving technologies within NESTLER's pilot zones. Conduct workshops for farmers on water-efficient methods to promote crop resilience in drought-prone areas.

4.1.2 Horizon 2020's Sustainable Food Systems Program

The Horizon 2020 initiative targets sustainability within food systems, focusing on reducing environmental impacts and promoting resilience across agricultural landscapes. Horizon 2020 places significant emphasis on research and innovation, which align well with NESTLER's goals in terms of building climate-resilient food systems. The Horizon 2020 program supports a wide range of projects aimed at tackling challenges related to land degradation, sustainable water use, biodiversity preservation, and minimizing agricultural inputs like pesticides, which impact food safety and yield quality.

Through collaboration with Horizon 2020, NESTLER could benefit by integrating insights into eco-friendly agricultural practices. For example, NESTLER could tap into Horizon 2020's findings on integrated pest management (IPM) techniques that minimize pesticide use while maintaining yield quality and preventing soil degradation. In addition, Horizon 2020 data on sustainable water use could be directly incorporated into NESTLER's climate resilience models, guiding farmers on efficient irrigation practices to prevent water scarcity impacts on crops. This integration could also advance NESTLER's predictive capabilities, particularly regarding yield forecasts under sustainable farming systems.

Actionable Steps:

- **Precision Farming Collaboration:** Integrate Horizon 2020's advancements in precision agriculture into NESTLER's technology stack. Use AI-powered sensors and drones to monitor crop health and soil conditions, providing real-time recommendations on pest control, nutrient application, and water usage.
- **Knowledge Sharing for IPM (Integrated Pest Management):** Apply Horizon 2020's IPM techniques within NESTLER's pest management features, helping farmers adopt eco-friendly pest control options that minimize chemical usage. Train local agricultural extension workers in these IPM practices to extend knowledge to more remote farmers.
- **Soil and Water Conservation Projects:** Partner with Horizon 2020 on projects to mitigate soil degradation and conserve water. Integrate soil management and water conservation insights into NESTLER's predictive models, focusing on soil erosion prevention, crop cover strategies, and terracing, which are vital in arid or mountainous African regions.
- **Policy Briefing for Sustainable Practices:** Collaborate with Horizon 2020 to create joint policy briefs targeting African and EU stakeholders, emphasizing the adoption of sustainable agricultural policies. These briefs can advocate for subsidies on sustainable agricultural inputs and provide data on the environmental benefits of sustainable practices.

4.1.3 Collaboration with European & Developing Countries Clinical Trials Partnership (EDCTP)

The EDCTP focuses on clinical research into diseases such as HIV/AIDS, malaria, tuberculosis, and emerging zoonotic diseases like Ebola. Although NESTLER is primarily an agricultural platform, it can collaborate with EDCTP by providing predictive analytics on zoonotic disease outbreaks that stem from interactions between livestock, wildlife, and humans. Since diseases like Ebola and COVID-19 often spill over from animals to humans, NESTLER's real-time data collection from IoT sensors in agricultural environments can contribute to early warning systems, helping EDCTP researchers target high-risk areas more effectively. In addition, the NESTLER platform's predictive models can be adapted to help EDCTP by assessing the impacts of agricultural practices on zoonotic disease spread. This integration would enable NESTLER to contribute to research aimed at breaking the cycle of zoonotic disease transmission at the intersection of human, animal, and environmental health, aligning with EDCTP's goals.

Actionable Steps:

- **Co-Development of Zoonotic Disease Outbreak Protocols:** With EDCTP's resources, NESTLER can establish protocols for rapid response during disease outbreaks. These protocols can involve testing and reporting mechanisms and guidelines on movement restrictions for livestock and public advisories, thereby controlling the spread of zoonotic diseases that could disrupt food supply chains.
- **Strengthening Lab and Diagnostic Capacity:** EDCTP could assist in funding and establishing diagnostic labs near agricultural zones identified as high-risk for zoonotic diseases. These labs would facilitate testing for pathogens in both livestock and humans, allowing for a rapid and coordinated response to health threats.
- **Joint Studies on Climate-Resilient Agriculture and Disease Links:** EDCTP's expertise in epidemiology and NESTLER's data on agricultural patterns can facilitate studies that investigate how climate factors (e.g., changing rainfall, temperature spikes) influence disease dynamics and food production. By exploring these intersections, the partners can inform adaptive practices in both agriculture and health that help communities better cope with climate impacts.
- **Field Research on Emerging Diseases and Vector Ecology:** Utilize NESTLER's network of IoT devices and EDCTP's clinical data to monitor disease vectors (e.g., tick) in agricultural areas. Real-time vector mapping could predict areas of risk for livestock and communities, aiding in vector control measures like targeted insecticide application or habitat modification.
- **Database on Agro-Environmental Health Hazards:** Pool resources to create a shared repository of information on Agro-Environmental Health Hazards. This would include data on diseases associated with crop and livestock production, pesticide exposure, and impacts of land use changes. This database could inform policymakers and public health experts on critical areas for intervention and funding.
- **Developing a Unified Health-Agriculture Data Interface:** Work with EDCTP to build a unified data platform that combines health and agricultural data, enabling easier cross-sector analysis. This interface would allow agricultural data (e.g., soil health, crop disease prevalence) to inform health

responses, while health data (e.g., outbreak hotspots) could guide agricultural practices to prevent cross-species disease transmission.

- **Mobile Health and Agriculture Alerts:** Develop a mobile alert system that integrates disease alerts from EDCTP with NESTLER's agricultural data. Farmers and public health officials could receive timely updates on disease risks, preventive actions, and safe handling procedures for livestock and crops in affected areas.
- **Integration with National Surveillance Networks:** Collaborate with EDCTP to align NESTLER's surveillance network with national health surveillance systems across African nations. By connecting data streams, both programs can ensure comprehensive monitoring of One Health risks, allowing for early intervention and resource mobilization when needed.

4.1.4 Partnership with Africa CDC and the EU

The Africa Centres for Disease Control and Prevention (CDC) and the EU have been pivotal in building the continent's capacity to respond to health crises [14]. NESTLER can collaborate with Africa CDC in two primary areas:

a. ***Disease Surveillance and Food Security Integration***: NESTLER's data-driven platform can be used to integrate zoonotic disease surveillance with food security monitoring. For example, real-time agricultural data from NESTLER could be combined with disease tracking data to predict outbreaks that affect both livestock and human health. The Africa CDC's existing training programs on diagnostics and health systems can also be extended to incorporate data analysis skills for stakeholders using the NESTLER platform, allowing health professionals to better understand how environmental factors affect disease transmission.

b. ***Technology and Infrastructure Development:*** NESTLER's collaboration with the Africa CDC could focus on the technology transfer aspect of setting up IoT networks in agricultural regions. The Team Europe Initiative aims to enhance local manufacturing and health infrastructure, and NESTLER can align with these goals by providing data technologies that support real-time health monitoring in agricultural settings, contributing to cross-sector disease surveillance.

Actionable Steps:

- **Shared Data on Zoonotic Disease Patterns:** Collaborate on a shared data platform that allows NESTLER to access Africa CDC's surveillance on zoonotic disease outbreaks. This data can inform NESTLER's predictive models and provide indirect assessments of food security risks related to zoonotic diseases, such as Rift Valley Fever, which affects both livestock and human health.
- **Training Programs on Zoonotic Risks:** Work with Africa CDC to develop and deliver training sessions for farmers, focusing on understanding zoonotic disease transmission within agricultural environments. Integrate a data-driven alert system in NESTLER that notifies farmers of potential zoonotic disease outbreaks affecting livestock or crops.
- **Collaborative Workshops:** Organize workshops with Africa CDC on topics like food safety, public health, and animal health best practices. These workshops can utilize NESTLER's real-time monitoring tools to demonstrate the importance of hygiene and disease control in animal farming, especially within mixed crop-livestock farming systems.

- **Community Outreach on Health and Food Security:** Partner with Africa CDC to disseminate food safety and disease prevention information in rural areas using accessible formats such as SMS alerts, radio broadcasts, and village meetings. This information can guide farmers in implementing biosecurity measures that protect both animal and human health, contributing to a resilient food supply.

4.2 NESTLER Contributions to Existing Initiatives

NESTLER may contribute to existing initiatives via a number of actions including, but not limited to:

- **Joint Data Platforms:** NESTLER could create shared data dashboards that integrate information from different sectors, including health, agriculture, and the environment, facilitating the One-Health approach. This shared platform would allow stakeholders from both Europe and Africa to visualize and analyse data on food security, zoonotic disease risks, and environmental changes in real time.
- **Capacity Building through Training Programs:** NESTLER's tools for data collection and analysis will be integrated into existing EU-Africa training programs. Collaborating with Africa CDC, EDCTP, and other initiatives, NESTLER can develop targeted training modules that teach African researchers and policymakers how to use its platform for monitoring food security and health risks. These efforts will ensure that NESTLER is not only a technological platform but also a driver of capacity building for African institutions.
- **Cross-sector Collaboration:** The NESTLER platform supports collaborative work between the agriculture and health sectors. Through joint pilot programs such as tracking disease outbreaks among livestock or assessing the environmental impact of agricultural practices on public health. NESTLER can facilitate cross-sector solutions to complex food security and health issues.
- **Cross-Border Disease Surveillance Networks**: The EU has supported Africa in developing and enhancing cross-border disease surveillance systems that integrate data from health and agricultural sectors. For example, the Africa PGI (Pathogen Genomics Initiative) enables genomic surveillance of emerging and re-emerging diseases. African countries with shared borders, such as Kenya and Uganda, have benefited greatly from this system, especially when tracking diseases that affect both animals and humans, such as Rift Valley fever and avian flu, that affect both human and animal health. The 2nd Phase of NESTLER with its proposed ideas on disease forecasting which will be evaluated at a later stage, is an important tool in this surveillance ecosystem, with the aim of helping African nations monitor and respond to disease outbreaks in real-time.
- **One-Health Disease Control Pilots:** Several pilot projects under NESTLER have demonstrated how data-driven disease control measures can be applied in agriculture and public health. For instance, pest surveillance and disease tracking pilots in Nigeria and Cameroon have used IoT sensors to monitor crops and livestock health. These pilots are part of a broader effort to integrate animal health data with human health surveillance systems, thereby reducing the spread of zoonotic diseases.
- **EU Support for Veterinary Health:** The EU has collaborated with African veterinary health organizations to improve veterinary services and ensure that animal diseases are effectively

managed. This includes supporting vaccination campaigns for livestock and developing early-warning systems for disease outbreaks that threaten both animal and human health. Such initiatives align with the broader One-Health approach by recognizing the interconnectedness of animal health, food security, and public health.

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6 Annex: Platform Evaluation Methodology

The evaluation methodology for the NESTLER platform is designed to provide a comprehensive assessment of its performance, usability, data accuracy, and impact on food security across the EU and African regions. This methodology ensures that the platform can meet the One Health initiative's goals by providing real-time, actionable insights to users, such as farmers, researchers, policymakers, and health professionals. The platform must deliver reliable data and predictive models that enhance agricultural productivity, manage pest outbreaks, and foster sustainable practices. The evaluation methodology covers several core areas including stakeholder engagement, data collection and integration, testing and validation, and continuous monitoring for improvement.

A key aspect of the platform's performance is its ability to integrate diverse data sources from IoT sensors, satellite imagery, and research reports, and transform this data into meaningful insights. Advanced AI algorithms and machine learning models play a crucial role in processing this data, generating predictions, and automating decisions in areas such as yield forecasting, pest control, and disease surveillance. The evaluation methodology also ensures that these models are not only accurate but scalable and adaptable to different environmental and geographical contexts, both within Africa and the EU.

The focus of this methodology is not solely on technical performance but also on user-centric outcomes, ensuring that the platform is intuitive and easy to navigate, particularly for smallholder farmers and other non-technical users. As the platform supports cross-regional collaboration, it must also accommodate regional variations in data quality and accessibility, making its evaluation across multiple regions crucial.

The evaluation has three primary objectives:

- **Evaluate Technical Performance**: This involves assessing the platform’s ability to handle data inputs from multiple sources, process the data efficiently, and maintain system reliability and uptime. The integration of AI algorithms is key to automating predictions and ensuring that data is processed in real time.
- **Assess Usability and User Experience:** The platform must be user-friendly for a broad spectrum of users, from researchers to farmers to policymakers. This includes evaluating how easily users can navigate the platform, interpret data visualisations, and derive actionable insights.
- **Measure Platform Impact:** The platform’s contributions to food security are measured by its ability to deliver actionable insights that support decision-making in areas such as pest management, yield improvement, and disease control.

By achieving these objectives, the evaluation methodology ensures that the platform supports broader food security goals while delivering a reliable, scalable solution across diverse regions.

6.1.1 Platform Assessment: Technical and Operational Aspects

The NESTLER platform assessment will evaluate the platform’s ability to support the strategic objectives outlined in the food security roadmap. The assessment will focus on three main areas:

- **Functionality:** The platform’s core functions will be evaluated to determine how effectively it

supports users in monitoring and managing food security challenges. This includes its ability to collect, process, and visualize data related to climate conditions, crop health, livestock management, and market access. The platform's GIS (Geospatial Information System) mapping and analytics tools are key features that will be assessed to ensure their effectiveness in providing actionable insights.

- **Data Integration Capabilities:** A critical component of the platform's assessment is its ability to integrate and process data from multiple sources. This includes data from IoT devices, government databases, satellite imagery, and user input. The platform must demonstrate real-time data processing capabilities and the ability to consolidate this data into a user-friendly dashboard for decision-making. The integration of climate data, pest monitoring systems, and livestock health metrics will be essential for addressing the challenges in the food security roadmap.
- **User Satisfaction:** User experience is key to the platform's success. The NESTLER Platform Questionnaire on Focus Group, such as policymakers, farmers, and researchers, regarding the ease of use, accessibility, and customizability of the platform. The level of support provided by the platform's team, such as tutorials and technical help, will also be evaluated. Usability testing will gauge how effectively users can navigate the dashboard, interpret data, and use insights to make informed decisions on agricultural interventions.

The evaluation of the NESTLER platform's technical and operational aspects will provide insights into:

- **The platform's reliability and responsiveness:** This includes the speed and efficiency with which the platform processes and displays data, and its ability to remain operational during high demand or extreme weather conditions.
- **Data quality:** Assessing whether the data integrated from various sources is accurate, up-to-date, and consistent. This is crucial for ensuring that stakeholders have reliable information to base their decisions on.
- **Security and scalability:** Ensuring that the platform's data storage and processing systems are secure and compliant with data protection regulations, as well as scalable to accommodate increasing numbers of users and data sources over time.
- **Usability and user feedback:** Understanding how well the platform meets the needs of its diverse users, from technical experts to local farmers, and incorporating feedback for continuous improvement.

6.2 Key Performance Indicators (KPIs)

The KPIs provide a measurable framework for assessing both the technical and user-centric performance of the platform. These KPIs were developed through consultations with stakeholders and benchmarking against other agricultural platforms.

Technical KPIs: These KPIs evaluate the platform's infrastructure, including its uptime, data accuracy, and the processing speed of AI models.

1. **System Uptime:** Measures the percentage of time the platform remains operational, ensuring uninterrupted access to data and services.

2. **Data Accuracy:** Assesses the precision of real-time data, including soil moisture readings, pest detection from images, and disease surveillance.
3. **Processing Time:** Evaluates the speed at which the platform processes incoming data and delivers predictions, ensuring real-time usability.
4. **Scalability:** Assesses the platform's ability to handle an increasing volume of data and users without degradation in performance.

User-Centric KPIs: These KPIs focus on user satisfaction and how easily users can engage with the platform's features.

1. **Usability:** Measures how intuitive the platform interface is for various user groups.
2. **User Satisfaction:** Collected via surveys, this KPI measures overall user experience.
3. **Adoption Rate:** Assesses the rate at which new users adopt and regularly use the platform.

Impact KPIs: These KPIs evaluate how well the platform contributes to food security and decision-making.

1. **Decision-Making Impact:** Assesses how effectively the platform's insights influence critical decisions related to crop and livestock management, disease control, and food security.
2. **Sustainability Contribution:** Evaluates how well the platform supports sustainable agricultural practices by reducing waste and promoting resilience.

The KPIs are crucial for evaluating the effectiveness and performance of the NESTLER platform in achieving its goals. These KPIs help measure the platform's technical performance, data accuracy, usability, and scalability, ensuring it delivers actionable insights for food security management. Each Use Case within the platform has its own specific KPIs, detailed in Deliverable D5.1, which will also be referenced here for alignment. These metrics ensure that stakeholders can rely on the platform for continuous, real-time access to critical data across various use cases. Each Use Case defined in D5.1 has data accuracy KPIs specific to the type of data being processed, whether it's for weather patterns, pest outbreak alerts, or yield predictions. These use case-specific KPIs ensure that data accuracy is maintained across different domains.

For data-driven decision-making in agriculture, the accuracy of data is fundamental. The NESTLER platform collects data from a variety of sources, including IoT sensors, satellite imagery, and field reports. Maintaining the integrity of this data is essential to provide trustworthy insights to stakeholders. Methodology that could be adopted for the platform assessment based on the KPIs is provided in the Annex section.

6.2.1 Data Accuracy: Ensuring Reliability of the NESTLER Platform

Data accuracy is one of the most crucial Key Performance Indicators (KPIs) for the NESTLER platform. It ensures that the information being collected, processed, and analysed is both reliable and actionable. Accurate data enables stakeholders, such as farmers, policymakers, and researchers, to make informed decisions about agricultural practices, food security, and health risks. Here are the detailed aspects of how data accuracy is ensured and evaluated within the NESTLER platform:

1. Data Collection from IoT Sensors. The platform collects real-time data from a variety of IoT sensors placed in farms and pilot sites. These sensors monitor critical variables such as: Soil moisture levels, Air and soil temperature, Rainfall and humidity, Pest and disease prevalence, Livestock health monitoring, and growth indicators. To ensure accuracy, the data gathered from these sensors is continuously compared to field data collected manually by agricultural workers. For example, if a sensor measures soil moisture at a certain level, this data can be cross validated with manual readings taken from soil samples at the same location and time. By validating sensor data against manual data, any discrepancies or inaccuracies are quickly identified and corrected, maintaining the reliability of the platform.

2. Benchmarking Against Known Standards. The accuracy of data is also measured against known benchmarks, which may include:

- **Scientific Standards:** The platform uses globally accepted agricultural and environmental standards as a benchmark to ensure the accuracy of data. For instance, soil nutrient levels or pest population thresholds are compared to established benchmarks for optimal crop production.
- **Historical Data:** Historical data from previous agricultural seasons, such as crop yield records or past weather patterns, are used as reference points to verify current readings. This method ensures that the data collected aligns with expected trends and helps detect anomalies that may suggest data inaccuracies or potential risks.
- **Satellite and Weather Data**: Satellite imagery and weather data from government or third-party databases provide additional layers of validation. Satellite data can be used to measure crop health and growth patterns, cross-checked with data from ground sensors to ensure consistency. Real-time weather data ensures that sensor readings for temperature and humidity are aligned with larger atmospheric trends, reducing the risk of data errors.

3. Data Integration and Processing Validation. Data integration is another critical phase where accuracy must be preserved. The NESTLER platform processes data from multiple sources, including sensors, satellite imagery, and user-inputted data.

During integration, several measures are employed to ensure data accuracy:

- **Data Harmonization:** This process standardizes the data from different sources into a unified format. For example, if two sensors provide readings in different units (e.g., inches of rainfall vs. millimetres), harmonization ensures they are converted to a common format for analysis.
- **Automated Data Cleansing:** The platform employs machine learning models that automatically identify and filter out erroneous or outlier data. For instance, if a soil moisture sensor malfunctions and starts providing implausible readings (e.g., reporting extreme values not in line with nearby sensors), the platform's system flags these values and either corrects or excludes them from analyses.
- **Real-time Error Detection:** Through continuous monitoring, any significant deviations between collected data and known standards (benchmarks) trigger error detection systems. Alerts are then sent to system administrators, allowing for rapid intervention, sensor calibration, or manual verification in the field.

4. Validation Through Field Trials. To further ensure data accuracy, the platform validates data by comparing its predictive outputs (e.g., yield forecasts or pest outbreak warnings) with actual field results. This is known as validation through field trials:

- **Predictive Analytics Verification:** For example, if the platform predicts a certain yield based on sensor data and environmental conditions, this forecast is compared with the actual yield harvested at the end of the season. Any inconsistencies between predicted and actual results are analysed to refine both data collection methods and the algorithms behind predictive models.
- **Pilot Testing:** During pilot phases in selected regions, data accuracy is tested intensively by agricultural experts who validate sensor readings, satellite data, and predictive models through hands-on observation and testing in the field.

5. Quality Control and Continuous Improvement. Moreover, the NESTLER platform offers tools for quality control and continuous improvement, including:

- **Regular Calibration of Sensors:** IoT sensors deployed in the field are regularly calibrated to maintain their accuracy over time. Calibration routines ensure that environmental wear and tear (e.g., exposure to extreme weather) does not degrade sensor accuracy.
- **User Feedback Loops:** Users of the platform, such as farmers or extension workers, can provide feedback on data accuracy through surveys and reporting mechanisms. If they notice discrepancies (e.g., incorrect pest predictions), this feedback is analysed and used to improve both data collection and processing algorithms.
- **Periodic Audits:** The platform undergoes regular audits by third-party experts to assess data integrity. These audits are a key part of ensuring that data accuracy is maintained across all aspects of the system.

6.2.2 System Uptime: Ensuring Reliability and Availability for Continuous Data Flow

System uptime is a critical KPI for the NESTLER platform as it directly impacts the reliability and availability of its services. While system uptime traditionally refers to the percentage of time that a system remains operational and available, in the context of NESTLER, it goes beyond just measuring uptime and focuses on maintaining reliable data flows throughout operational periods.

1. Uptime Definition and Target: Uptime measures the percentage of time that the NESTLER platform remains accessible without interruptions or outages. A high uptime (e.g., 99.5% or higher) is crucial, especially in the context of real-time agricultural data and health-related insights. Constant availability ensures that farmers, researchers, and policymakers can access the platform when critical decisions need to be made, such as during pest outbreaks or weather anomalies. The platform's architecture is built on robust cloud-based infrastructure, ensuring redundancy and fault tolerance. This means that even in the event of hardware or network failures, the platform continues to operate without significant downtime, achieving the targeted uptime levels.

2. Data Flow Reliability: In addition to uptime, the reliability of data flows is a significant aspect of this KPI. Even during periods when the platform is technically "up," it's essential that data flows remain consistent, uninterrupted, and accurate. This ensures that no data is lost or corrupted during transmission and that users receive the most up-to-date and valid insights.

Several factors contribute to the reliability of data flows:

- **Real-Time Data Transfer:** The NESTLER platform continuously processes data from multiple sources, including IoT sensors, satellite imagery, and user input. Maintaining uptime ensures that this data is transferred in real time without delay. For example, soil moisture sensors in farms transmit data that is then integrated with other environmental data. If data flows are interrupted, predictive models and analytics would be delayed, reducing the platform's utility.
- **Data Redundancy:** To mitigate the risk of data loss, the platform employs redundant data storage systems. In the event of a server or sensor failure, data is backed up and rerouted to ensure that critical information is never lost. This is particularly important when dealing with weather patterns, pest outbreaks, or disease monitoring, where continuous data collection is vital.
- **Error Detection and Correction Mechanisms:** The platform uses error detection mechanisms to identify potential data corruption. If an error is detected in the data flow—whether during transmission from a sensor or within the platform's cloud infrastructure—the system attempts to correct it or re-requests the data. This safeguards the integrity of the data being processed and ensures users are making decisions based on accurate and complete information.

3. Preventing Data Corruption During Transmission. To ensure proper operation the NESTLER platform should incorporate protocols and tools for preventing Data Corruption During Transmission. These include:

- **Secure Data Transmission Protocols:** The platform ensures that data is transmitted securely using industry-standard encryption protocols. This not only protects against data corruption but also prevents unauthorized access, ensuring that sensitive agricultural and health data is protected.
- **Health Checks and Monitoring:** The system performs periodic health checks on both hardware and software components to ensure smooth operation. This includes monitoring data transmission rates, identifying slow or failed connections, and triggering alerts when data flow disruptions occur. Real-time dashboards provide technical teams with visibility into any potential issues, allowing them to resolve problems before they impact the users.

4. Continuous Monitoring of System Uptime: NESTLER implements performance monitoring tools that constantly track the platform's uptime and data flow efficiency. Tools such as Datadog or New Relic might be integrated into the system to provide real-time insights into system health, automatically alerting the technical team if there is any downtime, lag, or data transmission issue.

To further ensure that uptime and data flows are uninterrupted, automatic failover mechanisms are in place. If one server or data center goes down, the system automatically switches to another, ensuring that the platform remains online without disrupting the flow of data.

***5. Real-World Application: Importance of Uptime*.** For agricultural stakeholders relying on real-time insights (e.g., monitoring pest infestations or tracking soil conditions), any disruption in system uptime or data transmission can have significant consequences. For example, if data from weather stations is delayed during a critical planting season, farmers might miss key windows for intervention, leading to reduced yields or crop failure. Therefore, ensuring both uptime and reliable data flows is essential for maintaining the platform's effectiveness.

6.2.3 Usability: Enhancing User Experience for Diverse Stakeholders

Usability is a core factor for the NESTLER platform's long-term success, as it needs to cater to a wide range of stakeholders, including smallholder farmers, policymakers, researchers, and agricultural extension workers. Each of these groups has different levels of technological proficiency and varying needs from the platform. Therefore, ensuring the platform is intuitive, user-friendly, and accessible is essential to achieving widespread adoption and impact.

1. Intuitiveness of the Platform: Usability focuses on how easy it is for users to accomplish key tasks, such as navigating the platform's interface, querying data, generating reports, and analysing outputs. A highly intuitive platform means that users do not need extensive training to interact with the system and can quickly find the data or functionality they require. Key areas of intuitiveness include:

- **Interface Simplicity:** The platform's interface should be designed with simplicity in mind, allowing even non-technical users, like farmers, to easily navigate. Features like a search bar, clear navigation menus, and contextual help make it easy for users to explore different sections without needing technical support.
- **Guided Workflows:** For complex operations such as predictive modelling or generating reports, guided workflows can help walk users through step-by-step processes, ensuring they understand each stage and can complete tasks efficiently.

2. Accessibility: Accessibility is another key component of usability, ensuring that all users, regardless of technological literacy or physical ability, can effectively use the platform. The NESTLER platform's accessibility can be enhanced by:

- **Mobile Compatibility:** Since many smallholder farmers and rural stakeholders access digital platforms primarily through mobile devices, ensuring that the platform is optimized for mobile use is critical. This includes designing a responsive interface that works seamlessly on both smartphones and tablets.
- **Language Options:** Offering the platform in multiple languages relevant to both EU and African regions increases accessibility for diverse user groups. For example, providing support in languages such as French, English, and Swahili can ensure broader engagement.
- **Assistive Technologies:** The platform should also accommodate users with disabilities by supporting screen readers and ensuring that the design adheres to Web Content Accessibility Guidelines (WCAG), including providing high-contrast text options, keyboard navigation, and captions for multimedia content.

3. Ease of Task Completion: The platform's usability will also be measured based on how easily and quickly users can complete tasks. This involves testing common user scenarios, such as:

- **Querying Data:** How easily can users filter data based on specific parameters (e.g., region, crop type, livestock or time frame)? This requires a streamlined search and filtering mechanism that provides real-time results.
- **Generating Reports:** Users, particularly policymakers and researchers, often require tailored reports summarizing specific data (e.g., crop and livestock yields or disease outbreaks). The platform must allow users to customize reports with ease, providing pre-built templates and customizable fields.

- **Real-Time Monitoring:** For users involved in pest management or climate forecasting, real-time monitoring tools should be intuitive, offering interactive maps, alerts, and dashboards that highlight critical issues without overwhelming the user with data.

4. User Testing and Feedback: User testing is an integral part of the usability evaluation process. The platform will undergo several rounds of testing with different stakeholder groups to identify areas for improvement. This involves:

- **Task-Based Testing:** In this method, users are asked to complete specific tasks on the platform while being observed. Tasks include querying data, generating reports, or analysing trends. Observers note areas where users struggle or encounter usability issues.
- **Surveys and Feedback Forms:** After using the platform, participants will complete surveys rating their experience on factors such as ease of navigation, clarity of data presentation, and system responsiveness. User satisfaction scores provide valuable insights for improving the platform.
- **Iterative Improvements:** Based on feedback from user testing, the platform's interface and workflows will be refined to address any usability challenges. For example, if users find it difficult to generate reports, improvements might include adding pre-configured report templates or simplifying the report generation process.

5. Measuring User Satisfaction: User satisfaction is a key performance indicator (KPI) that provides insight into the overall effectiveness of the platform. Satisfaction levels will be measured through:

- **Post-Usage Surveys:** After using the platform, stakeholders will be asked to rate their satisfaction on a scale based on their experience. This helps gauge whether the platform meets their expectations in terms of data accuracy, usability, and response times.
- **Usage Analytics**: By tracking user behavior, such as time spent on tasks, frequency of use, and most accessed features, developers can identify which areas of the platform are popular and which may need improvement.

6. Continuous Improvement Based on User Feedback: A continuous improvement cycle will be established to ensure the platform evolves based on user needs. This includes:

- **Regular Updates:** Rolling out updates to address identified usability issues or introduce new features requested by users.
- **Training and Support:** Providing ongoing training sessions, webinars, and helpdesk support to assist users in making the most of the platform's features.

6.2.4 AI Model Performance and Scalability

The NESTLER platform relies heavily on AI-driven predictive models to support decision-making in agriculture. These models are critical for forecasting key agricultural parameters such as crop yields, pest outbreaks, and disease propagation, making them essential for managing food security challenges across the EU and African regions. The two most important aspects of evaluating the effectiveness of these AI models are their accuracy and scalability.

1. Model Accuracy: Accuracy is a fundamental criterion for assessing AI model performance, ensuring that predictions align closely with actual field outcomes. Various metrics are used to evaluate the accuracy of these models, including:

- **Precision:** This metric measures the proportion of true positive predictions (e.g., accurate pest outbreak alerts) to the total number of positive predictions. High precision means that most of the model's predictions are correct, minimizing false alarms.
- **Recall:** This metric assesses the model's ability to identify all relevant instances in the dataset. For instance, recall measures how effectively the AI model can predict all potential pest outbreaks. High recall ensures that fewer outbreaks go undetected, which is crucial for timely interventions.
- **F1-Score:** The F1-score combines precision and recall into a single metric, providing a balanced view of the model's accuracy. This is particularly useful when the costs of false positives (e.g., unnecessary pesticide use) and false negatives (e.g., missed outbreaks) are both significant.

The accuracy of AI models is further validated by comparing their predicted outcomes with actual field data. For example, if the model forecasts a certain crop yield for the upcoming season, these predictions are later compared to the actual harvest results to ensure the model's reliability. Data collected from IoT sensors, satellites, and on-the-ground surveys are also integrated into the platform to improve model training and performance.

2. Scalability: Scalability refers to the AI model's capacity to maintain performance as data volume and user demand increase. As more data sources are integrated into the platform—from different regions, sensors, and satellite imagery—the platform must be able to handle these increases without compromising the speed or accuracy of its predictions.

The NESTLER platform is designed to support the growth of both users and data streams by implementing several scalability strategies:

- **Cloud-Based Infrastructure:** The platform leverages scalable cloud infrastructure, allowing it to dynamically allocate computing resources based on the volume of data being processed. This ensures that the system can handle large datasets and complex AI algorithms without slowing down, even as more regions and stakeholders are added.
- **Distributed Computing:** To manage the increasing computational load, NESTLER uses distributed computing techniques, where data processing tasks are spread across multiple servers. This enhances the platform's ability to manage high data volumes and complex model computations in parallel.
- **Modular Architecture:** The platform's modular design allows for the integration of new datasets and user groups without needing a complete overhaul of the system. This architecture ensures that as the platform expands to cover new regions, it can continue delivering accurate predictions and real-time insights.

Scalability testing involves stress-testing the platform by increasing the number of users and datasets to simulate real-world conditions. These tests ensure that the platform can maintain performance without latency issues or data processing errors, even under heavy loads. Additionally, by testing AI models

against larger datasets and across different geographical regions, the platform ensures that predictions remain accurate and reliable in diverse agricultural contexts.

3. AI Model-Specific KPIs and Scalability Testing in Use Cases. For each specific use case defined in D5.1, tailored KPIs measure the performance and scalability of the AI models. For example:

- In **pest outbreak management**, KPIs focus on how accurately and quickly the models can predict pest infestations.
- In **yield prediction**, KPIs assess how well the models adapt to varying climatic conditions and agricultural practices across regions.
- For **disease surveillance**, the platform ensures that AI models can scale across borders, providing accurate data and predictions for livestock and zoonotic disease control.

6.3 Stakeholder Engagement

Stakeholder engagement is a critical aspect of the platform's development and evaluation. The NESTLER platform must address the needs of diverse groups, including farmers, researchers, policymakers, and extension workers. Early consultations (Annex: Practical Approach for NESTLER Platform Assessment with Focus Groups) provided valuable insights into their expectations, and ongoing workshops and focus groups will allow for continuous refinement of the platform's functionality. Stakeholders play an ongoing role in the evaluation, providing feedback through surveys and real-world testing of the platform's predictive capabilities, data accuracy, and usability. This engagement ensures that the platform remains relevant to the stakeholders' needs and that its evolution is guided by real-world requirements.

6.4 Data Collection and Integration

Data collection and integration lie at the heart of the NESTLER platform's functionality. The platform must manage and analyse data from various sources, including IoT sensors, satellite imagery, and other digital monitoring devices. This data is processed in real time to provide predictive insights into agricultural trends, pest outbreaks, and climate impacts. Primary Data Sources include real-time inputs from IoT sensors installed in agricultural fields, and surveys conducted by agricultural extension workers. Secondary Data Sources comprise historical data from government databases, research reports, and publicly available datasets.

The platform's cloud-based architecture allows for seamless data integration and harmonization, ensuring that disparate data formats are standardized for accurate analysis. The real-time integration of spatial, temporal, and structured data supports a holistic view of food security across different regions.

6.5 Testing and Validation Process

The testing and validation process ensures that the platform is reliable, scalable, and user-friendly. Technical testing focuses on performance, security, and scalability, ensuring that the platform can handle large volumes of data without compromising on response times or accuracy. User Acceptance Testing (UAT) engages real-world users, such as farmers, researchers, and policymakers, to evaluate the platform's usability and predictive capabilities.

The validation process also includes real-world testing, where the accuracy of predictions (e.g., crop yields, pest outbreaks) is measured against actual outcomes in the field. The impact of the platform is

assessed by comparing results before and after platform adoption, providing tangible evidence of its contributions to food security.

6.6 Continuous Monitoring and Improvement

Once deployed, the platform will undergo continuous monitoring and improvement, guided by real-time KPI monitoring and ongoing feedback from users. Regular updates will introduce new features, improve data accuracy, and enhance user experience, ensuring that the platform remains responsive to emerging challenges in agriculture and food security.

By embedding a feedback loop into the platform's operation, users will continuously report on its performance, enabling ongoing refinement and ensuring that it evolves in line with user needs and technological advancements.

6.7 Practical Approach for NESTLER Platform Assessment

The following table provide some practical approaches for NESTLER platform Assessment.

Table 7: Workshop Preparation & Execution

Approach for Workshop Preparation and Execution	
Define Workshop Objectives	• Introduce the NESTLER platform to the focus group and showcase its functionality. • Ensure participants understand how the platform aligns with their specific roles (researchers, policy-makers, farmers, etc.). • Collect initial feedback and insights from participants on their expectations and potential areas for improvement.
Identify Focus Groups and Audience Needs	• Ensure the workshop content is tailored to the needs of different groups (e.g., crop farmers, policy-makers, livestock researchers). • Segment the audience based on their involvement in the platform (e.g., those who use it for data visualization vs. those who use it for policymaking).
Develop Workshop Agenda	• Introduction & Welcome: Brief explanation of NESTLER's objectives, participants' roles, and the workshop purpose. • Platform Demonstration: Live demo of key platform features, focusing on specific pilots and their geographic relevance. • Group Activities: Break participants into smaller groups to discuss how they could use the platform in their roles. Have them explore specific functionalities. • Open Discussion & Q&A: Provide a platform for participants to share their initial thoughts. • Next Steps (15 minutes): Set clear expectations for the post-workshop assessment and platform evaluation.
Select Facilitators and	• Assign facilitators to guide participants through the platform,

Organise Roles	answer technical questions, and moderate discussions. • Designate a note-taker or use a digital tool to capture feedback in real time.
Key Messages to Convey	
One Health and NESTLER's Role	Explain how the platform supports the One Health approach by integrating data on human, animal, and environmental health to inform decision-making processes. Emphasize its role in addressing food security risks and health outbreak management.
Importance of Interdisciplinary Collaboration	Highlight the need for collaboration between stakeholders (researchers, farmers, policy-makers, etc.) and how the platform bridges gaps in communication, data access, and risk assessment.
Data-driven Decision Making	Emphasize the value of accurate, real-time data in improving food security and health outcomes. NESTLER's GIS and data mapping features allow for more informed and timely decisions.
User - Centered Design	Reinforce that the platform is built with the user in mind. Encourage participants to provide feedback during the workshop to help fine-tune the platform to meet their needs.
Next Steps for Evaluation	Convey the importance of their role in assessing the platform after the workshop and outline how they will contribute to the post-workshop evaluation process.
Medium for Engagement and Planning	
Digital Tools for Planning	• Use an online platform such as Zoom or Microsoft Teams for hosting the workshop virtually, especially for participants that are located in different countries. • For in-person sessions, have printed materials and QR codes linking to survey form.
Pre-workshop Engagement	• Send out pre-workshop materials (such as brief guides about the platform) via email or groups on instant messaging tools like WhatsApp or Telegram to prepare the participants. • Create a shared Drive or Dropbox folder where participants can access and explore additional resources about the platform.
Workshop Feedback Tools	• At the end of the session, use quick surveys on platforms (Google Forms) to collect immediate reactions. • Encourage participants to use the platform between the workshop and the assessment to provide hands-on feedback.

Post-Workshop: Timeline for Assessment	
Immediate Feedback	Gather preliminary thoughts on the platform and workshop in real-time using live polling or digital feedback tools.
Platform Usage Period	Allow focus groups to use the platform over a specific period (e.g., 1 week), during which they can explore the functionalities in their specific contexts.
Assessment & Reporting	• After the usage period, schedule a follow-up meeting or send out the questionnaire for a detailed evaluation. • Summarize the feedback, identifying key areas of improvement and success stories from different pilots.