Analytical Framework

MATS Deliverable 2.4

MATS
making agricultural trade sustainable

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Summary

The MATS project aims to expand and enhance the available knowledge on the relationships between agricultural markets, trade, investments, policy, environmental sustainability, and human well-being. It intends, through the improvement of the design, governance, and implementation of trade regimes and policies at the private sector, national, EU, African and global levels, to set a new benchmark in agricultural trade policy analysis to deliver novel solutions for the necessary sustainability transition. This deliverable presents the analytical framework developed, and adopted by MATS, to achieve such objective.

Systems thinking is used as the underlying approach for the development of the analytical framework, because of the need to capture (i) vertical and (ii) horizontal dynamics. First, (i) agricultural trade affects several dynamics, from macro, to meso and ultimately micro. This high degree of vertical reach, which results in the emergence of several feedback loops, must be analysed systemically, across the entity of the food system. Second, (ii) agricultural trade policy affects the choices of actors, which result in social, economic, environmental, and governance dynamics. These dimensions of sustainable development are interconnected with one another and form additional feedback loops.

Building on the above, MATS proposes an analytical framework that is problem-driven, multi-dimensional in the definition of sustainability, multi-method in the selection and use of relevant methods and models, uses past trends to learn about social, economic, environmental, and governance dynamics, and uses forecasts to estimate the benefits of sustainable trade policy, allowing to identify the required enabling conditions to unlock action, and finally formulate transition pathways that trigger policy uptake.

Unlike other work in this field, MATS, via the use of this framework, aims at breaking silo-based thinking and analyses, offering a more holistic and comprehensive analysis of the extent to which policy affects behaviour, using an evidence-based approach aided by science.

Eight steps are identified for the implementation of the MATS analytical framework. These are not dissimilar to other research being performed for policy analysis. On the other hand, there are a few peculiarities, especially in relation to the use of a systemic approach, that are essential for the assessment of all

facets of sustainability for agricultural trade policy. The eight is presented and then applied to three selected case studies, as illustrative examples.

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[1] R = Report, P = Prototype, D = Demonstrator, O = Other

[2] PU = Public, CO = Confidential, only for members of the consortium (including the Commission Services)

Contents

List of Abbreviations

CAP	Common Agricultural Policy
CBAM	Carbon Border Adjustment Mechanism
CGE	Computable General Equilibrium
CLD	Causal Loop Diagram
CS	Case Study
EU	European Union
EUROSTAT	European Statistical Office
FAO	Food and Agriculture Organization
FASSDEP III	Third Food and Agriculture Sector Development Plan
FDI	Foreign Direct Investment
FIES	Food Insecurity Experience Scale
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GRI	Global Reporting Initiative
GTAP	Global Trade Analysis Project
ILO	International Labour Organisation
LDC	Least-Developed Country
MATS	Making Agricultural Trade Sustainable
NUTS	Nomenclature of Territorial Units for Statistics of EUROSTAT
PCSD	Policy Coherence for Sustainable Development
SAM	Social Accounting Matrices
SD	System Dynamics model
SDG	Sustainability Development Goal
SEEA AFF	System of Environmental-Economic Accounting for Agriculture, Forestry and Fisheries
SSM	Soft Systems Methodology
ST	Systems Thinking
TEEB	The Economics of Ecosystems and Biodiversity
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
WASH	Water, Sanitation and Hygiene for All
WP	Work Package

1 Introduction

1.1 Developing an analytical framework in the context of MATS objectives

The MATS project aims to expand and enhance the available knowledge on the relationships between agricultural markets, trade, investments, policy, environmental sustainability, and human well-being. It intends, through the improvement of the design, governance, and implementation of trade regimes and policies at the private sector, national, EU, African, and global levels, to set a new benchmark in agricultural trade policy analysis to deliver novel solutions for the necessary sustainability transition.

We acknowledge that there is ample literature on the impacts of land cover change and land-use practices concerning socioeconomic and environmental sustainability. On the other hand, we find that knowledge is lacking on the extent to which agricultural trade policy influences behavioural choices related to land use and production practices, and governments' ability to regulate markets, which ultimately determine whether the outcomes are sustainable or unsustainable at local, national, and international level. Specifically, the FAO, UNDP, and UNEP indicate that agricultural policy can influence farmers' decisions related to (a) the choice of production inputs, (b) the choice of production methods, practices, and markets, (c) the choice of crops to grow and livestock to farm, and (d) patterns of land use and agricultural land expansion (FAO, UNDP and UNEP, 2021). We set to explore the relationships between agricultural trade policy, investments, and sustainability outcomes, by considering indicators of process, impact, output, and outcome.

To achieve stated goals, MATS includes three interconnected and systemic operational features: a multi-method analysis (a set of 15 case studies on trade and investment dynamics, an integrated multi-model simulation, and an analysis of institutional, regulatory, and legal frameworks), a novel multi-actor approach, and a clustering with other trade-related research projects to benefit from synergies.

WP2 of the project, which builds upon the results from WP1, has three specific objectives:

- Identification of relevant frameworks, indicators, and tools for assessing the relations between agricultural trade and sustainability.
- Critical review and synthesis of the results of previous studies that have used computational models for assessing the relations between agricultural trade and sustainability.
- Development of a novel analytical framework, comprising indicators, methods, and models, enabling conditions and transition pathways to be used in WP3, WP4, and WP5, and providing guidance on agricultural trade policy sustainability assessments.

Figure 1 shows the process and flow of T2.4. The three main elements (indicators, models, and methods for presenting results) are supported by a review of existing analytical frameworks for agricultural trade sustainability. Indicators are selected to measure and assess the impacts at social, economic, environmental and governance levels of agricultural trade. In other words, these indicators are identified to perform a systemic analysis of the relationship between trade policy and multidimensional sustainability outcomes. They underpin the use of a systemic approach, and are investigated in detail in WP2, specifically in T2.1, T2.2, and T2.3. The results of the three tasks are integrated into T2.4 to create a new, comprehensive analytical approach. This approach in turn will provide the necessary framework for the case study assessments in MATS, and the basis for the systems dynamic modelling of WP3, as well as for the analysis of institutional, regulatory, and legal frameworks (WP4), and for a multi-actor forecasting, foresight, and back-casting approach to explore transition pathways towards sustainable trade (WP5).

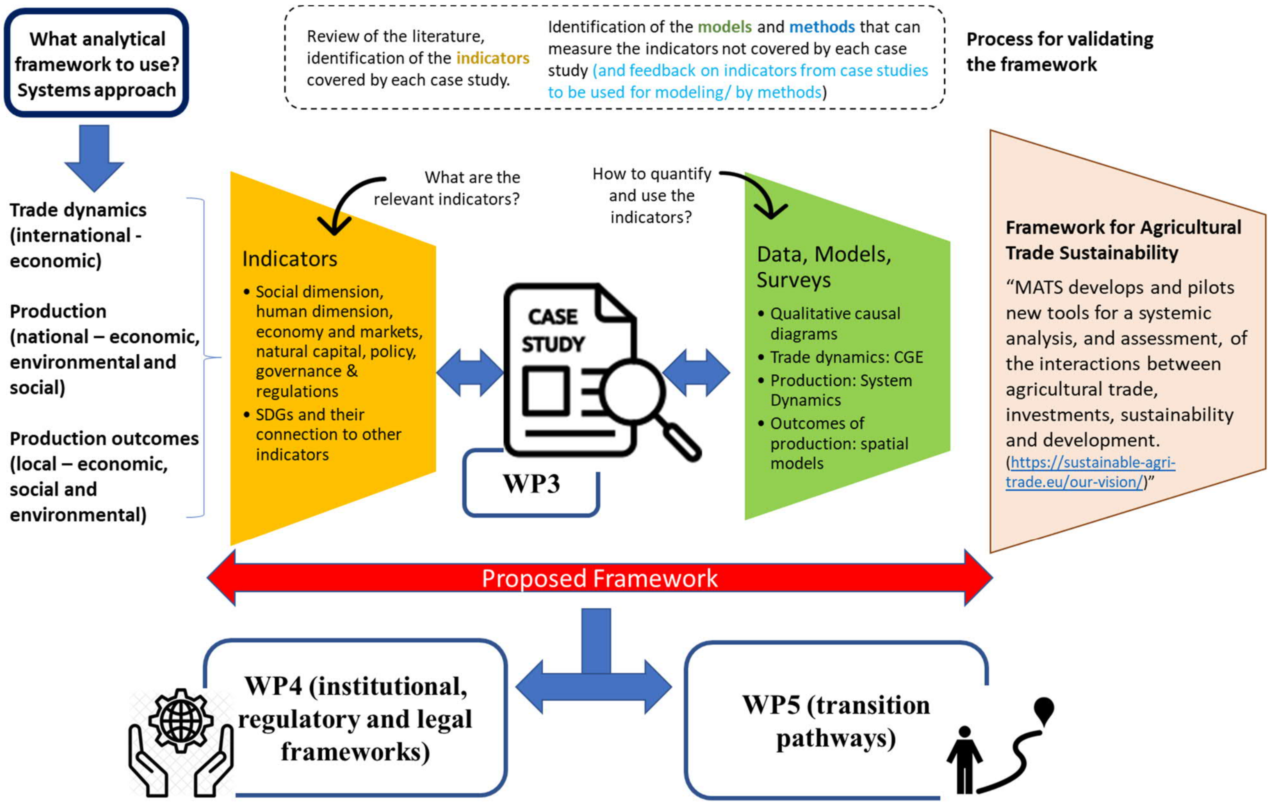

Figure 1: Process and flow of T2.4.

The framework has been created to support various types of assessments in relation to agricultural trade sustainability, measured in relation to trade, investment, agricultural production, production outcomes and governance indicators. In this respect, the framework has profited from - and is well aligned with – the EU Taxonomy (European Commission, 2021a), a "green classification system that translates the EU's climate and environmental objectives into criteria for specific economic activities for investment purposes". In this context, the framework identifies a set of indicators to characterize and define the sustainability of agricultural trade. In doing so, it supports the identification of investments, in alignment with the Platform on Sustainable Finance (European Commission, 2021b), and promotes transparency by adopting a systemic and multi-dimensional approach to sustainability.

Acknowledging that agricultural trade policy affects, and is affected by environmental, social, governance and economic dynamics (i) at the international level, (ii) at the national level, and (iii) at the local, landscape or watershed level (e.g., cutting across NUTS 1 – 3, the Nomenclature of Territorial Units for Statistics of EUROSTAT, depending on the reach of the policy considered), we have identified indicators that are relevant to each of these dynamics.

The framework will be further described in later sections of this document, with the following flow:

- The remaining subsections of Section 1 provide information on the process followed to create the framework and present its building blocks.
- Section 2 introduces the analytical framework, explains the rationale for the use of a systemic approach in the formulation and use of the framework, to capture, analyse and understand the many interconnections and paths linking agricultural trade policy and sustainability outcomes.
- Section 3 introduces the indicators selected, starting from the literature review and the results of T2.1, to measure the interlinkages between social, economic, environmental and governance dimensions of agricultural trade.
- Section 4 explains how the analytical framework supports the work carried out in MATS, across work packages. Starting with case studies (WP3), the framework can support identifying the correct boundaries of the analysis, shed light on the type of methods and models available to fill information gaps, and then support the identification of enabling conditions (WP4) and the formulation of transition pathways (WP5), all using a multi-dimensional approach to sustainability, a transparent approach to measuring and modelling performance, a multi-actor approach to assess governance and power dynamics, and a co-creation approach to reflect the needs of the specific policy context.
- Section 5 presents how the framework can be applied in practice, via the use of 8 steps. It offers examples from existing work for 3 case studies, although these should be only considered illustrative at this stage.

1.2 Process followed to create the framework

Initially, to set the stage for the analysis, we have reviewed the outcomes of T2.3, with an overview of the available tools to assess agricultural trade sustainability, outcomes, and mechanisms of agricultural trade policy. From this work it emerges clearly that the use of a systems approach is required, given the central role that agriculture plays in affecting social, economic, governance and environmental indicators at local, national, and global level. Further, T2.3 has highlighted the importance of investigating the interconnections existing across indicators, including SDG indicators (assessed in detail in T2.1), how to deal with power issues, how to engage with different ways of understanding a given situation, and more. This is to better understand the ramification of investments for enhancing agricultural trade and production sustainability. As a result, after acknowledging the need to use a systems approach, after identifying indicators and exploring their interconnections, and after quantifying relationships for impact analysis, we have formulated and followed a three-step approach for the creation of the framework proposed in this report.

First, we have carried out a comprehensive literature review, aligned with the materials reviewed in T2.2, to determine which social, economic, environmental and governance indicators are most commonly presented in studies that focus on agricultural trade, production and production outcomes. We have then compiled a list of indicators that provides a comprehensive view of policy impact from international trade (top-down) to the local level (bottom-up). This has allowed us to assess the extent to which the studies reviewed miss critical information on trade policy outcomes, mechanism, practices, and markets based on their area of focus and methods/models used. We then went one step further and compared the indicators selected to the SDGs, building on the work performed in Task 2.1. This allows to not only track indicators, but also to assess the extent to which all MATS relevant SDGs, and hence all dimensions of sustainable development, are considered in the analysis performed with the framework. This being said, we acknowledge that the list of indicators proposed still does not address all the needs of all audiences (actors); further, it may well be that not all indicators are relevant to all audiences. This list of indicators is nevertheless anticipated to be relevant for studies on agricultural trade sustainability, starting from the 15 case studies analysed in MATS (WP3), while also contributing to the work of WP4 (institutional, regulatory, and legal frameworks) and WP5 (transition pathways).

Second, based on the work performed in Task 2.2, we have reviewed the simulation models utilized to assess the performance of agri-food value chains, including the impact of agricultural trade policy, and resulting decision-making on (i) international trade, (ii) national production and (iii) production and governance outcomes. This literature review highlights that macroeconomic, multi-country models are primarily used to assess outcomes at the international trade level (i), national macroeconomic models, coupled with land use and agriculture models are primarily used at the national level (ii), and spatially explicit models, with emphasis on landscape impacts (e.g. from deforestation, water pollution, climate change) are employed at the local level (iii). This review of the literature allows us to determine the extent to which simulation models are providing a complete, or partial set of indicators for the assessment of agricultural policy sustainability. If critical indicators are missing, the framework proposed provides information on how to interpret current results (acknowledging that some policy outcomes could not be quantified), and on what additional methods and models are available to fill such gaps.

Third, once the indicators were identified and models are used to fill data gaps in the analysis, we have assessed how the results of such a multi-dimensional analysis could be utilized for the identification of enabling conditions (e.g., institutional, regulatory, and legal frameworks, the focus of WP4) and the formulation of transition pathways (the focus of WP5).

These three main components, including the use of indicators, qualitative and quantitative models, and methods, allow us to create a framework that provides a comprehensive in-depth assessment of the linkages existing between agricultural trade policy, investment, production outcomes, and repercussions on local human well-being and ecological sustainability. With the indicators considered in the framework we can identify, and possibly anticipate, whether a given agricultural trade policy will create trade-offs (e.g., between economic and environmental outcomes such as biodiversity; or between international and local outcomes), or conversely, whether it will create synergies with local and national development goals (e.g., a trade policy that support crop diversification may increase income creation and improve nutrition, resulting in stronger socio-economic performance in producing countries, while ensuring cost-effectiveness for the production and trade of a variety of food products).

1.3 Building blocks of the framework

WP2 has set its overall goal of identifying relevant frameworks, indicators, and tools for assessing the relations between agricultural trade and sustainability. Different tasks within WP2 cover indicators (T2.1), models (T2.2) and sustainable trade tools (T2.3) for assessing the sustainability of agricultural trade. Each of these research areas has been considered in the creation of the framework formulated in Task 2.4. The following sections describe each task of WP2 and how the knowledge they created has been used as an integral part of the framework presented in this document.

1.3.1 SDG indicators for Assessing the Sustainability Impacts of Agricultural Trade (T2.1)

The main goal of T2.1 consists in identifying relevant SDG indicators and assessing their suitability for analysing trade and agriculture sustainability outcomes. A selection process has been carried out from the 248 SDG indicators that lead to a final list of 56 indicators that are considered relevant for the goal of MATS, which is to identify leverage points that can reduce the negative impacts of agricultural trade on socio-economic and environmental sustainability. These indicators have been selected to deliver a systemic view of the agri-food trade and its impacts.

One of the main findings of this process indicated that while the SDG indicators are useful as an input to design the MATS analytical framework, they are not sufficient to measure the linkages between agri-food trade and sustainability with a systemic view. Specifically, SDG indicators are mainly broad impact indicators, thus, they present deficiencies in measuring the complex interrelations across dimensions of development, and their connection to process (e.g., governance). Furthermore, the SDG indicators were not conceived to be applied to individual stakeholders (e.g., actors in agri-food value chains, such as farmers, processors, retailers, consumers, and households), which are the primary focus of the MATS case studies. Therefore, a comprehensive analytical framework should also include indicators that are more focused on the flows, interactions, processes, and inputs of the systems, and applicable to individual actors. From a more practical view, it has been found that the case studies which have been designed in the initial stages are mainly focused on the socio-economic and environmental impacts of agri-food trade, capturing less policy and governance aspects, knowledge exchange, investment and innovations, and human as well as social capital aspects.

1.3.2 Synthesis of model-based studies (T2.2)

The main goal of T2.2 was to identify, review and synthesize studies that have used computational models which either assess the outcomes of agricultural trade policy, or of choices related to land use and production practices (which are indirectly impacted by agricultural trade policy, among other factors). Particular attention was paid to assessing the heterogeneity of the methods and models reviewed, and the key factors that explain differences in modelling outcomes (i.e., offering an interpretation of results based on the method and model used).

The literature review and model comparison carried out in T2.2 was based on (i) relevant research topics directly or indirectly impacting the agri-food value chain or being impacted by it. Examples include the choice and use of production inputs (e.g. water), resulting outputs (e.g. food production and trade); international markets and local dynamics (e.g. shaping demand and supply, affecting nutrition and other social outcomes); climate change impacts, adaptation efforts (investments) and the extent to which climate scenarios were considered (e.g. use of monthly or annual climate forecasts, quantification of the impact of climate change using longer-term trends or extreme events, or both); (ii) model characteristics and underlying assumptions, e.g. partial vs general equilibrium models; static vs dynamic models; sectoral vs integrated models; single vs multi-country models; (iii) model boundaries, e.g. coverage of sustainability dimensions, and policy support capabilities, e.g. forecasting via simulation vs optimization.

1.3.3 Sustainable trade toolbox (T2.3)

Task 2.3 provides an analysis of relevant frameworks, approaches, methods, and tools to assess the agri-food trade from a sustainability perspective, and with a systemic view.

Deliverable 2.3 presents the results of the Task in the form of a compilation of instruments within a toolbox format. Is in the intent of this deliverable to cover a diverse range of tools for analysing and advancing agricultural trade as a lever for sustainability, while supporting the use of these tools in a more systemic way.

To build the Sustainable Agri-Food Toolbox, a three-stage methodology was elaborated. Is important to note that we define a toolbox as a compilation of instruments that span from guiding principles and approaches to targeted methods, tools, and indicators.

The first stage of the methodology focuses on defining criteria to identify and select relevant frameworks, approaches, methodologies, methods, tools, and indicators; in the second stage, those criteria are applied when consulting various sources (incl. literature, project partners) to identify and select relevant instruments; finally, in the third stage, the information gathered in the second stage is summarized and presented in a fact sheet, designed around descriptors that facilitate future use of the toolbox.

Text Box: Overview of the methodology adopted in T2.1, T2.2 and T2.3

SDG indicators for assessing the sustainability impacts of agricultural trade (T2.1)

A selection process was carried out with MATS project partners, starting from the 248 official SDG indicators to a final selection of 56 indicators, those considered to be most relevant to MATS. The selection process considered: their contribution of the SDG indicators to assessing the linkages between agricultural trade, sustainability, investment, and human welfare; the estimation of the SDG indicator at a geographical scale appropriate for MATS; the possible redundancy with other indicators; the potential usefulness of the SDG indicators for the 15 MATS case studies.

Three additional criteria were used for the final selection of the SDGs indicators, including the geographical scope of the indicator, the measured item, and a comparison with case studies. Finally, to ensure interconnectivity between the different WPs and to address the needs of the case studies, a consultation with MATS partners and case study leaders was carried out.

Synthesis of model-based studies (T2.2)

The methodology used to identify, review and assess the methods and results of agricultural trade-related studies was structured as follow:

- A literature review focused on topics relevant to MATS, to identify model characteristics and assumptions, and model's abilities and results.
- An assessment of the complementarity of methods and models, like CGE models, System Dynamics, and partial equilibrium models, to determine the potential to cover a broader range of sustainability indicators with simulation models.
- An assessment of the extent to which the results of the studies reviewed align with the assumptions and features of models used (i.e., interpretation of results based on structural and numerical assumptions).
- Creation of a summary of the results of the review, to identify what methods and models could be used in the context of MATS and beyond.

A large number of documents from the grey literature (e.g., academic papers and reports) were reviewed and clustered into three groups: Global Agri-Food Value Chains, Agricultural Production, and Agricultural Production Outcomes.

<u>Sustainable trade toolbox (T2.3)</u>

The methodology of T2.3 developed over three stages. The first one focuses on criteria definition in order to identify and select the relevant frameworks, approaches, methodologies, methods, tools, and indicators to analyse agri-food trade from a systems perspective and contribute to MATS purpose of identifying key leverage that foster the positive and reduce the negative impacts on sustainability and human well-being. Secondly, those criteria are applied when consulting academic and grey literature related to agriculture, food production, trade, and sustainability – with a special focus on food systems frameworks – and seeking inputs and feedback of MATS consortium members to identify and select relevant instruments. Finally, in the third and last stage, the information collected was summarized and presented in the form of a factsheet, designed around descriptors that allow future use of the toolbox. Specifically on the literature review of food systems frameworks, all searches were limited to documents in English, published from 2008 onward, when the food system approach started being broadly used as a framework to understand challenges related to agriculture and food. Once the publications were identified, all the abstracts were reviewed to select those that propose or discuss conceptual and methodological frameworks for analysing food systems, using the following exclusion criteria: (i) publications with a partial scope or too broad scope of analysis, (ii) publications focused on case studies that do not discuss/reflect upon the food systems framework applied, (iii) publications focused on specific methods or tools that do not discuss/reflect upon the food systems framework applied.

2 The analytical framework: using a systemic approach to assess the sustainability of agricultural trade

The assessment of the sustainability of agricultural trade requires the use of a systemic approach. There are many reasons for reaching this conclusion. As described in T2.3, several interdependencies shape the dynamics of the food system in relation to food security, environmental and economic sustainability, and human well-being. Agricultural trade policy has played an important role in affecting this balance over time. Specifically, systems thinking has contributed to the creation of a better understanding of food systems by (a) making sense of broader sustainability and human wellbeing issues related to agri-food trade, (b) shedding light on the food systems' dynamic behaviour and (c) acknowledging the role of agency in how problematic aspects in food systems are framed and addressed.

In the context of this framework, the use of systems thinking is required because of two main reasons, related to (i) vertical and (ii) horizontal dynamics.

First, (i) agricultural trade affects several dynamics, from macro, to meso and ultimately micro. Agricultural trade policy is designed to impact international trade. In doing so, it affects national production, and ultimately local land use and production practices. This high degree of vertical reach, which results in the emergence of several feedback loops, has to be analysed systemically, across the entity of the food system. It may well be the case that a policy that is advantageous at the national level for large producers, is instead detrimental for small farmers and local communities.

Second, (ii) agricultural trade policy affects the choices of actors, which results in social, economic, and environmental impacts. These three dimensions of sustainable development are interconnected with one another and form feedback loops, which become evident at the local level. To provide an example, trade policy may favour the production and export of grains, by providing a guaranteed price that stimulates production at the local level. The price signal to farmers may trigger the decision to only grow grains, using a mono-cropping rather than an agro-ecological approach. Further, a guaranteed price and sales volumes would stimulate efforts to reduce costs, favouring quantity over quality, to increase profitability. The consequences of these choices may result in the lack of fresh fruit and vegetables, whose price is likely to increase due to a lack of local supply, creating issues for nutrition and human health as a result of reduced accessibility and affordability. Further, mono-cropping may result in soil impoverishment, loss of biodiversity and soil erosion, also due to the higher vulnerability to climate conditions, and the extensive use of fertilizer may result in excessive nutrient loadings and water quality issues. These dynamics do not only impact the local population in terms of social sustainability and well-being, but also negatively re-affect land productivity, investment potentials and the sustainability of grain production in the future.

In light of the vertical and horizontal dynamics highlighted above:

a) the selection of indicators in the proposed framework focuses on the social dimension, human well-being dimension, economy and markets, natural capital, policy, governance, and regulations and, on a case-by-case basis on specific knowledge and technologies (to cover all facets of development, in connection with the SDGs),

b) the categorization of case studies targets trade, value chain, production, and production outcomes (to address international, national, and local dynamics) and establishes a direct connection with the type of methods and models available to support qualitative and quantitative analysis, and,

c) several types of methods and models are considered, with a preference for those that support knowledge integration (to be able to explicitly link biophysical trends and governance to socio-economic performance).

This highlights how the proposed framework uses systems thinking as an underlying approach, and it is built using indicators, methods and models that support the operationalization of a systems approach.

Building on the above, Figure 2 presents the analytical framework developed for MATS. It also shows how the framework is embedded in the project conceptualization and workflow across work packages, from WP1 to WP6. Further, Section 5 and Figure 4 introduce 8 steps for the implementation of the framework, with examples for 3 selected case studies.

The top left side of Figure 2 highlights agricultural trade policy as an entry point. The analysis of policy design characteristics and observed impacts allows to formulate the problem statement. This is performed taking into account the linkages between agricultural trade, markets, investments, environmental sustainability and human well-being (WP1). Some of these linkages may have been neglected in policy design, resulting in the emergence of side effects.

Next comes the conceptualization of the analysis required to assess in more detail the shortcomings of the current policy and the potential areas of improvement of a new, and more sustainable trade policy. This pertains the identification of relevant indicators, in the context of local governance, actors and power dynamics, as all well by considering the SDGs. The SDGs are important so that all dimensions of sustainability are considered.

Following the conceptualization stage, a first assessment is conducted. This consists of data collection (both soft and hard) and in the identification of models (both qualitative and quantitative) that can reduce information gaps. This assessment focuses on the analysis of past and current performance, to create a shared understanding of the drivers of change that gave rise to the problem identified.

The tools required for conceptualization and the assessment of past performance are presented in WP2.

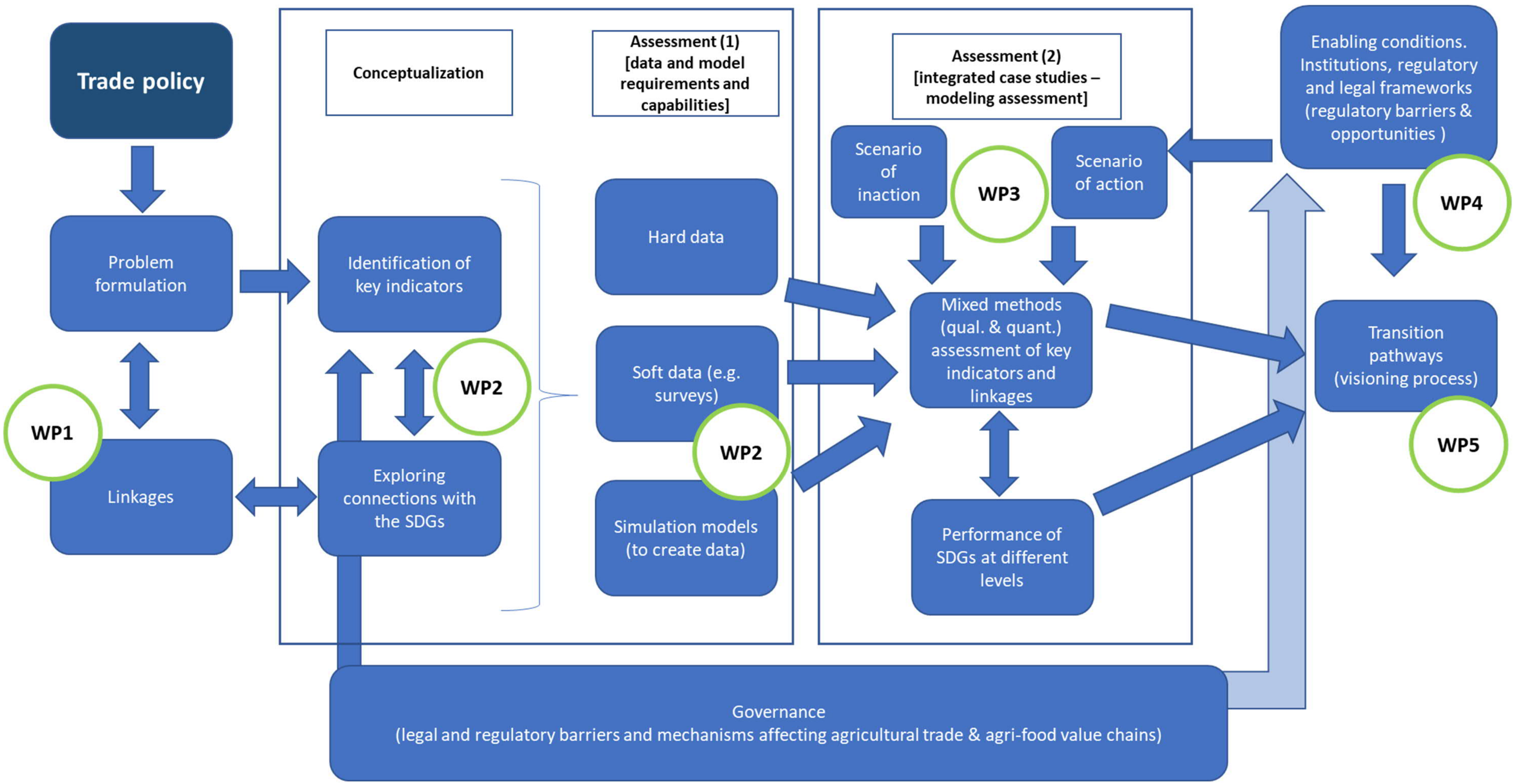

Figure 2: MATS analytical framework

A second type of assessment is then performed, one that is forward-looking. In this case, attention is paid to the likely outcomes of the implementation of a new or improved agricultural trade policy. In this context two scenarios are compared, ones of inaction and one of action. Mixed methods can be used in this phase, both qualitative and quantitative, to forecast performance against the indicators identified in the conceptualization of the analysis (i.e., a set of indicators customized to the project, but that take into account all dimensions of sustainable development, see Section 3). This assessment will be piloted and performed for 15 case studies in WP3, as well as at the global level with macro simulation models (CGE and System Dynamics).

Following the analysis of future scenarios, comes the identification of enabling conditions, including institutions, regulatory and legal frameworks (WP4). These are conditions that are required to ensure the effective implementation of the policy, resulting in the elimination of the problem and in the creation of new opportunities. This part of the analysis is carried out using the outcomes of the 15 MATS case studies, taking into account global literature, as well as innovative macro modelling analysis developed in MATS.

A final stage pertains the creation of transition pathways, indicating what are the steps necessary, over time and with specific roles and responsibilities for different actors, to realize the advantages offered by the new agricultural trade policy and the enabling conditions at hand (WP6). This final step considers all the information generated in earlies stage and, once again, leverages knowledge of the context in which the policy is designed and implemented (governance, power dynamics) to elaborate an effective theory of change or even a strategy and action plan.

We, therefore, propose an analytical framework that is problem-driven, multi-dimensional in the definition of sustainability, multi-method in the selection and use of relevant methods and models, uses past trends to learn about social, economic, environmental and governance dynamics, and uses forecasts to estimate the benefits of sustainable trade policy, allowing to identify the required enabling conditions to unlock action, and finally formulate transition pathways that trigger policy uptake.

Unlike other work in this field, MATS, via the use of this framework, aims at breaking silo-based thinking and analyses, offering a more holistic and comprehensive analysis of the extent to which policy affects behaviour, using an evidence-based approach aided by science.

3 Selecting indicators for the sustainability of trade and its outcomes

3.1Types of indicators considered

We considered several types of indicators in MATS to assess the sustainability of agricultural trade: (i) input, (ii) process, (iii) output, (iii) outcome and (iv) impact indicators (FAO, 2009; Simister, 2016).

Input indicators in the context of our analysis refer to the policy and other intervention options considered to improve the sustainability of agricultural trade. These are indicators that are specific to each case study analysed, within and beyond MATS, and are hard to categorize given the breath of the agri-food system and the variety of trade policy provisions available. As an illustrative example, we can consider the ban on the trade of products that use chemical fertilizers in the production process.

Process indicators refer to whether the policy or intervention option has been implemented, and to what extent. As in the case of input indicators, these are context and case case-study-specific. On the other hand, there are certain indicators that can be generalized, such as governance indicators pertaining on the way in which the policy or intervention is implemented. Indicators in this context may include the extent to which consultations have taken place, if the information has been shared and awareness created, and whether the new policy has been enforced.

Output indicators measure the direct consequence of the implementation of the policy or intervention. These are defined based on the type of intervention implemented, i.e., they cannot be generalized with the same indicators being used for all type of interventions. Indicators include whether the products imported into the country are in fact free of chemical fertilizers.

Outcome indicators measure both whether the objective has been reached, and how well. This is a broader range of indicators that includes social, economic, environmental and governance dimensions. Indicators include the reduction in chemical fertilizer use, and the outcomes on land productivity, production, and trade volumes.

Impact indicators consider both positive and negative, direct, indirect, and induced effects produced by the intervention. Indicators include income creation for farmers, the reduction in water pollution and improvements in soil productivity (e.g., due to an increase of organic carbon and nutrients) and the improvement of nutrition and human health. The SDGs, given their breadth, can be used to assess the outcomes and impacts of intervention options, in a multi-dimensional way in the context of sustainability.

As indicated earlier, most of the studies consulted, the quantitative models reviewed, as well as the SDGs, primarily focus on outcome and impact indicators. For this reason, in this framework we also consider qualitative methods (e.g., Causal Loop Diagrams (CLDs)) that explicitly explore causality, allowing us to link the (policy) input to process, output, outcomes and impact indicators.

3.2 Geographical scale considered across the value chain

Work for T2.4 started with a literature review comprising scientific journal articles, book chapters and reports on agricultural production, production outcomes, and global agri-food value chains. From prior knowledge and through this literature review, we developed an initial set of indicators that presents the main impacts of agriculture trade policy. These indicators were then reviewed with MATS consortium partners and cross-checked for overlaps with the work carried out in T2.1 (on the identification of relevant SDGs), T2.2 (on the indicators considered in qualitative and quantitative models) and T3.3 (on the indicators and dimensions of development considered in sustainability tools).

What especially interested us were the effects that trade policy could have on society, economy, environment, and governance[3], as well as their interactions in the form of feedback loops (e.g. impact of poor governance on trade policy sustainability outcomes) (Shenggen, Headey, Rue, & Thomas, 2021; Blanchard, Bown, & Johnson, 2016).

The list of indicators we have created, presented in Annex 1, considers different dimensions of sustainable development (social dimension, human dimension, economy and markets, natural capital, and policy, governance & regulations). Table 2 adds a different characterization, ranging from the broader context of international trade, down to the country level, and to the smallest scale of analysis referring to regional or landscape outcomes of production. These indicators enable us to connect trade policy-focused modelling approaches at these levels with the micro-, meso-, and macro-level value chain mechanisms and issues to be addressed at case-study level, while considering all relevant dimensions of sustainable development.

The differentiation between international, national, and local outcomes of trade policy is aimed at identifying what indicators are most commonly used when carrying out different types of assessments, to directly inform case study analysis. Studies that focus on global agri-food value chains generally cover production flows across countries and impacts on food prices. National studies focus instead on production, GDP, and employment or, in other words, on how agriculture trade impacts national development. Studies that focus on the outcomes of production at the local level instead include impacts on nutrition, labour conditions, jobs and income, market access as well on ecological sustainability.

The analytical framework brings together these international, national, and local levels connects trade policy impacts and outcomes with value chain issues to be

[3] Gereffi et al. (2005) define governance mechanisms as formal and informal rules and instruments that firms deliberately design to coordinate the behaviours of different actors (Schrage & Gilbert, 2021).

addressed at case study levels. In this way, the analytical framework uses feedback mechanisms to inform the different levels of analysis (e.g., case studies providing novel information on indicators, so that indicators can be refined in future modelling efforts – see double, blue arrows in Figure 1).

The full list of indicators identified is presented in Annex I. The following sections explain their use in the framework, in relation to their connection to the SDGs and how these indicators are used to assess the coverage of sustainability dimensions in the case study analysis, as well as in WP4 and WP5.

3.3 Matching indicators to the SDGs

The indicators introduced in the previous section and presented in Annex 1 were identified based on the literature review and knowledge elicitation within the MATS consortium. The selection was performed considering the frequency with which these indicators are found in various types of assessments, the extent to which they were supported by data or modelled estimates and complemented by relevant indicators for the 15 MATS case studies.

On the other hand, most of the papers and reports reviewed did not connect indicators of agriculture trade sustainability either to sustainability or to the SDGs. Given the focus of MATS, it is critical that any indicator representing or explaining agriculture trade policy is connected to sustainability, and particularly to the SDGs, by connecting the SDGs in practical ways to value chain actors and thus to case study analyses (e.g. connecting SDGs to GRI indicators) (Barkemeyer, Preuss, & Lee, 2015; Olanipekun, Omotayo, & Saka, 2021; Sisaye, 2021; Shinkareva, Kaurova, Maloletko, Vinichenko, & Karácsony, 2021). Table 1 presents the correspondence between the indicators listed in Annex 1 and the SDGs. The matching of indicators with the SDGs in Table 1 is made taking into account the pre-selection of relevant SDG indicators performed in T2.1. Matching relevant indicators of agriculture trade policy to the SDGs allows for the estimation of whether policy implementation results in sustainable outcomes and impacts at the regional, national, and local level, supporting the work of WP4 (institutional, regulatory, and legal frameworks) and WP5 (transition pathways) of MATS.

It should be noted that this table (and Table 2 also) represents a simplified view of indicators. Many of the indicators identified influence one another, in dynamic ways and form feedback loops.

This table is meant to serve as a checklist, to identify which areas of sustainability are covered by a given case study or assessment, and whether these areas are addressed qualitatively or quantitatively (see Section 5). Practically, all key dimensions of sustainable development should be covered by each case study or assessment, but only the indicators of relevance to the assessment should be analysed.

Table 1: Overview of the indicators selected and their connection to SDG indicators, as per the results of T2.1

	SDG indicator	
Social dimensions		
Ownership rights	5.a.1	Proportion of total agricultural population with ownership or secure rights over agricultural land, by sex; and (b) share of women among owners or rights-bearers of agricultural land, by type of tenure
Social Protection	1.3.1	Proportion of population covered by social protection floors/systems, by sex, distinguishing children, unemployed persons, older persons, persons with disabilities, pregnant women, new-borns, work-injury victims and the poor and the vulnerable
Discrimination	10.3.1	Proportion of population reporting having personally felt discriminated against or harassed in the previous 12 months on the basis of a ground of discrimination prohibited under international human rights law
Unemployment rates	8.5.2	Unemployment rate, by sex, age and persons with disabilities
Human rights (Child labour, forced labour)	8.7.1	Proportion and number of children aged 5–17 years engaged in child labour, by sex and age
Working conditions	8.3.1	Proportion of informal employment in total employment, by sector and sex
	8.8.2	Level of national compliance with labour rights (freedom of association and collective bargaining) based on International Labour Organization (ILO) textual sources and national legislation, by sex and migrant status
Human dimensions		
Poverty rates	1.1.1	Proportion of the population living below the international poverty line by sex, age, employment status and geographic location (urban/rural)
Access to basic services	1.4.1	Proportion of population living in households with access to basic services
Food security and nutrition (e.g., famine, nutrition, food quality)	2.1.1	Prevalence of undernourishment
	2.1.2	Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES)
	2.2.2	Prevalence of malnutrition (weight for height >+2 or <-2 standard deviation from the median of the WHO Child Growth Standards) among children under 5 years of age, by type (wasting and overweight)
Health	3.9.1	Mortality rate attributed to household and ambient air pollution
	3.9.2	Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services)
	3.8.1	Coverage of essential health services
Economy and Markets		
Volume traded	17.11.1	Developing countries and least developed countries' share of global exports
Prices (unit value, distortions...)	2.c.1	Indicator of food price anomalies
Income creation	8.5.1	Average hourly earnings of employees, by sex, age, occupation and persons with disabilities

		SDG indicator
Subsidies & tariff lines	2.3.2	Average income of small-scale food producers, by sex and indigenous status
	12.c.1	Amount of fossil-fuel subsidies (production and consumption) per unit of GDP
	10.a.1	Proportion of tariff lines applied to imports from least developed countries and developing countries with zero-tariff
Production	2.3.1	Volume of production per labour unit by classes of farming/pastoral/forestry enterprise size
	2.4.1	Proportion of agricultural area under productive and sustainable agriculture
	12.3.1	Food loss index and (b) food waste index
Value added (GDP)	8.1.1	Annual growth rate of real GDP per capita
	8.2.1	Annual growth rate of real GDP per employed person
Natural capital		
Exposure to extreme climatic events	13.1.1	Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population
Access to environment friendly technology	17.7.1	Total amount of funding for developing countries to promote the development, transfer, dissemination and diffusion of environmentally sound technologies
Natural resource use	6.4.1	Change in water-use efficiency over time
	6.4.2	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources
	7.2.1	Renewable energy share in the total final energy consumption
	8.4.1	Material footprint, material footprint per capita, and material footprint per GDP
GHG emissions	13.2.2	Total greenhouse gas emissions per year
Water related ecosystems	6.6.1	Change in the extent of water-related ecosystems over time
Landscape changes	11.3.1	Ratio of land consumption rate to population growth rate
	15.1.1	Forest area as a proportion of total land area
Water pollution	3.9.2	Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services)
	6.3.2	Proportion of bodies of water with good ambient water quality
Soil erosion	15.3.1	Proportion of land that is degraded over total land area
Policy, governance & regulations		
Legal Framework	5.1.1	Whether or not legal frameworks are in place to promote, enforce and monitor equality and non-discrimination on the basis of sex
Public revenues and expenditure (agriculture sector, essential services, pro-poor, and conservation/ biodiversity)	2.a.1	The agriculture orientation index for government expenditures
	2.a.2	Total official flows (official development assistance plus other official flows) to the agriculture sector
	2.b.1	Agricultural export subsidies
	1.a.2	Proportion of total government spending on essential services (education, health and social protection)
	1.b.1	Pro-poor public social spending
	15.a.1	Official development assistance on conservation and sustainable use of biodiversity; and (b) revenue generated and finance mobilized from biodiversity-relevant economic instruments

4 Assessing the contribution of the framework

MATS aims to identify key leverage points for changes in agricultural trade policy that foster the positive and reduce the negative impacts of trade on sustainable development and human rights.[4] Research is carried out at the macro, meso- and micro-level, where trade policy emerges, as well as with national and subnational case studies.

An assessment of the contribution of the analytical framework, which also served as an initial verification of its comprehensiveness and usefulness, has been performed using the 15 cases studies analysed by MATS in WP3, as presented next. We also explore the extent to which, and how, the framework will provide inputs to the work of WP4 (institutional, regulatory, and legal frameworks) and WP5 (transition pathways). The expectation is that the framework will be used both in the MATS project across several work packages as well as beyond MATS, by any researcher and policy analyst interested in assessing agricultural trade policy sustainability.

4.1 Setting the boundaries of MATS case studies (WP3)

Table 2 presents a visual representation of the key focus areas of the case studies considered in the MATS project. While all case studies have a focus on trade, an effort has been made to group them into three sub-categories, those centred on (multi-country) trade flows, national production, and production-induced sustainability outcomes (social dimension, human dimension, economy and markets, natural capital, and policy, governance & regulations). The categories are not mutually exclusive, since the impacts of trade policy can cut across geographical and political boundaries, though they should represent the leading topic of the case studies. Similarly, there is no single case study that covers all indicators of sustainability, which is fair and expected given the complex dynamics of food systems; on the other hand, each case study covers different dimensions and thematic areas of sustainability. Further, when taken together, all the MATS case studies address most indicators in relation to the trade issues analysed.

According to the literature review performed in T2.4, most of the studies analysed typically focus on economic outputs and outcomes, generally showing a lower coverage of environmental and social aspects, and often fully neglecting governance and its dynamics of power. On the other hand, when reviewing the coverage of sustainability dimensions and indicators of MATS case studies, we can observe a more systemic and balanced approach. Table 2 shows that most case studies consider indicators that cover almost all sustainability dimensions (social dimension, human dimension, economy and markets, natural capital, and

[4] https://sustainable-agri-trade.eu/our-vision/

policy, governance & regulations). Further, all case studies consider at least 3 of 5 dimensions, and 12 out of 15 case studies cover at least 4 dimensions.

While this is very encouraging for MATS, there is still an opportunity for WP3, WP4 and WP5 to expand the analysis to areas where indicators may be missing, even where there is full coverage of all sustainability dimensions.

Specifically, starting from indicators, we find that the most commonly considered indicators in the MATS case study plans are poverty, income creation, labour productivity and volume traded, followed by labour rights. In alignment with the findings of our literature review, economic and market indicators are considered to be always relevant, regardless of the micro-, meso-, macro scope of the analysis. Further, considering dimensions of sustainable development, we find good consideration of the social dimension and policy, governance & regulations. The human dimension and natural capital receive instead comparatively less attention.

When looking at specific case studies, some aim at covering a large number of indicators (e.g., CS7 and CS8, which focus on dairy value chains in West Africa and Belgian imports of ethanol from sugar cane), while others target only a few indicators and dimensions (e.g., CS3, CS9 and CS11, assessing respectively the sustainability of the Finnish dairy sector, human rights and environmental due diligence in the coffee value chain, and private standards and sustainable trade). It should be noted that the coverage of indicators and dimensions of sustainable development should not be used as metric to determine the quality or usefulness of a case study. It may well be that certain case studies focus on a specific information gap and aim at generating new knowledge, while other case studies leverage existing knowledge across research areas and policy domains. Both approaches are valuable, and the framework indicates how results could be interpreted in relation to a broader set of sustainable development dimensions and indicators.

Overall, the case studies differ from one another, and so does the depth of the proposed analysis. However, in order to have a more comprehensive understanding of sustainability in relation to agricultural trade, all the dimensions of sustainable development presented in Table 1 and Table 2 should be analysed with qualitative or quantitative approaches. This being said, the indicators of relevant should be chosen on a case-by-case basis, depending on their relevant for the analysis.

Table 2: indicators and SDGs considered across case studies.

		MULTI-COUNTRY TRADE FOCUS				NATIONAL PRODUCTION FOCUS							PRODUCTION OUTCOMES FOCUS				#
	SDG #	CS4	CS10	CS14	CS15	CS1	CS2	CS6	CS7	CS8	CS11	CS12	CS13	CS3	CS5	CS9	
Social dimension																	
Ownership rights	5.a.1			X				X		X	X	X					5
Social Protection	1.3.1							X	X	X	X	X					5
Discrimination	10.3.1	X				X			X						X		4
Unemployment rates	8.5.2	X			X		X		X			X				X	6
Human rights (Child labour, forced labour)	8.7.1	X															1
Working conditions	8.3.1		X	X	X		X	X	X				X			X	8
	8.8.2		X	X			X	X	X		X	X	X				8
Human dimension																	
Poverty rates	1.1.1		X	X	X	X		X	X	X		X	X		X	X	11
Access to basic services	1.4.1	X							X	X							3
Food security and nutrition (e.g., famine, nutrition, food quality)	2.1.1					X			X	X					X		4
	2.1.2				X	X									X		3
	2.2.2					X									X		2
Health	3.9.1									X							1
	3.9.2	X								X							2
	3.8.1																0
Economy and Markets																	
Volume traded	17.11.1	X	X	X	X	X			X		X	X	X				9
Prices (unit value, distortions...)	2.c.1							X							X		2
Income creation	8.5.1						X								X		2
	2.3.2		X		X	X		X	X	X		X	X	X	X		10
Subsidies & tariff lines	12.c.1									X							1
	10.a.1																0
Production	2.3.1	X		X			X		X		X	X	X	X		X	9
	2.4.1	X		X			X	X							X		5
	12.3.1					X	X							X	X		4
Value added (GDP)	8.1.1				X												1
	8.2.1																0
Natural capital																	
Exposure to extreme climatic events	13.1.1	X															1
Access to environment-friendly technology	17.7.1						X		X							X	3
Natural resource use	6.4.1																0
	6.4.2	X		X										X			3
	7.2.1																0
	8.4.1		X	X	X			X					X	X			6
GHG emissions	13.2.2		X	X						X				X			4
Water-related ecosystems	6.6.1			X													1
Landscape changes	11.3.1			X				X		X							3
Water pollution	15.1.1	X								X							2
	3.9.2	X															1
	6.3.2	X															1
Soil erosion	15.3.1							X									1
Policy, governance & regulations																	
Legal Framework	5.1.1	X			X			X	X	X	X	X					7
Public revenues and expenditure (agriculture sector, essential services, pro-poor, and conservation/ biodiversity)	2.a.1		X			X	X						X		X	X	6
	2.a.2	X	X			X	X					X	X		X		7
	2.b.1	X	X		X	X	X					X	X				7
	1.a.2				X		X		X	X							4
	1.b.1								X	X							2
	15.a.1					X						X					2

4.2 Addressing knowledge gaps, adopting new methods and models (WP3)

As indicated above and shown in Table 2, gaps have emerged when applying the framework and considering several dimensions of sustainable development in relation to agriculture trade. This is true both from the review of the literature and from an early assessment of the 15 MATS case study plans. On the other hand, the MATS case studies taken together use a more systemic approach, touching upon several indicators and, in the vast majority of cases, all dimensions of sustainable development. On the other hand, there is room in MATS to work on additional indicators and to expand the boundaries of case study work to cover as many dimensions of sustainability as possible and meaningful.

In this section, we provide information on (i) what models, tools and methods can be used, (ii) in relation to social, economic, and environmental indicators, and at which levels (micro-, meso-, macro). We find that this is the primary area in which the framework can support the case study analysis of WP3. While several models and methods can be used to complement traditional trade policy analysis, the indicators identified, and the review of models and tools carried out in WP2 can strengthen the case study analysis by shedding light on best practices for studies that focus on multi-country trade dynamics, national production, and production outcomes at the sub-national level.

While we attempt to identify indicators, methods and tools that could be universally valid and useful to assess the sustainability of agriculture trade, we acknowledge that customization is required to effectively consider the unique social, economic, and environmental characteristics of the context in which trade policy is implemented. This is particularly true for simulation models and has already emerged from an initial review of the 15 MATS case study plans. As a result, we have identified models that support measuring sustainability from different angles, e.g., using a thematic or sectoral entry point vs. employing a more macro approach. Ideally, indicator selection takes place at the beginning of the policy process (i.e., we need to know what to measure and how). Based on the indicators required, models can then be selected that provide the information needed. On the other hand, often this initial analysis of indicators is narrowly focused, resulting in narrow analysis performed also with simulation models. To support the use of a complete list of indicators, we identify the models available to fill gaps, and then show how the results of a more systemic and integrated analysis can be presented.

In the context of MATS, we propose the use of those methods and models that support systems analysis, either via the creation of new models or the coupling of existing models. As a result, we propose to use Causal Loop Diagrams (CLDs) as qualitative models, to frame the analysis using broad boundaries and exploring causal relations across indicators.

We then suggest using CGE models for international trade analysis, coupled with spatially explicit analysis to estimate the repercussions of trade-induced land cover change on ecosystem services provisioning. It is worth noting that, in addition to the 15 case study assessments, WP3 of MATS will include a macroeconomic analysis, performed to assess the impacts of improved sustainability on international trade agreements. In this case also, the objective is to generate new knowledge, using macro models to shed light on the impact of introducing sustainability metrics (e.g., GHG accounting) in the evaluation of international trade policy.

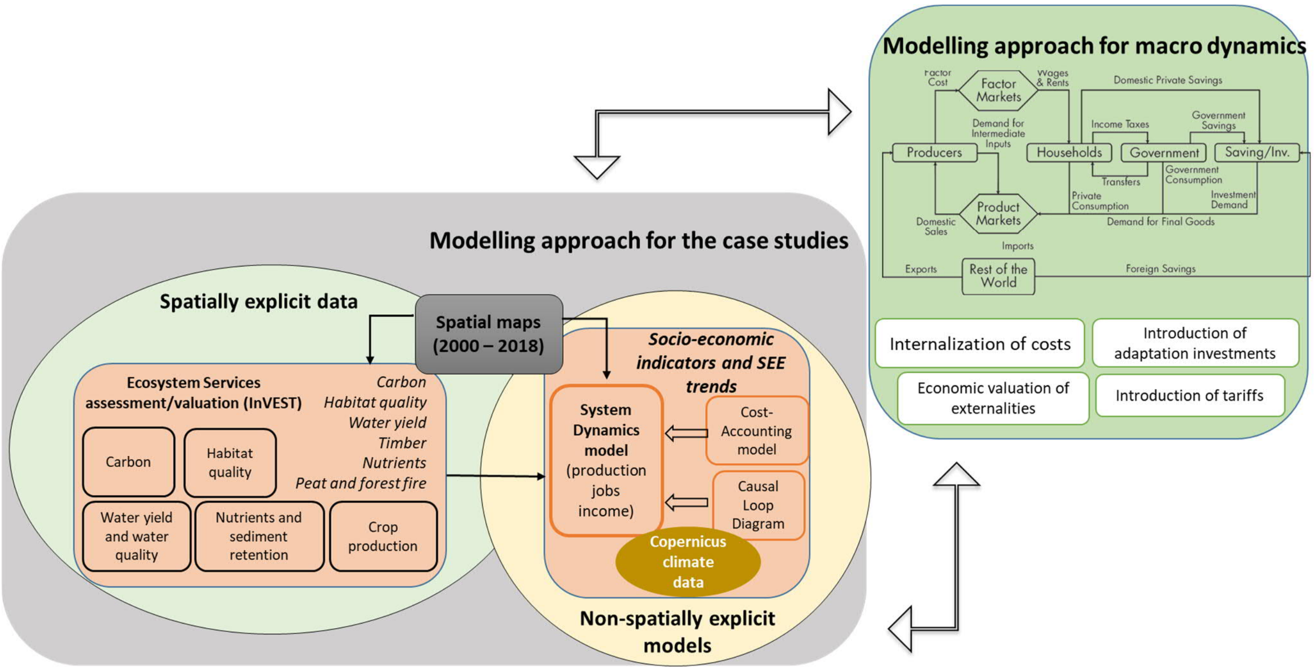

Figure 3: MATS approach to the analysis of international trade policy dynamics, integrating a macroeconomic multi-country CGE model (Bassi & Costantini, 2021) with the Green Economy Model (GEM) (Bassi, 2015), a multi-dimensional System Dynamics model.

At the national and sub-national level, we propose to use System Dynamics models, as knowledge integrators, also coupled with spatially explicit models for the estimation of ecosystem services. The System Dynamics model will integrate social, economic, and environmental indicators, and governance when possible, and provide inputs to the spatial analysis as well as receive outputs from maps.

Since we aim for this analytical framework to be used beyond MATS, below we summarize the main models reviewed in T2.2, reaching beyond those that will be used in WP3, and indicate how these can be used to quantify and assess the social, environmental, governance and economic indicators shown in Table 2.

<u>*Social indicators*</u>

Starting with social indicators, the following models have been identified in T2.2 in the context of trade analysis (e.g., the Gravity Approach), national production (e.g., CGE), and production at the local level (e.g., Agricultural Production Growth Models).

- Computable General Equilibrium (CGE) models - the main social indicators that CGE can model, according to the results of T2.2, are unemployment, tax revenue replacement, and income distribution.

- Partial Equilibrium models - the main social indicators that Partial Equilibrium models can consider, according to the results of T2.2, are food security and human well-being.
- The Gravity Approach - cultural and social variables that are considered include common official language and/or currency and/or a colonial past among trading partners.
- System dynamics - these models can consider social indicators such as population dynamics, employment and income creation, food demand and supply (hence nutrition), access to resources and exposure to pollution in relation to human health.
- Regression models – can be used to investigate how crop prices affect nutrition, and several human health indicators.

Economic indicators

In relation to economic indicators, several models have been found to be relevant for trade analysis (e.g., CGE, and Partial Equilibrium models), others for national production (e.g., Optimal Crop Allocation) and others for production outcomes at the local level (e.g., System Dynamics).

- Computable General Equilibrium (CGE) models - the main economic indicators that CGE can model, according to the results of T2.2, are government and households accounts, and production across sectors.
- Partial Equilibrium models - the main economic indicators that Partial Equilibrium models can consider, according to the results of T2.2, include production and sectoral GDP, prices for main agricultural commodities, and balancing demand and supply.
- The Gravity Approach - economic variables considered include the size of importing economy, per capita income differential of the trading countries, their degree of openness, the existence of a favourable exchange rate, and the presence of general trade agreements.
- System dynamics - these models can consider a large variety of economic indicators including government and households account, as well as GDP at the national level. Production costs and revenues can be estimated at the local level. Investment required under different land-use practices is also estimated by SD models, and compared with the outputs, outcomes, and impact of policy implementation.
- Regression models – exchange rates, and household consumption expenditure are two of the main economic indicators considered in regression models.

Environmental indicators

In relation to environmental indicators, some of the models are relevant for trade analysis (e.g., Regression models, System Dynamics), others for national production (e.g., Calibrated programming models) and others for production outcomes at the local level (e.g., Sustainability Assessment Models, System Dynamics).

- Computable General Equilibrium (CGE) models - the main environmental indicators that CGE can model, according to the results of T2.2, are energy demand, greenhouse gas (GHG) emissions, land use requirement, and irrigation needs.
- Partial Equilibrium models - the main environmental indicators that Partial Equilibrium models can consider, according to the results of T2.2, include water demand and supply, and land use.
- System dynamics - these models allow to consider various environmental indicators, such as land use and land productivity, water demand and supply, GHG emissions from land cover change, land use and livestock (including manure management), soil nutrient balances and water pollution.
- Regression models – GHG emissions are one of the most environmental indicators considered in these models.
- Optimal Crop Allocation models – allow to forecast land-use change and estimate specific ecosystem services resulting from optimal land cover allocation.

More detail on the methods that will be used in MATS for the analysis performed in selected case studies, and the implementation process followed in WP3, are explained in more detail in Section 5.

4.3 Identifying institutional, regulatory, and legal enabling conditions (WP4)

The overall goal of WP4 is to gain a better understanding of the role of institutional, regulatory, and legal frameworks in view of the impacts of agricultural trade on the SDGs and in respect of global agreements on environmental and climate challenges.

Three main tasks are of relevance to the framework. T4.1 provides guidelines for the assessment of the influence of (trade) policy regimes and market-related institutional and governance arrangements in the case studies, and synthesizes the related lessons learned from the set of 15 case studies with attention paid to the EU legal and institutional arrangements for Policy Coherence for Sustainable Development (PCSD). T4.2 analyses the coherence of EU policy frameworks in view of their impacts on SDGs and in respect of global agreements on environmental and climate challenges. Finally, T4.3 analyses the political economy of trade regimes (drivers, obstacles), and of the different positions and trends in trade relations.

There are several elements of connection between the framework and WP4.

- As a starting point, the framework informs the analysis performed for the 15 MATS case studies, promoting the use of a systemic approach. The results of these assessments are used in T4.1 to summarizes results and lessons learned. The systemic approach aligns well with Policy Coherence for

Sustainable Development (PCSD) adopted in WP4, which aims at utilizing the potential synergies between policies to support the development and avoid or minimize negative side effects. As a result, both the characterization of sustainable development (with emphasis on different dimensions) and the more detailed list of indicators proposed in the framework can support the possible emergence of synergies and side effects in WP4.

- Second, the framework supports expanding the analysis of WP4, untangling the complexity of the relations existing between trade policy, investments to sustainability, in a given context (first in relation to each case study, but also expanded -thanks to T4.1- to other and more global contexts).
- Third, it connects the analytical framework to the EU taxonomy, because of the use of a systemic approach, and the selection of indicators that cover various dimensions of sustainability and stimulate transparency. WP4 will address transparency directly, emphasizing digitalization as an example, which carries the potential to create a trust for consumers into sustainability claims in trade and value chains, lead to a shift in demand, and trigger a lasting and self-sustaining transition to improved sustainability.
- Fourth, it supports the work of WP4 on how to deal with greenwashing, which is countered by transparency and the use of a systemic approach, as offered by the framework.

WP4 in turn leverages the contribution of the framework, generating useful input for other work carried out in MATS, for instance for WP5 on transition pathways. Specifically, WP4 identifies the enabling conditions required to realize the positive outcomes observed in the case studies. It considers technology transfer, legal frameworks, ownership rights, social protection and more. Emphasis is put on indicators of social stability, on the goal to create trust for the regulator (consumer protection, unfair competition, patents, human rights protection). This is critical for lasting change. In this respect, jurisdiction is key, as shown by the case studies, as well as geography, type of value chain impacted and more. This is why it is critical to extrapolate lessons learned from the CS to a global context (T4.1), using a coherent and harmonized framework, so that the knowledge created in WP4 can be applied across many and varied value chains.

Finally, WP4 practically connects all levels of analysis present in the framework: it assesses how action on trade (top top-down) results in decisions about methods of production (bottom bottom-up). This information is then used to generalize the assessment of enabling conditions, reaching back to trade policy recommendations (top top-down). In other words, it goes full circle, levering top top-down action to trigger bottom bottom-up action, creating new market dynamics.

4.4 Formulating transition pathways and policy recommendations (WP5)

The overall goal of WP5 is to derive transition pathways for desirable changes in trade relations at macro, meso and micro level, and instruments and to formulate corresponding policy recommendations. To achieve this goal, visioning and backcasting processes that use the results from WP1-WP3 are implemented. The visioning includes the formulation of transition scenarios 2035 for the development of agricultural trade and the elaboration of possible transition pathways. The transition pathways will, together with the results of WP4, inform the policy recommendations.

Three main tasks are of relevance to the framework. T5.1 offers a visioning process focused on sustainable trade regimes. Relevant actors are identified, and a workshop is then used to discuss a desired future state of sustainable agricultural trade in 2035. A carefully moderated participatory approach is used to ensure that relevant issues are considered, and biases are overcome. T5.2 focuses instead on the back-casting of desirable changes in trade relations and instruments, to design transition pathways. Based on information from the 15 case studies, the results of WP4, and the visioning process, a roadmap describing required and reasonable changes is developed for local, regional, national and European authorities.

There are several elements of connection between the framework and WP5, specifically in relation to methods and breadth of the analysis.

Concerning methods, there is a close alignment between the framework and both the visioning and back-casting exercises offered inWP5. Specifically:

- Indicators: the framework identifies key dimensions of sustainable development and indicators of relevance in the context of agriculture trade policy. WP5 can offer a critical review of this approach and the indicators identified, verifying cross-consistency in the multi-stakeholder visioning process.
- The use of qualitative methods: The framework proposes the use of Causal Loop Diagrams (CLD) to support the assessment of case studies. This is a process where knowledge “emerges” from the conversation, and where a shared understanding is created among participants. The method of visioning utilized in WP5 is very similar and allows for new factors and indicators to emerge and become part of the analysis, based on the input provided by the participants. On the other hand, while the CLDs will focus on case studies (one at a time), the visioning exercise will expand the boundaries to societal preferences, actions, and outcomes. This complements the approaches employed in other WPs, from bottom-up to top-down.
- Case studies: the lessons learned emerging from case studies, which use a systemic approach informed by the framework, will inform the identification of enabling conditions in WP4 and the visioning process of WP5, and will provide useful content for the back-casting exercise, although this will be broader and reach sustainability not only for those actors directly impacted by the trade policy, but for all actors and the entire society.

Concerning the breadth of the analysis, the framework emphasizes the role of agricultural trade in shaping development at various levels. It supports framing the analysis for the case studies, and then this information is elevated to the societal level in both WP4 and WP5. This allows us to go full circle with MATS and to inform decision-making for various actors, taking into account their specific needs and goals for sustainability, across micro, meso and macro geographical boundaries.

5 Implementing the framework

5.1 Overview of the eight implementation steps

The implementation steps of the proposed framework are not dissimilar to other research being performed for policy analysis. On the other hand, there are a few peculiarities, especially in relation to the use of a systemic approach, that are essential for the assessment of all facets of sustainability for agricultural trade policy. Figure 4 presents the 8 steps in relation to the key components of the analytical framework, accompanying its implementation across MATS work packages.

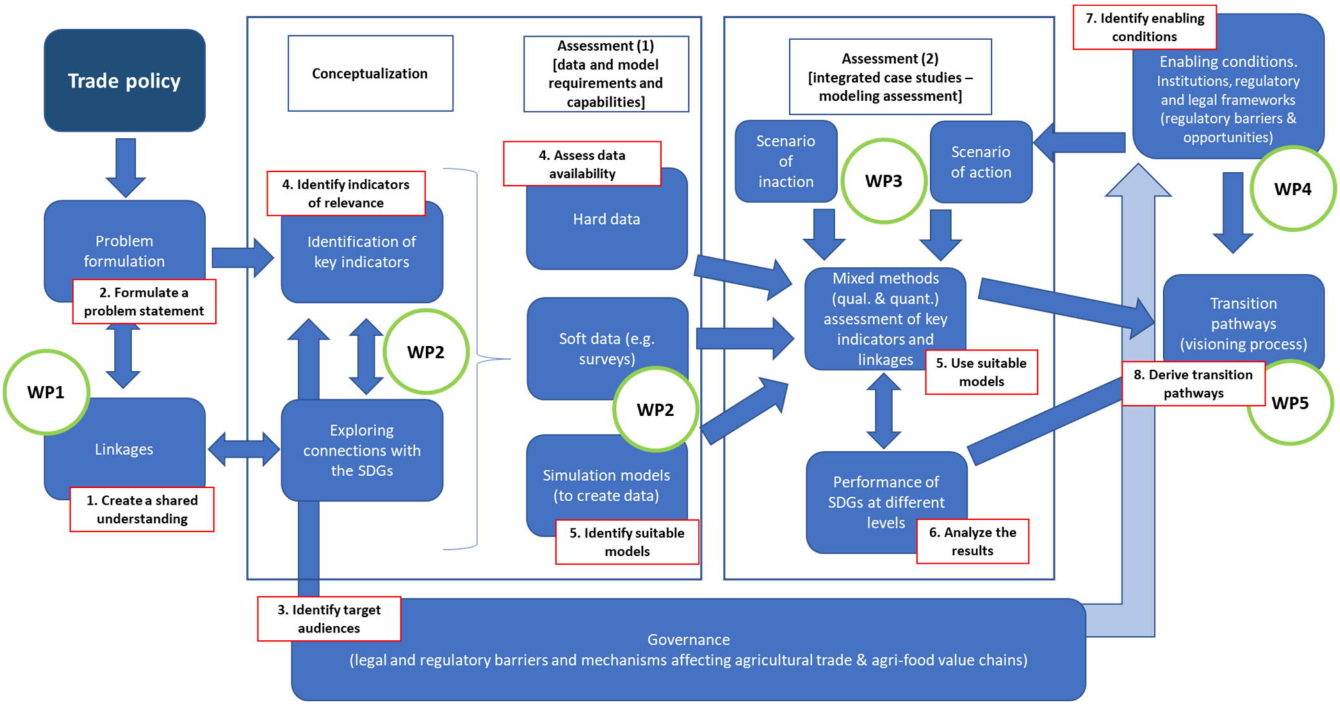

Figure 4: Overlaying the analytical framework with the 8-step implementation process.

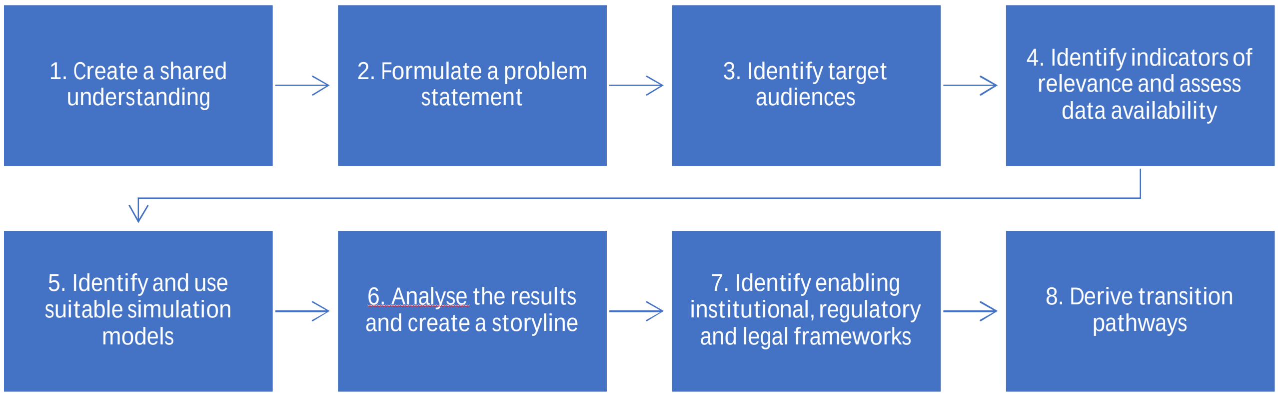

Figure 5: Implementation of the framework via an 8-step process.

The key steps for the implementation of the framework are presented in Figure 5 and described below:

1. Create a shared understanding of the issue, and related opportunities, by using qualitative approaches, for instance formulating a system map (or Causal Loop Diagram (CLD)). This is a critical, initial step that sets the stage for all subsequent activities. The system map should be formulated using a co-creation, multi-actor approach. It is important to involve participants with different types of expertise, as well as various actors with diverging views (e.g., some may be preoccupied with economic performance, others with environmental preservation). The more views are captured in this exercise, the more systemic the analysis will be. Further, co-creating the diagram with local actors will create a sense of ownership for the process, which will facilitate the presentation, validation, and dissemination of results later in time. As indicated above, the co-creation of a system map sets the stage for a participatory and engaging policy analysis exercise.

   Besides the CLD, the Sustainable Trade Toolbox (D2.3) provides a broad range of instruments with the potential to support this step, which could be found using the following keywords as search criteria: "situation mapping", "interrelations", "linkages", "participatory approach". Furthermore, depending on the nature of the problem or opportunity to be assessed, keywords should be used that are related to the topics of policy, governance & regulations; human dimension, social dimension, environmental dimension, or economy & markets, and the indicators related to them.

   Figure 6 presents an example of CLD, created to analyse the main drivers of change in the agri-food system. This diagram was co-created with more than 15 experts, all authors of the TEEB Agri-Food report (Zhang, Gowdy, Bassi, Santamaria, & DeClerck, 2018). The diagram presents indicators, how these are interconnected with one another, and the feedback loops that shape trends over time (depicted with the reinforcing (R) and balancing (B) signs). The diagram highlights how social, economic, environmental and governance co-exist and interact in the food system.

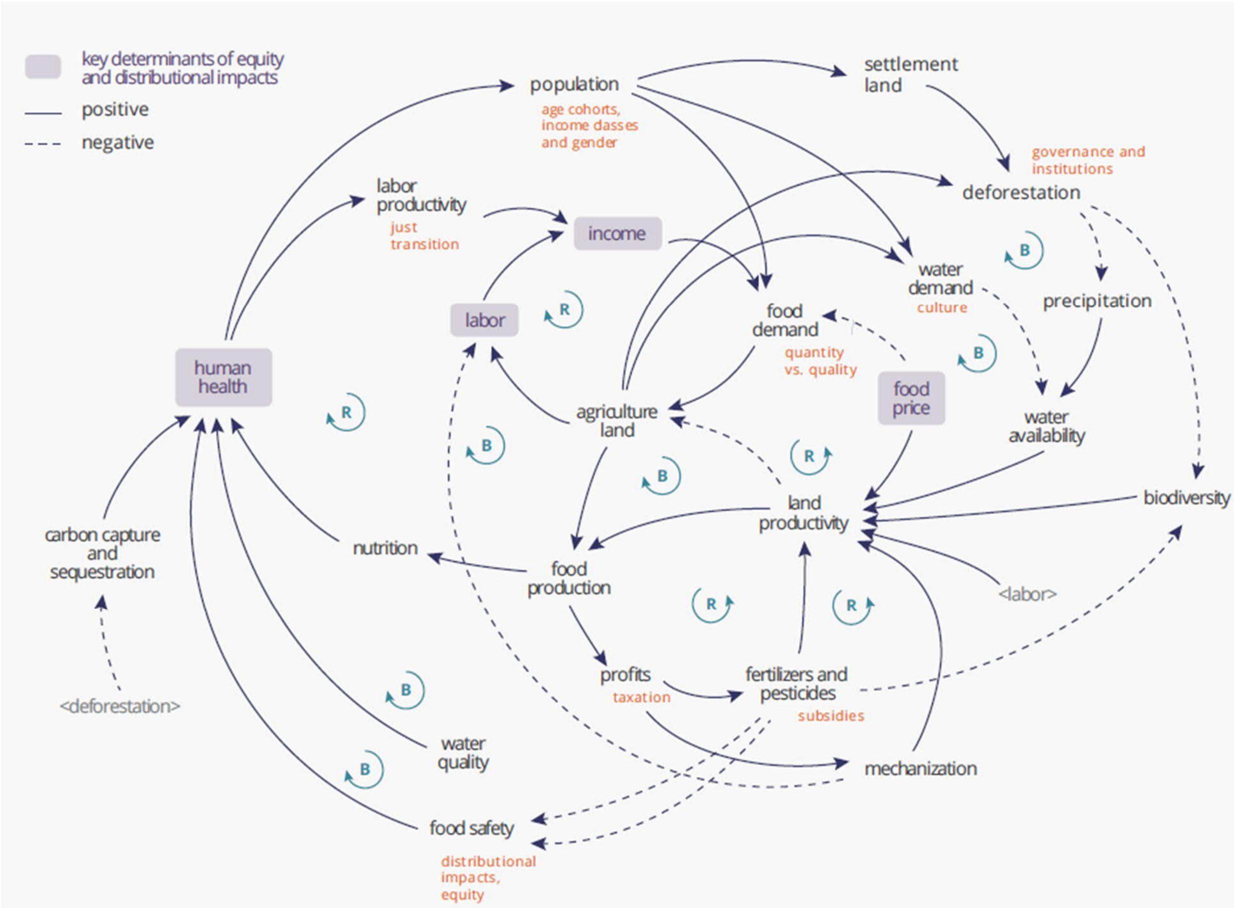

Figure 6: CLD presented in the TEEB Agri-Food report, depicting the main drivers of change in the agri-food system (Zhang, Gowdy, Bassi, Santamaria, & DeClerck, 2018).

2. Formulate a clear and concise problem statement. It is very important, especially when working with systems analysis, to have a clear and well-defined focus. It is easy to expand the analysis in all directions, with the risk that it becomes weaker due to its hardly manageable complexity. A well-crafted problem statement allows instead to narrow down the analysis of causes and effects, and to more easily identify entry points for intervention, to improve the sustainability of agricultural trade policy.

   Of particular importance in the process of formulating the problem statement is the inclusion of those stakeholders to which the problem statement pertains and their ownership over the final outcomes of such process. Otherwise, such exercises might risk reinforcing existing narratives that serve the status quo and established inequalities.

   The Sustainable Trade Toolbox proposes a set of instruments to support this step, which could be found under the keywords “situation framing”, “participatory approach”, “perspectives analysis”, and “agency”.

3. Identify key target audiences. Once the problem is formulated, it is time to identify target audiences (actors) beyond those identified in the problem formulation step. It is important to assess the extent to which the problem affects other audiences, and for what reason. This assessment should also consider what audiences may be impacted by the outcomes of those

sustainable trade policies that are designed to solve the problem. This exercise can be done with the support of the system map.

4. Identify indicators of relevance and assess data availability. Indicators are required to describe and explain the problem, support the formulation of intervention options, evaluate them, and monitor their performance. We propose to use, as a starting point, the indicators identified in the system map, Table 1 and Table 2, which can serve as a checklist (i.e., a starting point from which relevant indicators can be selected, while covering all dimensions of sustainable development). The indicators can focus on input, process, output, outcome, and impact. Different categorizations can also be used, for instance indicators for problem identification, policy formulation, policy assessment, implementation, and monitoring & evaluation, relevant to each audience and actor.

   The Sustainable Trade Toolbox proposes a set of instruments to support this step, which could be found under the keywords of “inputs”, “output”, “impact”, “impact assessment”, “externalities”, “performance analysis”, “indicator-based”, “indicators”.

   Further, data availability should be assessed for all key indicators, including their drivers of change as well as effects (e.g., deforestation being driven by land cover change, affected by loss of land productivity). It is important to measure the problem; equally important is the analysis of the strength (underlying trends and drivers of change) of the causes of the problem. Similarly, it is crucial to measure the extent to which the problem is causing undesirable direct and indirect effects. These data are required to better understand the system in it past and current state, as well as to evaluate the impact of an improved agricultural trade policy (e.g., does it address all causes of the problem, and does it avoid all the undesirable impacts observed in the past?).

5. Identify and use suitable methods and models to fill information gaps, both qualitative and quantitative, and -where relevant ad possible- create new scenarios and simulations. Simulation models can be used to reduce uncertainty, by creating alternative future scenarios, with different assumptions or provisions included in the policy to analyse. In doing so, simulation models can also fill data gaps, with “modelled estimates” replacing the lack of observations. Simulation models are particularly useful when the policy analysed is innovative, or more comprehensive than what was observed in the past. It is in this circumstance that systems models, like those based on System Dynamics, can be used as “exploratory” tools. On the other hand, the range of available models is broader, as indicated in T2.2. Qualitative models can be used in isolation or to complement quantitative models, and better interpret their results. Being quantitative models are simplified representation of reality, the analysis emerging from their use tends to be more narrowly focused than what emerges from qualitative assessments.

The Sustainable Trade Toolbox can be consulted to support the identification of relevant methods and models using the following keywords: "simulation models", "sustainability assessment models", "forecasting", "valuation", "partial equilibrium models", "computable general equilibrium models", "optimal crop allocation models", "spatial models", "scenarios", "system dynamics".

At this stage a table could be prepared to summarize the indicators of relevance, data availability and the modelling approach chosen to fill data gaps (Table 3).

Table 3: Indicators selected as being relevant for the MATS framework, to analyse the multi-faceted nature of sustainability of agricultural trade policy, indication of the availability of data, and the modelling approach used to fill data gaps and generate future scenarios

Indicator	*Relevant?*	*Data availability*	*Modelling approach*
Social dimension			
Ownership rights			
Social Protection			
Discrimination			
Unemployment rates			
Human rights (Child labour, forced labour)			
Working conditions			
Human dimension			
Poverty rates			
Access to basic services			
Food security and nutrition (e.g., famine, nutrition, food quality)			
Health			
Economy and Markets			
Volume traded			
Prices (unit value, distortions...)			
Income creation			
Subsidies & tariff lines			
Production			
Value added (GDP)			
Natural capital			
Exposure to extreme climatic events			
Access to environment-friendly technology			
Natural resource use			
GHG emissions			
Water-related ecosystems			
Landscape changes			
Water pollution			
Soil erosion			
Policy, governance & regulations			
Legal Framework			
Public revenues and expenditure (agriculture sector, essential services, pro-poor, and conservation/ biodiversity)			

6. Analyse the results of the simulations and create a storyline. All the indicators of relevance should be used to analyse results, ensuring that the analysis performed is comprehensive and systemic. Once qualitative and quantitative methods are employed and results generated (e.g. with simulations created, using models that integrate various indicators reflecting the many facets of sustainability), it is important to assess whether (a) the new trade policy solves the problem observed, (b) it creates any new side effect or synergy with other indicators of sustainable development, and (c) what trends are triggered (e.g., it may be that a "worse before better" pattern

emerges from the implementation of the new policy, requiring the introduction of complementary measures to improve short term performance).

7. Identify enabling institutional, regulatory, and legal frameworks. Having estimated the likely multi-dimensional impacts of the investments and actions (e.g., behavioural change) in the case study, it is time to identify what enabling conditions are necessary for a successful transition. Institutional, regulatory, and legal frameworks should be considered to (i) realize the positive outputs, outcomes, and impacts, and (ii) prevent and avoid the emergence of side effects and trade-offs. This analysis reaches beyond the geographical boundaries and context of the specific case study, as discussed in WP4.
8. Derive transition pathways. With knowledge of outputs, outcomes and impacts of sustainable trade policies, and awareness of the necessary enabling conditions to realize them, future pathways can be formulated. This can take the form of a science-backed theory of change, or even an action plan with a well-defined timeline, roles and responsibilities, and indicators for monitoring and evaluation, as described by the work performed in WP5.

   Regarding the process of analysing the results to inform decision-making – through forecasting and visioning - the Toolbox proposes a broad range of instruments that could support this step, which could be found using the following keywords: “participatory approach”, “agency”, “power relations”, “performance assessment”, “impact assessment”, “transition pathways”, “visioning process”, “desirable changes”, “decision making”.

The eight steps presented above highlight how the framework is envisaged to be implemented in a differential way in the analyses of the case studies, since case studies differ in their extent to which they implement a mixed methods approach and draw from The Sustainable Trade Toolbox. MATS will test the framework for all 15 case studies of the project, and in some cases novel modelling work will likely be introduced. Specifically, innovative modelling approaches will be tested for 3 of the 15 case studies of MATS, in WP3, since these 3 case studies are more closely related to quantitative methods. More details are presented in the following subsections.

5.2 Case Study 3: The Finnish dairy industry

1- Create a shared understanding

This case study focuses on national dynamics, but cuts across economic and environmental concerns, ultimately impacting social indicators also. The goal is to quantify the environmental and climate impacts of the Finnish diary sector, to estimate the potential impact of a policy that puts a price on such impacts, and ultimately affects the profitability and competitiveness of the sector. A system map will be used to better understand these interconnections, and how different actors are impacted by current and upcoming environmental and climate dynamics.

2- Formulate a clear and concise problem statement

The research questions for this case study are: (i) what are the environmental and climate impacts of dairy production? (ii) Is there a link between certain production practices and specific environmental outcomes? (iii) How can Finnish dairy products compete if the EU redesigns trade agreements in a way that environmental externalities of dairy production are accounted for?

3- Identify key target audiences

The key target audiences are farmers' organizations and farmers, in relation to the environmental impact of the sector and the economic impact of policy. On the policy side, relevant audiences include the public sector and policy makers, and specifically the Finnish Ministry of Agriculture and Forestry.

4- Identify indicators of relevance and assess data availability

Relevant indicators are presented in Table 4. Secondary data will be collected from Statistics Finland, Finnish Natural Resources Institute and previous Finnish research. The GTAP database will be used to carry out the economic analysis. The National GHG Inventory Report and IPCC guidance will be used for the estimation of GHG emissions.

5- Identify and use suitable methods and models

The case study explores the potential effects of redesigned EU trade regimes on Finnish agriculture, namely the dairy sector. The research will combine (i) the System of Environmental-Economic Accounting for Agriculture, Forestry and Fisheries (SEEA AFF) with economic modelling, in the form of input-output modelling and social accounting matrices (SAM) and the use of a CGE model and (ii) a systems model that is used to estimate the impact of dairy production on emissions (e.g. considering emissions from land-use using a spatially explicit approach, land management practices, enteric fermentation and manure management; considering carbon taxes). Indicators of emissions productivity (e.g., GHG per kg of protein) will be estimated, to benchmark the performance of the Finnish sector with other countries.

The use of this approach allows for the quantification of environmental and climate impacts (system dynamics model), and allows for a better calibration of policy impacts, from an economic perspective (CGE model). The system dynamics model will allow the assessment of farm-level performance, while the

CGE model grants the possibility to look at both the upstream and downstream effects of new trade regimes for the dairy value chain.

Table 4: Indicators selected as being relevant for CS3, availability of data, and modelling approach proposed

Indicator	*Relevant?*	*Data availability*	*Modelling approach*
Social dimension			
Ownership rights			
Social Protection			
Discrimination			
Unemployment rates		X	
Human rights (Child labour, forced labour)			
Working conditions			
Human dimension			
Poverty rates		X	CGE
Access to basic services			
Food security and nutrition (e.g., famine, nutrition, food quality)		X	
Health		X	
Economy and Markets			
Volume traded		X	CGE
Prices (unit value, distortions...)		X	CGE
Income creation	X	X	CGE
Subsidies & tariff lines		X	CGE
Production	X	X	System Dynamics
Value added (GDP)		X	CGE
Natural capital			
Exposure to extreme climatic events		X	System Dynamics
Access to environment-friendly technology			
Natural resource use	X	X	System Dynamics
GHG emissions	X	X	System Dynamics
Water-related ecosystems		X	System Dynamics
Landscape changes		X	System Dynamics
Water pollution			
Soil erosion			
Policy, governance & regulations			
Legal Framework		X	
Public revenues and expenditure (agriculture sector, essential services, pro-poor, and conservation/ biodiversity)		X	CGE

6- Analyse the results of the simulations and create a storyline

The results will be analysed considering simultaneously environmental impacts and resulting economic repercussions (in terms of reduced profitability and competitiveness of the sectors and resulting trend dynamics).

Further, the results will be analysed at the national level concerning production, GHG emissions and value value-added, as well as at the sub-national level in relation to production, related land use and emissions, and potentially impacts on biodiversity.

7- Identify enabling institutional, regulatory and legal frameworks

The case study will consider the rural, agricultural, and environmental policies, as well as the introduction of the carbon border adjustment mechanism (CBAM). It will assess the impact of the implementation of such policy under a scenario of inaction, as well as under a scenario of proactive action, aimed at reducing GHG emissions and other environmental impacts.

The Common Agricultural Policy (CAP) and EU trade agreements/regimes will be considered in relation to legal and institutional frameworks.

8- Derive transition pathways

The case study will assess the potential environmental and climate impact in the case of a redesign of EU trade agreements. The related insights will inform policy action to reduce the environmental externalities of dairy production, with a preventive approach. The related analysis can inform discussions about the potential role of a more localised (Finnish and EU) production.

5.3 Case Study 5: Sustainable value chains and livelihoods in Ghana

1- Create a shared understanding

Domestic poultry meat in Ghana is currently not able to compete with imported products, for three main reasons: (i) high production and transaction costs, (ii) lack of compliance with quality standards for poultry value chain activities and poultry meat, and (iii) low level of products processing.

We propose to follow the principles of Soft Systems Methodology to review, refine and validate the problem statements. We will engage actively with different actors, acknowledging that the same situation can be seen in different ways, using different perspectives.

To create a shared understanding of the context of interest, we propose to gather information from different sources and with different methods, including interviews, group discussions, and rich pictures, via the use of participatory processes. Finally, we propose to express all the information gathered in a Causal Loop Diagram (CLD), also co-created processes, to build a shared understanding among all actors involved.

2- Formulate a problem statement

Ghana relies heavily on imports to meet domestic demand for animal protein. One of the underlying causes is that poultry value chains in the country cannot compete with imports, either in quality or prices. As a result, there is a missed opportunity in enhancing and supporting local markets to improve the livelihoods of small farmers and others that are part of domestic poultry value chains. In this regard, special attention is given to policy frameworks and governance mechanisms that affect the competitiveness and sustainability of domestic poultry meat and thereby affect the protein self-sufficiency in the country, as well as the livelihoods of poultry farmers and other agents involved in the poultry value chain.

3- Identify target audiences

The key target audiences are farmers and farmers' organizations, input suppliers, public officers and policy makers, financial institutions, R&D institutions, processors, traders, and consumers.

4- Identify indicators of relevance and assess data availability

Relevant indicators are presented in Table 5. Concerning data collection, the methodological framework proposed requires the active engagement of different stakeholders. We plan to carry out interviews with key actors, and participatory workshops that include break-out sessions to open the discussions and promote sharing and mutual understanding between participants. We collect data on subsidies, import regulations, financial aid, technical support, and investments, all factors that led to the status quo. We will also collect data on expected outcomes, measuring domestic poultry meat competitiveness, contribution to family incomes, food and nutrition security, and prevalence of poverty.

5- Identify and use suitable methods and models

The methodological approach used for the quantification of scenarios of inaction and action will be based on the TEEB Agrifood framework. This will allow us to explore the interactions of the poultry system with environmental, social, human, and produced capitals. This framework will be used in combination with systems tools such as Soft Systems Methodology (SSM), Systems Thinking (qualitative) and System Dynamics (quantitative).

Soft Systems Methodology will allow us to collectively identify the central issues and feasible and desired transformations, while acknowledging differences in the views of different actors. System diagrams will be used under a group model model-building approach, which will allow us to co-create simulation models to explore alternative scenarios, identify leverage points in the system and inform policy and decision-making.

A customized System Dynamics model will be created to represent production practices and resulting economic competitiveness. This model will include the stock of chicken, quantity and quality feed and other production practices along the value chain, and then track environmental outcomes (e.g., GHG emission, nitrogen). The models will be used to test the outcomes, and economic viability, of policies that would simultaneously improve competitiveness and reduce the environmental burden.

Table 5: Indicators selected as being relevant for CS5, availability of data, and modelling approach proposed

Indicator	*Relevant?*	*Data availability*	*Modelling approach*
Social dimension			
Ownership rights			
Social Protection			SSM
Discrimination	X		SSM
Unemployment rates		X	
Human rights (Child labour, forced labour)			
Working conditions			SSM
Human dimension			
Poverty rates	X	X	
Access to basic services		X	
Food security and nutrition (e.g., famine, nutrition, food quality)	X	X	System Dynamics
Health		X	SSM
Economy and Markets			
Volume traded		X	System Dynamics
Prices (unit value, distortions…)	X	X	SSM
Income creation	X	X	System Dynamics
Subsidies & tariff lines	X	X	
Production	X	X	System Dynamics
Value added (GDP)			System Dynamics
Natural capital			
Exposure to extreme climatic events			
Access to environment-friendly technology			
Natural resource use			

GHG emissions			System Dynamics
Water-related ecosystems			SSM
Landscape changes			SSM
Water pollution			SSM
Soil erosion			
Policy, governance & regulations			
Legal Framework			
Public revenues and expenditure (agriculture sector, essential services, pro-poor, and conservation/ biodiversity)	X	X	System Dynamics

6- Analyse the results of the simulations and create a storyline

The results of simulation models are expected to provide insights into forecasting and visioning, acknowledging the reflections made among actors about the desired transformation for the system under analysis, in response to their interests, concerns and expectations.

The analysis of the results will be made through participatory processes, to identify leverage points to move the system towards the desired transformation, propose potential interventions in that regard, and finally discuss their feasibility.

Once the results are analysed, potential pathways and interventions to trigger system change towards the desired transformation - outlined and agreed upon by actors – will be included in a document designed to inform decision-making. This document will contain reflections on the feasibility of those pathways and interventions, considering the scenarios resulting from the modelling exercise.

7- Identify enabling institutional, regulatory, and legal frameworks

Policy frameworks play a crucial role in enhancing the market of domestic poultry meat products and thus the protein self-sufficiency of Ghana. On the one hand, policy frameworks may provide enabling conditions to improve the quality of domestic poultry meat products and thus comply with the quality standards to access markets. This by designing training and technology transfer services that cope with the needs of poultry farmers, by providing financial support to improve poultry farming activities, and by improving the availability and affordability of quality inputs and facilities. Despite the progress made through the Third Food and Agriculture Sector Development Plan (FASSDEP III) – promoting investments to develop technologies and provide farmers with quality services and facilities – there is still work to do to better cope with farmers’ needs. On the other hand, policy frameworks may include protectionists measures that control importations or offer domestic products with better starting conditions to compete (e.g., subsidies for poultry inputs).

8- Derive transition pathways

This case study will inform decision-makers on the most effective leverage points for increasing the competitiveness of domestic poultry meat production, enhancing its quality, and reducing its production and transaction costs to better compete with imported products. Therefore, it will enhance smallholder livelihoods and contribute to country animal protein self-sufficiency.

It can be envisaged that, among other options, poultry farmers should apply cost-efficient practices and technologies that improve poultry farming performance (for reducing production and transaction costs); poultry farmers should ensure the quality of inputs, the right use of veterinary products, and the appropriateness of husbandry, processing, and storage practices and facilities (for complying with quality standards); poultry farmers need to access appropriate facilities and have enough technical and financial capacities for making good use of them (to offer diversified/processed poultry products).

5.4 Case Study 14: Pork exports from Brazil to the EU

1- Create a shared understanding

This case study aims to explore the linkages between the EU-Mercosur trade agreement, pork production in Brazil, soybean production and the related dynamics of land-use change, and the consequent socio-economic and environmental impacts.

We propose to follow the principles of Soft Systems Methodology to review, refine and validate the problem statements. We will engage actively with different actors, acknowledging that at the same situation can be seen in different ways, using different perspectives.

To create a shared understanding of the context of interest, we propose to gather information from different sources and with different methods, including interviews, group discussions, and rich pictures, via the use of participatory processes. Finally, we propose to express all the information gathered in a Causal Loop Diagram (CLD), also co-created processes, to build a shared understanding among all actors involved.

2- Formulate a problem statement

The recent expansion of large-scale soy cultivation has caused significant socio-economic and environmental (undesirable) impacts, particularly in the Cerrado areas of the Matopiba region of Brazil. Additional to the deforestation of environmentally sensitive areas, there are reported land conflicts, displacements of traditional land users and water conflicts associated with the expansion of soybeans in Matopiba, with severe impacts on smallholder livelihoods.

Moreover, the recent EU-Mercosur agreement that set a quota of 25 thousand tons of export pork for Mercosur countries under a competitive tariff of EUR 83/ton have can the capacity to impact the pork value chain and increase even more the pressure on land use and other socioeconomic and environmental externalities due to the lack of provisions for indirect land-use changes resulting for the use of soybeans as animal feed in pork production.

The research question for this case study is “What are the links between the EU-Mercosur agreement, pork production in Brazil, soybean production and related land-use changes, pork trade and socioeconomic and environmental impacts?”

3- Identify target audiences

The key target audiences are farmers and farmers’ organizations, input suppliers, public officers and policy makers, financial institutions, processors, traders, and consumers.

4- Identify indicators of relevance and assess data availability

Relevant indicators are presented in Table 6.

Concerning data collection, the methodological framework proposed requires the active engagement of different stakeholders in data collection. It is worth highlighting that the questions addressed are highly contested, where many local actors are expected to deny the existence of issues, for economic gains. In this regard, we plan to carry out interviews with key stakeholders and organize participatory workshops that include break-out sessions to open the discussions and promote sharing and mutual understanding between participants.

Considering key indicators, we will measure aspects related to the natural environment, specifically focused on pressure on inputs (land, use change, water use, deforestation), and the social-economic impacts of the new agreement (work conditions, incomes, the general livelihood of small producers, etc.). In addition, national and international policy regulations will be included in the analysis in order to establish the links between regulatory frameworks and the socio-economic changes in the territory (subside, environmental regulations, tariffs, etc.).

5- Identify and use suitable methods and models

The case study aims to explore the pork trade system in Brazil under a food system approach. The case study will use the TEEB-AgriFood framework in exploring the interactions of the food system with environmental, social, human, and produced capitals. The framework will be used in combination with other systems tools such as Soft System Methodology (SSM) – for collectively identifying the issues and the feasible and desired transformations in the current system while acknowledging the different ways in which the system, the issues and the transformations proposed are perceived by different actors. A System Dynamics model, developed using a group model building approach, will be created to forecast land cover change and related impacts (e.g., on GHG emissions, as well as nitrogen and phosphorous loadings). The System Dynamics model will be coupled with a spatially explicit analysis (i.e., future land cover maps will be created) to refine the estimation of carbon sequestration, and add forecasts of soil erosion, water retention and habitat quality.

Table 6: Indicators selected as being relevant for CS14, availability of data, and modelling approach proposed

Indicator	*Relevant?*	*Data availability*	*Modelling approach*
Social dimension			
Ownership rights	X		SSM
Social Protection			
Discrimination			
Unemployment rates			System Dynamics
Human rights (Child labour, forced labour)			
Working conditions	X		SSM
Human dimension			
Poverty rates	X		SSM
Access to basic services			
Food security and nutrition (e.g., famine, nutrition, food quality)			SSM
Health			SSM
Economy and Markets			
Volume traded	X		System Dynamics

Prices (unit value, distortions...)			
Income creation			System Dynamics
Subsidies & tariff lines			
Production	X		System Dynamics
Value added (GDP)			System Dynamics
Natural capital			
Exposure to extreme climatic events			
Access to environment-friendly technology			
Natural resource use	X		System Dynamics
GHG emissions	X		InVEST
Water-related ecosystems	X		InVEST
Landscape changes	X		InVEST
Water pollution			InVEST
Soil erosion			InVEST
Policy, governance & regulations			
Legal Framework			
Public revenues and expenditure (agriculture sector, essential services, pro-poor, and conservation/ biodiversity)			System Dynamics

6- Analyse the results of the simulations and create storyline

The results of simulation models are expected to provide insights into forecasting and visioning, acknowledging the reflections made among actors about the desired transformation for the system under analysis, in response to their interests, concerns and expectations.

The analysis of the results will be made through participatory processes, to identify leverage points to move the system towards the desired transformation, propose potential interventions in that regard, and finally discuss their feasibility.

Once the results are analysed, potential pathways and interventions to trigger system change towards the desired transformation - outlined and agreed upon by actors – will be included in a document designed to inform decision-making. This document will contain reflections on the feasibility of those pathways and interventions, considering the scenarios resulting from the modelling exercise.

7- Identify enabling institutional, regulatory, and legal frameworks

Through the recent EU-Mercosur agreement a quota of 25 thousand tons of export pork will be available for Mercosur countries under a competitive tariff of EUR 83/ton. This agreement will significantly change the situation for pork value chains, and lead to increases in pork production and the amount of pork feed needed. This market expansion might impact pork value chains and create additional pressure on land use.

The EU-Mercosur agreement contains provisions for direct land-use change, intending to prevent deforestation due to the European imports of soybeans and other crops. On the other hand, no provision addresses the indirect land-use change that might originate from additional pressure on the input markets due to growing pork exports.

8- Derive transition pathways

The analysis will provide policymakers with a systemic view of the full context of pork and feed production, reaching beyond the value chain. It will highlight the politically and socially relevant issues related to land and water grabbing, expected land-use changes and displacement of smallholders, increasing deforestation and loss of biodiversity in environmentally sensitive areas.

The systemic analysis provided will support the creation of a shared understanding among different actors regarding, in relation to the outcomes and impacts of different future pathways (e.g., including the potential emergence of synergies and trade-offs).

The case study will provide local and international actors with evidence that can inform decision-makers in advancing food system reform towards improved sustainability, for the benefit of smallholder livelihoods.

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Annex 1: Indicators selected

Social Dimension

To highlight and analyse the impacts that trade, production, and outcomes of production have at the societal level we have selected indicators, concerning (i) ownership rights, (ii) social protection, (iii) discrimination, (iv) unemployment, (v) human rights, and (vi) working conditions.

i) Ownership rights: this indicator highlights the role that they can play in the development of a sustainable value chain (Mehraban, Kubitza, Alamsyah, & Qaim, 2021). This includes the control over productive assets and inputs, including land, water, seeds etc. This indicator is crucial when dealing with Least Developing Countries (LDCs). The SDGs that can be linked to this are 1, 5, 10, 11 and 12.

ii) Social protection: The UN defines social protection as "all the measures providing benefits in cash or in-kind to guarantee income security and access to health care" (UN, 2018). This indicator is indeed useful to measure the social conditions of people, e.g. workers, not only in relation to working aspects (e.g. social impacts, working conditions) but rather considering the role of institutions in assuring a certain threshold of guarantees and inclusion (Djankov & Panizza, 2020; Gaupp, et al., 2021). This indicator can be linked to many SDGs, specifically to SDGs 1,5 and 11.

iii) Discrimination: from a human rights approach, this indicator would allow capturing the multiple dimensions, causes, and consequences of socially unstainable agricultural and trade practices. This indicator includes popular participation, partners accountability, human dignity, and rule of law (Global Network for the Right to Food and Nutrition, 2021)

iv) Unemployment: employment creation is critical to ensure income generation (the salary level is considered in a separate indicator), achieve economic autonomy and thus reducing reduce the consequences stemming from unemployment such as poverty and famine (Howitt, Medellín-Azuara, MacEwan, & Lund, 2012; Wiebe, 2021).

v) Human rights (child labour, forced labour): these are moral principles or norms for standards of human behaviour and are protected by local and international law. We consider specifically child labour and informal labour, as per SDG 8.

vi) Working conditions: related to human rights and gender issues (Martínez-Castillo, 2016; Walters, et al., 2016). Working conditions are found in SDG 8, but impact the performance of several additional SDGs 1,3,5,10,11,12.

Human Dimension

To highlight and analyse the impacts that international trade, production, and outcomes of production have at the human dimension level we have selected indicators, concerning (i) poverty, (ii) access to basic services, (iii) food security and nutrition, and (iv) health.

i) Poverty rates: measured as the proportion of the population living below the international poverty line by sex, age, employment status and geographic location (urban/rural), as found in SDG 1.

ii) Access to basic services: as per SDG 1, it reflects the proportion of the population living in households with access to basic services. Basic services refer to those essential services that are needed for the continuity of life.

iii) Food security and nutrition: "Food security and nutrition" can be defined as a situation where people have always access to food, which is consumed in enough quantity and quality to meet their nutritional needs. In this respect, we consider the prevalence of undernourishment, the level of food insecurity, by age and gender in rural and urban areas, as per SDG 2.

iv) Health: a set of critical indicators to measure the general wellbeing of the population, whether of a small community or a country, but also at the global level (Jones, et al., 2017; Wiebe, 2021). We focus on mortality attributed to pollution and unsafe water and sanitation, and the coverage of health services, as per SDG 3.

Economy and Markets

An assessment of the economic consequences of agriculture trade is found frequently in the literature. The indicators considered are (i) volume traded, (ii) food prices, (iii) income creation, (iv) subsidies & tariff lines, (v) production, and (vi) value added (GDP).

i) Volume traded: enables to measure the amount of products that are sold on the international market, stimulating global agri-food value chains between importer and exporter (Enahoro, Bahta, Mensah, Oloo, & Rich, 2021; Porfirio, Newth, Finnigan, & Cai, 2018). The volume traded is found in SDG 17, but directly affects SDGs 8 and 12.

ii) Prices (unit value, distortions): prices are a critical driver and outcome of agriculture trade policy, together with the availability of products and accessibility to markets. Further, one element that will influence prices is climate change, due to extreme weather events and diminished production (Baker, et al., 2018; Beckman, Estrades, & Aguiar, 2019). This indicator is impacted by government action (see policy, governance and regulations indicators) and directly impacts the number and types of food and agricultural markets (i.e., the impact of trade on existing markets, including informal, formal, rural, urban, as well as on the formation new markets through new export options or more territorial and direct markets).

iii) Income creation: is fundamental to determine the affordability of food, as well as the potential contribution of agriculture to consumption, access to services and economic growth more in general (Agamile, Dimova, & Golan, 2021; Mehraban, Kubitza, Alamsyah, & Qaim, 2021). Income creation includes the average hourly earnings (salary level, found in SDG 8) and the average income of small-scale food producers (SDG 2).

iv) Subsidies & tariff lines: as indicated above, government policy can greatly impact choices related to land use, crops grown, and production practices employed. We consider in this case fossil fuel subsidies (SDG 10), and tariffs applied to imports (SDG 12), but can expand the analysis to any measure aimed at affecting market prices.

v) Production. This is the most cited indicator in the literature in relation to the outcomes of agriculture trade policy. Production and consumption are also drivers of change in market trends and consequently influence demand, which in turn impacts society, economies, and the environment (Elobeid, Carriquiry, Dumortier, Swenson, & J Hayes, 2021; Porfirio, Newth, Finnigan, & Cai, 2018). Production can be placed at the roots of many interrelated factors that affect several SDGs such as SDGs 1,2,5,6,8,9,10,11,12 but also those related to climate (13,14 and 15).

vi) Value added (GDP), as previously indicated, production and trade are drivers of national GDP (Angulo, et al., 2011; Robinson, et al., 2015). GDP not only impacts economic dynamics but also affects the provision of public services.

Natural Capital

Indicators related to natural capital include resource use, emissions, and other environmental impacts, as well as exposure to climate extremes. We also consider access to environment-friendly technology.

i) Exposure to extreme weather events: It is undeniable that in recent decades we have witnessed an increase in droughts, floods, hurricanes, heatwaves, and other climate-related disasters. All these events not only have an immediate impact on the population but also have long-term consequences on production and subsequent trade (Streimikis & Baležentis, 2020; Solomon, Simane, & Zaitchik, 2021).

ii) Access to environment-friendly technologies: we consider the total amount of funding for developing countries to promote the development, transfer, dissemination, and diffusion of environmentally sound technologies (SDG 17), to determine the extent to which technology and sustainable practices are available.

iii) Natural resource use: this indicator encompasses the changes that arise from the access, use, and control of resources such as water, land, and forests as input to agricultural activity. The use may be direct, devoting a given amount of water to agricultural production, involving necessarily a consumption of the resource, whose efficiency depends on the way it is managed. Negative consequences may arise from harmful agriculture practices, such as the use of fertilizers which reduce the quality of soil, nutritional characteristics of food, and human health over time. Natural resource use spans across SDG 6, 7, and 8.

iv) GHG emissions: agricultural trade closely relates to land cover change, land-use practices, livestock, and manure management, all of which cause GHG emissions (Jones, et al., 2017; Rosenstock, Rufino, Butterbach-Bahl, Wollenberg, & Richards, 2016).

v) Water-related ecosystems: water ecosystems are critical for agriculture production and food processing. In the reports and papers reviewed, an explicit connection is made between water-related ecosystems and biodiversity, and agriculture production (Weng, Chang, Cai, & Wang, 2019; Holzkämper, 2017).

vi) Landscape changes: land-use change is a common outcome of agriculture activity, also promoted or caused by trade policy, also involving societal consequences (Weng, Chang, Cai, & Wang, 2019; Howitt, Medellín-Azuara, MacEwan, & Lund, 2012). This indicator can also include land tenure, as one of the key drivers for uncontrolled land cover change.

vii) Water pollution: water is becoming a scarce resource, while, at the same time, water pollution is on the rise. SDGs 6 and 12 in addition to 13 and 14 are directly impacted by water pollution (SDG 3) (Streimikis & Saraji, 2021; Bunge, et al., 2021).

viii) Soil erosion: it results in reduced soil productivity, lower water retention and higher risk of floods, as well as resulting damage to infrastructure and challenges to nutrition (Sandhu, 2021; OECD. Publishing, 2001).

Policy, governance & regulations

Concerning policy, governance & regulations, we have considered (i) legal frameworks, and (ii) public revenues and expenditures. The indicators considered include the ability of governments to regulate, such as setting minimum prices for certain agricultural products (also found in the economy and markets group of indicators), provide providing a public distribution system (via budget allocation), have having public food reserves to buffer against food price volatility (captured under nutrition), promotion of marketing cooperatives (indicated under market access), prioritization of local and regional trade/production before export (as policy input to consider in specific case studies), and more. Practically this group of indicators represents the context in which the government and other institutions operate.

i) Legal frameworks: generally referred to as a set of laws or legal mechanisms aiming at shaping the future towards the desired direction. We consider specifically whether or not legal frameworks are in place to promote, enforce and monitor equality and non-discrimination. In this category we could include many and varied type of policies. In the context of MATS, these are identified in each case study, and then generalized in the context of work performed in WP4 and WP5.

ii) Public revenues and expenditure: government revenues are impacted by the volume of production and trade in the agriculture sector. On the side of expenditure, governments have often intervened in markets through incentives or regulations to support the production and commercialization of a specific product or commodity. Foreign Direct Investment (FDI) also affects change in the agri-food value chain, sometimes in alignment with government priorities, some other times in contrast. This group of indicators aims to measure the impacts of possible interventions on both the revenues and the expenditures of a country, including in terms of investments in public goods and services (processing and storage facilities, training and capacity building, education and health services, adaptive technology, targeted infrastructure, public agricultural research) that are essential for agriculture and food markets to serve the needs of more marginalised groups such as smallholders, women and young people and those living in more remote rural areas. SDGs 8,9,11 and 12 are the SDGs directly impacted by public finances (generally found in SDGs 1, 2 and 15) (Ouraich, Dudu, Tyner, & Cakmak, 2019; Arquitt, 2020).