Mainstreaming Integrated Assessment Models by embedding behavioural change and actor heterogeneity, and increasing their outreach to citizens, communities and industrial actors

CHOICE D3.1 Stakeholder workshops for co-design, review and use of the interactive simulation environments (ISE)

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List of abbreviations and acronyms

Abbreviation	Meaning
IAM	Integrated Assessment Model
ISE	Interactive Simulation Environment
FeliX	Full of Economic-Environment Linkages and Integration dX/dt (FeliX)
FABLE	Food, Agriculture, Biodiversity, Land-Use and Energy (FABLE)

Executive Summary

The Deliverable 3.1 report is a deliverable under Task 3.4, *Developing Improved IAM Interfaces for Optimising User Engagement*, within Work Package 3 of the CHOICE project. It focuses on the conceptual design and feedback from the evaluation workshop of the Interactive Simulation Environments (ISEs) for two Integrated Assessment Models (IAMs): the FABLE Calculator and the FeliX model. This is intended to complement Deliverable 3.2, which addresses the technical design and implementation of the ISEs.

The report begins with an introduction to each IAM, outlining the conceptual design, which emphasises the motivation behind key data and visual design decisions. It then describes the structure and agenda of the ISE Evaluation Workshop, where each ISE was demonstrated, and user feedback was collected. The workshop included dedicated sessions for each tool, with participants asked to evaluate the ISEs based on three core dimensions: *usefulness*, *accessibility*, and *engagement appeal*.

Feedback collected during the workshop is presented and analysed, highlighting user comments and suggestions for improvement across the two models. The report concludes by discussing the limitations of the workshop and challenges encountered during this phase of ISE development and outlines the next steps for advancing the FABLE Calculator and FeliX ISEs.

1. Introduction

1.1 Background

Integrated Assessment Models (IAMs) are computational tools which play a significant role in informing climate action by simulating complex interactions and feedback between the socioeconomic system and natural systems (Van Vuuren et al., 2011). Over the years, IAMs have served as mediators between science and policy, and their relevance is expected to persist or even grow as the impacts of climate change become increasingly visible (Van Beek et al., 2020).

Why do IAMs need to be "mainstreamed"?

Despite their importance, IAMs can be hard to comprehend and trust by non-experts due to their technical intricacies (Kelly & Kolstad, 1999; Nikas & Doukas, 2016; McMahon et al, 2015). This poses a challenge as the growing urgency of the climate crisis demands a greater emphasis on technological, economic, and socio-cultural transformations necessary to enable climate action (van Beek, 2020; Doukas & Nikas, 2020). The active inclusion of policymakers and diverse stakeholders in discussions is needed to ensure relevance, acceptance and legitimacy of these solutions (McGookin et al., 2024). IAMs should broaden their scope of engagement to involve a wider range of public and societal stakeholders and play a more active role in processes such as participatory scenario development.

How can ISE help in mainstreaming IAMs?

An increasingly adopted way to gain wider engagement and usability is through online platforms or Interactive Simulation Environments (ISE)[1] (Wong-Parodi, 2020). Some examples of existing efforts would be Scenario Explorer of the IPCC's Sixth Assessment Report (Byers et al., 2022), EUCalc's (2020) Transition Pathways Explorer and Climate Interactive's (2021) En-ROADS.

ISEs are defined as digital platforms that allow users to engage with and manipulate virtual models of real-world or hypothetical systems, which often have capabilities for real-time feedback and include user interfaces for interaction, visualization and data analysis. They act as intermediaries between modellers and other users (Moss, 2016), offering various functionalities to explore different climate action scenarios and facilitate learning of system complexities (Rooney-Varga et al., 2018).

Following a similar line of thinking, the CHOICE project will develop two ISEs for two of its models, FeliX and the FABLE Calculator, which enable fast, interactive simulations that facilitate user engagement in different aspects of the food system.

[1] Other synonymous terms include *decision support tools*, *data platforms*, *interactive web tools* and *policy platforms* (Curley, 2024)

1.2 Purpose and scope

The Deliverable in the Context of Task 3.4

This deliverable builds on the progress of earlier internal presentations held in M3 and M12 under Task 3.4, *Developing Improved IAM Interfaces for Optimising User Engagement*, where these sessions introduced some proposed ideas behind the Interactive Simulation Environments (ISEs). As the ISEs have now reached a more advanced stage of development, a stakeholder workshop was held in M18 (at the time of writing) to gather feedback on their first iteration. Finally, a final workshop will be scheduled for M30 to introduce a finalised iteration. This report supports this ongoing process by identifying key areas for refinement and outlining clear next steps for further development.

The objective of this deliverable is:

- to present the preliminary version of the two ISEs and the principles underlying their development
- to report on the stakeholder workshop and the feedback on the *usefulness, accessibility and engagement appeal* of these ISEs,
- to outline the next development steps based on this feedback.

Structure

With this purpose, we describe the current state of the conceptual designs of FeliX and FABLE Calculator ISEs in the next section, focusing on the main motivations for design choices in data and visualizations.

Subsequently, we present the outcome of the stakeholder workshop conducted with CHOICE pilot representatives, project members and stakeholders, where these preliminary ISEs were evaluated, and discuss the implications of this feedback for finalization of the ISEs.

2. CHOICE Interactive Simulation Environments (ISEs)

An interactive simulation environment is characterised by the underlying model, specifications and content of the user interface, and how the user interacts with this model, that is, the decisions a user can make based on the provided information and levers, and the simulation results the user can view, as well as their visualization format. Below, we describe these characteristics for FeliX and FABLE Calculator ISE.

2.1 FeliX ISE

2.1.1 Overview of the FeliX model

Background, Purpose & Scope

The Full of Economic-Environment Linkages and Integration dX/dt (FeliX or FeliX 2.0) model is a System Dynamics-based Integrated Assessment Model (IAM) that supports a continuous simulation of the complex and dynamic economic-environmental-social interactions among global systems, i.e., population, education, economy, energy, water, land, food, carbon cycle, climate, and biodiversity.

FeliX is one of the few models that explicitly model human behaviour in human-natural systems (Ye et al., 2024). It addresses the main limitations of conventional IAMs (neglecting feedback perspectives and nonlinear interactions among systems) and covers the breadth of social, economic, and environmental aspects in one integrated framework. However, the current version of FeliX does present some limitations, most notably its resolution as a global-scale model and the lack of sectoral details (Ye et al., 2024).

Previous Use Cases

FeliX is now primarily applied to areas of sustainable development, though it has also been used to explore climate change mitigation previously (Walsh et al. 2015; Walsh et al., 2017). Recent notable works include: developing a diet change module to analyse the main drivers of global dietary shifts and their impacts on the food system (Eker et al., 2019); examining the effects of model uncertainty and structural complexity on sustainable development projections under global change scenarios (Moallemi et al., 2022); and developing a poverty module to evaluate the effectiveness of socioeconomic and environmental policies in addressing global poverty (Liu et al., 2023).

Technical Features

FeliX is developed using the licensed software Vensim DSS and requires it for the full functionality of the model. The model has a time horizon from Year 1900 to 2100, with a time step of 0.125 years. The runtime of FeliX is within seconds; the differential equations describing the system structure are solved by efficient numerical methods. The model is calibrated for the period 1900–2022 using reputable data from established repositories (e.g. FAOSTAT, IPCC, the World Bank, etc), with the projection period extending from 2022 to 2100.

2.1.2 Conceptual Design for FeliX ISE

This section on conceptual design focuses on explaining key motivations and choices rather than specific implementation details. This distinction is crucial at this early stage of the FeliX ISE design process, as refining these core motivations will help guide future development.

Our approach to conceptual design is adapted from Janes et al. (2013), which emphasises selecting the "right" data and "right" visualisation as design choices that serve user goals. In FeliX ISE, data selection should effectively narrow down (within the ten thousand variables in the IAM) the most relevant sets of inputs and outputs for users. Regarding visualisation, the interface should be visually structured in alignment with how users would engage with the tool for their goals. Below, the user goals are discussed and how our data and visualisation choices support them.

Identifying User Goals

Continuing the framework of Janes et al. (2013), the link between user goals and design choices can be seen as a hierarchy of "levels" where user goals (conceptual level) involve various questions (operational level), which require data and visualisation (quantitative level) to fulfil. For the first iteration of the FeliX ISE, this is illustrated in Table 1.

It is crucial to acknowledge that the target audience and purpose of the ISE are tentatively conceptualised by the modelling team in this draft, as they have not yet been formally defined. The underlying premise of the ISE is to facilitate a link between IAM modellers, who provide solutions, and potential users, who have specific needs. The current stage of development is still in the exploration of the feasibility and alignment between these two groups.

Table 1. Conceptualised hierarchy of goals, to questions, to data and visualisation needs in the FeliX ISE. The starting point was to identify different user categories of varying levels of expertise within the target group of non-experts.

Goals (Conceptual Level)	Example Questions (Operational Level)	Data and Visualisation Needs (Quantitative Level)
Consumers: Understand personal environmental footprints from food consumption	How does my food consumption behaviour affect the environment?	**Inputs:** Relatable inputs are more focused on the choices made as an individual. **Outputs:** Common indicators used in environmental discourse, e.g. 1.5 degC temperature change. **Engagement:** Learning how each input (individual behaviour) affects each output (environmental impacts)
NGOs and Advocacies: Promoting Climate Action	What kind of strategies could lead to significant environmental benefits?	**Inputs:** Inputs that explore a wide range of factors that determine food demand, e.g. behavioural factors **Outputs:** Outputs focused on important environmental indicators **Engagement:** Exploring what kind of conditions are necessary to create climate action.
Policymakers: Explore various scenarios of	How do different demand-side mitigation scenarios shape future	**Inputs:** Policy-relevant scenarios within political, economic, and social constraints. **Outputs:** Outputs focused on important environmental indicators

demand-side mitigation strategies	environmental impacts?	**Engagement:** Constructing multiple scenarios and comparing various future pathways for decision-makers.

Data Design Choices

The conceptualisation of data highlights potential synergies and conflicts in the selection of inputs and outputs, which are factored into data decision choices.

For **inputs**, varying stakeholder interests are expected—e.g. consumers may prefer to explore actions at a local level, while NGOs and policymakers might be more interested in regional or global dynamics. The challenge is that the FeliX IAM was originally designed as a global model. A reasonable compromise is to retain global-level variables but frame them in a way that makes them accessible and meaningful from a local or individual perspective.

The selected scenario inputs are chosen in consideration of the current structure of the FeliX IAM where the interactions related to these inputs are more comprehensive and detailed. The input types include *Diet Change Behavioural Factors, Diet Composition, Food Loss and Waste by Food Categories, and Food Loss and Waste by Supply Chain* broadly because FeliX structures food demand extensively through interactions such as diet populations and behaviour factors.

In this iteration, more variables are provided than strictly necessary—for example, food loss and waste can be explored either by food category or by supply chain (and not both). This approach allows us to test which framing users in the workshop find more relatable. Specific variables are detailed in Appendix A (Screenshots of FeliX ISE).

There is broad consensus on the types of **outputs** that should be included, as these are informed by user interests in understanding the state of the environment and the environmental impacts of food behaviours. However, the specific variables and measures that represent these interests are selected based on alignment with the current state of scientific literature, ensuring the use of well-established and credible indicators.

The current set of selected outputs is categorised based on environmental pressures as outlined by Springmann et al. (2018): *Food systems, Land use, Climate change, Fertiliser use, Biodiversity, and Water.* The specific indicators within these system categories are initially drawn from what is available in the FeliX model due to time constraints, but there is an intention to extend or develop new variables based on feedback and requests. The specific variables included in this iteration are listed in Appendix A (Screenshots of FeliX ISE).

Visualisation Design Choices

Conceptualising engagement needs serves to guide the design of the visualisations. Some considerations are listed below, with the current ways to deal with them through design decisions. A screenshot of the FeliX ISE can be seen in Figure 1 with more screenshots on each tab of the input and output panels found in Appendix B (List of Input and Output Variables of FeliX ISE).

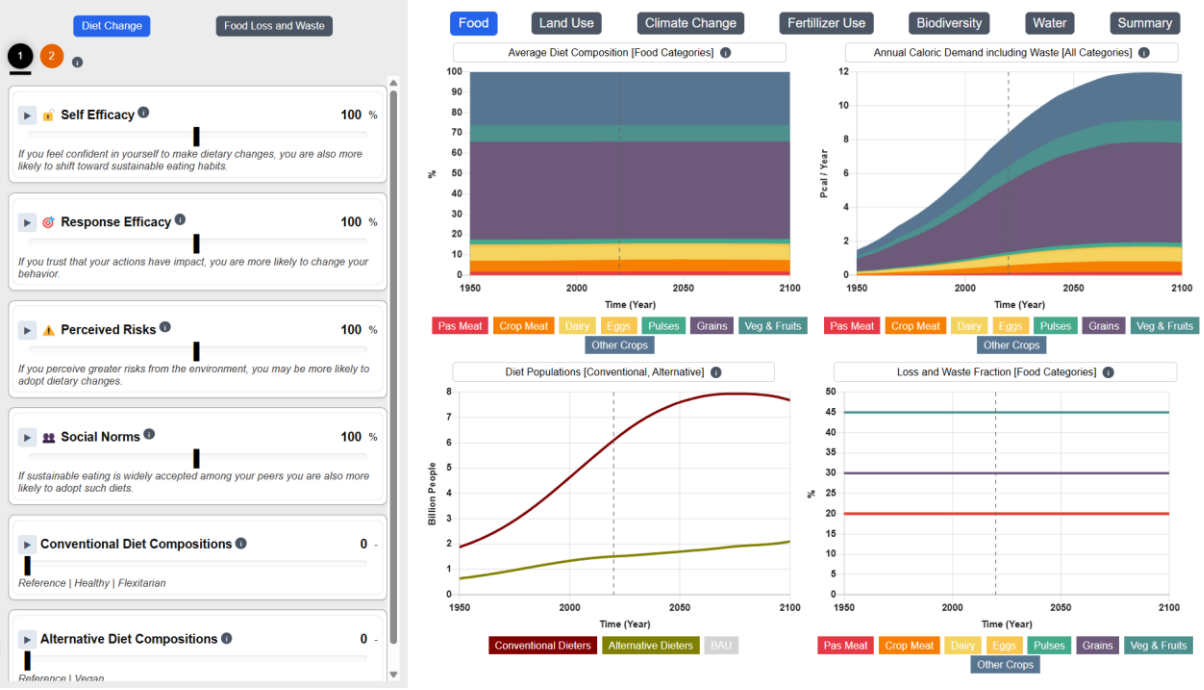

Figure 1. Screenshot of the default view in the FeliX ISE interface. The left panel holds the various scenario inputs while the right panels hold the scenario outputs. On the top left-hand corner, the buttons 1 and 2 in black and orange represent the switch between two custom scenarios for the *Comparing Scenarios* functional usage.

In consideration of their engagement needs, the ISE is also broadly designed to account for these three **functional usage** types:

- *Educational Use.* It supports users, particularly individuals new to systems thinking, in understanding basic causal relationships between behavioural inputs (e.g., diet choices) and environmental outcomes, helping to build intuition around complex systems.
- *Achieving Targets*. This allows the exploration of how various combinations of behavioural interventions can align with specific environmental or policy targets. This can be particularly valuable for NGOs and advocacy groups seeking to identify or communicate viable pathways to change.
- *Comparing Scenarios*. The need to account for multiple scenarios is integral in the policy process to account for the range of possible futures. The ISE should enable users to develop and analyse scenarios comparatively within the interface.

In general, the ISE is largely centered around allowing users to explore connections between many inputs and many outputs. The design should make navigation intuitive—this is achieved through a layout that features separate panels for inputs and outputs, along with additional tabs that help organise and explore the complexities.

Additionally, it needs to be able to manage multiple scenarios. Specifically, the capacity to build and compare scenarios is important. One feature that supports this is the Scenario tab (see Figure 1), which allows users to save two sets of scenario inputs and visualise their simulation results side by side on two graphs.

This also gives more clarity in the **information engagement style** that structures the visual priorities of the ISE (Janes et al., 2013).

The ISE requires a more “push” (as opposed to a “pull) approach (Janes et al., 2013) which describes the control of how information released between the tool and the user. No matter the user type, it seems more useful for the ISE to “push” information about the complex and broad

range of environmental consequences, as opposed to depending on the user to “pull” information they require.

Some ways these translate into implementation are how the output panel is a multigraph, i.e. 4 output graphs per page (see Figure 1), where the choices of output variables and arrangement ought to be important to capture the user’s attention when the scenario changes. Additionally, a summary tab is included that shows the main indicators for each environmental system.

However, “pushing” also needs better accessibility to address the risk of cognitive overload (Janes et al., 2013); hence, much of the design should allow for easy-to-understand data, fast to consult, attention to information is used effectively and visual appeal to keep the user’s interest.

2.2 FABLE Calculator ISE

2.2.1 Overview of the FABLE Calculator

Background, Purpose & Scope

The Food, Agriculture, Biodiversity, Land-Use, and Energy (FABLE) Consortium is a global network of research organisations dedicated to developing long-term pathways for food and land-use systems, that are consistent with the achievement of global sustainability goals. By connecting local experts worldwide from inter-disciplinary backgrounds through a global network, FABLE fosters cross-country learning and innovation in modelling and stakeholder engagement to address critical challenges in nutrition and food security, agricultural production, biodiversity protection and climate mitigation.

FABLE has developed the FABLE Calculator, an Excel-based open-source model that computes the evolution of agriculture, land use and land use change, and consumption with flexible scenario design up to 2050.

Previous Use Cases

The FABLE Calculator has been applied in several countries to support sustainable land-use and agricultural policy decisions.

In Wales, UK, policymakers used the FABLE Calculator to compare land sparing and land sharing approaches (Jones et al., 2023). This work informed Wales’ Low Carbon Delivery Plan and continues to shape policy discussions on sustainable diets.

Since 2019, the FABLE Mexico team has collaborated with the Secretary of Agriculture and Rural Development (SADER) to develop long-term land-use pathways. The FABLE Calculator was adapted to better represent key crops, enabling more accurate policy assessments. This work has supported cross-sectoral sustainability efforts in Mexico’s agricultural sector.

In the United States, FABLE, in partnership with the Platform for Agriculture and Climate Transformation (PACT), is modelling the impact of the Inflation Reduction Act (IRA) investments on agricultural emissions. By exploring different implementation scenarios, this analysis aims to provide transparent insights into the climate impact of IRA and Farm Bill investments.

Technical Features

The FABLE Calculator (Mosnier et al., 2020) is an open and free Excel-based accounting tool used to study the potential evolution of food and land-use systems from 2000 to 2050. It focuses on agriculture as the main driver of land-use change and tests the impact of different policies and changes in the drivers of these systems through the combination of many scenarios. It includes 76 raw and processed agricultural products from the crop and livestock sectors and relies extensively on the FAOSTAT (2023) database for input data (FAO, 2023).

For every 5-year time step over the period 2000-2050, the Calculator computes the level of agricultural activity, land use change, food consumption, trade, greenhouse gas (GHG) emissions, water use, and biodiversity conservation according to selected scenarios. Users can replace data from global databases with national or subnational data. The FABLE Calculator emphasises transparency and ease of use to facilitate cross-sector discussions and create a shared vision for transforming food and land-use systems.

2.2.2 Conceptual Design for FABLE CALCULATOR ISE

The design of the FABLE Calculator ISE (as described in D3.2) was guided by a development methodology that integrates the Scrum development process with a UX workflow, following an extended sprint model. This model allows iterative progress while ensuring that UX and design considerations are consistently interconnected. Work consists of multiple sprints, each beginning with a design sprint (led by the design team) followed by a development sprint (executed by the development team). The design team consisted of specialists from Environmental Reliability and Risk Analysis (ERRA) and SDSN Association Paris, while the development team included experts from ERRA.

The first sprint model lasted from M1 to M10, and more specifically, during the design sprint (M1–M6), the SDSN and ERRA design teams focused on conceptual design, functional requirements, and user interaction flows, considering UI/UX and usability aspects. During the development sprint, SDSN provided the excel-based FABLE calculator to ERRA. The user requirements were identified through bilateral meetings, as described below:

- Initially, SDSN explained thoroughly the need for an open-accessible web-based tool implementation. As discussed, FABLE Calculator ISE aims to implement a user-friendly and intuitive UI, that provides easy navigation of FABLE outputs and makes it accessible to a wide audience.
- Moreover, the possible end-users of the FABLE-calculator were identified. More specifically, the goal of FABLE Calculator ISE is to provide both experts and non-experts a reliable and easily navigable tool for assessing how various demographic scenarios and policy choices affect sustainability outcomes.
- The web-based tool shall be based on the datasets incorporated in the relevant country-specific excel. The first excel provided, incorporated datasets for Greece. As soon as new excel files for more countries are provided, the web-based tool will be updated to include them to the online version of FABLE Calculator ISE.
- Moreover, the input parameters were identified. The input parameters selected are the following: country, pathways and parameters for scenarios. A detailed description of the input parameters are described in Table 2 below (screenshots are included in Appendix C (Screenshots of FABLE ISE)):

Input parameters		
Parameter	Description	Value
country	The available countries for FABLE Calculator ISE	Greece, Spain, South Africa, Colombia
pathway	A combination of different scenario selection	CurrentTrends is used as predefined pathway, but also Custom pathways can be created by the users
parameters for scenarios	A list of parameters that can be changed	○ Calibration year (2010,2015,2020) ○ GDP (SSP1-SPP3) ○ Population (UN_medium, UN_high etc.)

Input parameters		
Parameter	Description	Value
	through the selection of different scenarios.	○ Share of food supply which is wasted (Current, Increased, Reduced) ○ Share of consumption which is imported (I1-I3) ○ Evolution of exports(E1-E3) ○ Livestock productivity (NoGrowth, BAUGrowth etc.) ○ Crop productivity (NoGrowth, LowGrowth etc.) ○ Land available for agricultural expansion (FreeExpansion etc.) ○ Afforestation (NoAffor etc.) ○ Ruminant density (NoGrowth, BAUGrowth etc.) ○ Trade adjustment (No, Yes) ○ Level of activity of the population (Low, Middle, High) ○ Climate change (NoChange etc) ○ Protected areas expansion (NoChange etc) ○ Post-harvest losses (NoChange, Reduced) ○ Biofuel demand (NoChange etc) ○ Evolution of price (Average, Current dollars) ○ Global warming potential coefficient (SAR, AR4-AR6) ○ Urban area expansion (CurrentTrend etc.) ○ Agroecological practices (NoChange, Diversified etc.) ○ Irrigated harvested area (NoGrowth, LowGrowth etc.)

Table 2 Input parameters that were implemented in the FABLE Calculator ISE during the first sprint

The requirements outlined in the first sprint (M1-M10) led to the development of an initial version of the FABLE Calculator ISE. This version was tested and reviewed by ERRA and SDSN. Following these reviews, key improvements were identified and agreed upon, which were incorporated into the next sprint model.

During the second sprint (M11-M17), the feedback collected from the previous sprint was thoroughly reviewed, and additional requirements were defined. The additional requirements that influence the design of the tool are outlined as follows:

- The output data to be displayed in the FABLE Calculator ISE were selected. Specifically, the chosen outputs include: Food, Production, Jobs, Trade, Biodiversity, Land, GHG (Greenhouse Gas), and Water.
- The equations necessary for generating the outputs were defined.
- The visualisation charts used to present the output data were specified. More specifically, a description of the charts that are used is provided below (screenshots are included in Appendix C (Screenshots of FABLE ISE)):

Visualisation charts	
Output	**Chart**
Food	Stacked bar chart

Production	Stacked bar chart
Jobs	Stacked bar chart
Trade	Bar chart
Biodiversity	Stacked bar chart
Land	Line chart
GHG	Stacked bar chart
Water	Bar chart

Table 3 Visualisation charts that were include in the FABLE Calculator ISE following the second sprint.

The second internal version of the FABLE Calculator ISE was demonstrated during the ISE evaluation Workshop held on March 27, 2025, as detailed in the next chapter to gather valuable feedback from users. This feedback is instrumental in enhancing the usability of the FABLE Calculator ISE and improving the overall user experience.

The feedback from the workshop has been utilised to refine and define new design requirements that have been included in the design of the FABLE Calculator (as described in D3.2) and as a next step, the next version of the tool will be developed. A detailed summary of the collected feedback is provided in Section 3.3.2 Feedback on FABLE Calculator ISE.

3. ISE Evaluation Workshop

3.1 Workshop settings

General Information

The workshop took place on 27 March 2025 from 1300 to 1530 CET on Zoom. A total of 27 attendees participated: 5 ISE collaborators/ presenters, 20 CHOICE partners from various pilot studies and work packages, and 2 external visitors (see Appendix D (Workshop Participant List)). Most of the CHOICE partners who participated were involved in pilot projects, where they explored the potential of using these tools for their stakeholders.

While all participants were expected to attend the evaluation of both ISEs, some joined or left midway, leading to variations in participation levels. Consent was also obtained for the video recording of the workshop as well as the collection of survey data with respect to their names and roles, which will be used for reviewing feedback with greater nuance.

Also, the FeliX and FABLE Calculator ISEs were deployed and shared via the agenda a week prior to the workshop.

Flow of the Workshop

The workshop, which lasted 2.5 hours, followed a structured agenda. It began with a joint introduction, considering both ISEs, where an overview of FeliX and FABLE was presented, along with suggested areas for feedback. This was followed by two dedicated sessions, where an hour was given to FeliX and FABLE Calculator each to conduct presentations and allow for the collection of ISE-specific feedback. The workshop also concluded with a broader discussion to gather comparative feedback on both ISEs, addressing insights that did not necessarily fit within the more focused sessions. Table 4 summarises the schedule of the Workshop.

Table 4. Schedule of the Workshop

Time	Activity	Facilitators
1300 - 1310	Introduction	IIASA & SDSN
1310 – 1410	FeliX ISE	IIASA
1410 – 1420	Break	
1420 – 1520	FABLE Calculator ISE	SDSN
1520 – 1530	Concluding Discussions	SDSN & IIASA

Areas of Feedback

It is acknowledged that the FELIX and FABLE Calculator ISEs have distinct specifics and needs, particularly as they cater to different audiences and pilot projects. However, even as the format and model-specific feedback questions differ, a set of key feedback areas were established prior to the workshop to guide the structure and comprehensiveness of the feedback collected.

Below is the list of these feedback areas with additional adjacent concepts and guiding questions:

Usefulness – Does the ISE provide relevant and actionable insights?

- Fit for **Purpose** – Does it align with the goals and needs of different users?
- Trustworthiness – Do users trust the model and its results?
- Data Relevance – Are the inputs and outputs meaningful and useful to the user?

Accessibility – Is the interface easy to use and navigate?

- Clarity – Are complex concepts communicated clearly and understandably?
- Cognitive Load – Is the interface very overwhelming?
- Intuitiveness – Can you grasp the interface without confusion easily?
- Navigation – Can users easily find what they need?
- Readability – Are colours, fonts, and design elements (input fields, output graphs) optimised for easy reading and accessibility?

Engagement Appeal – Is the interface visually compelling and interactive?

- Input Design – Are the input designs engaging?
- Output Design – Do output graphs effectively highlight key insights?
- Interactive Elements– Are there any additional interactive elements that can enhance the user experience?

Moving forward, the reporting of the results will also use the structure of *Usefulness, Accessibility* and *Engagement Appeal.*

3.2 FeliX ISE

3.2.1 FeliX Workshop Settings

The session was facilitated by Ryan Tan (IIASA). The FeliX session was structured into two main phases of 30 minutes each: the first dedicated to showcasing the ISE and the second to gathering and discussing user feedback.

Demonstration & Hands-on Exploration. The session began with an introduction to the FeliX ISE including a guided walkthrough of its user interface. Live demonstrations showcased different use cases, highlighting various ways of interacting with the tool in line with the functional usage types (see Section 2.1.2 Conceptual Design for FeliX ISE), namely 1*) Educational Use, 2) Achieving Targets,* and *3) Comparing Scenarios.*

Since the ISE currently lacks built-in guidance, this segment was largely one-directional. However, participants were invited to engage in a short interactive exercise, allowing them to explore the interface by building and sharing simple scenarios.

Interactive Feedback & Discussion. The second half of the session focused on collecting feedback using Miro board as a collaborative space. As shown in Figure 2, the Miro board was divided into three main columns, corresponding to the three feedback areas outlined in the Section 3.1 Workshop settings. Each column was further divided into sub-panels that aligned with specific feedback categories.

This phase was designed to be more interactive, allowing participants to provide open-ended comments and suggestions, and other participants were encouraged to support them with stickers on the board, and even respond with additional insights. The facilitator also engaged with the participants in real time, responding to general observations and guiding the discussion.

In the following section, the results on the 3 feedback areas – (*1) Usefulness, (2) Accessibility,* and *(3) Engagement Appeal* will be described.

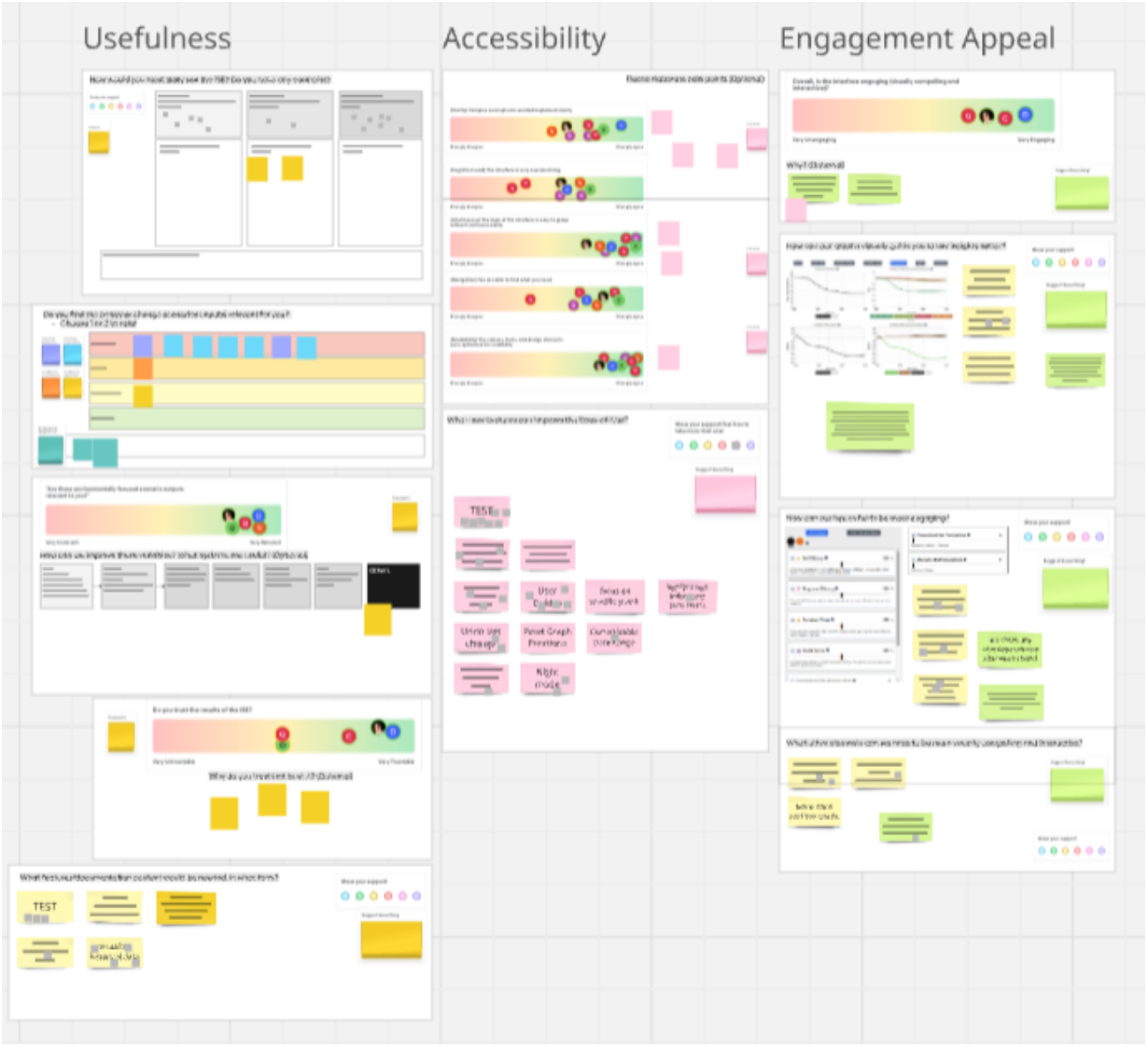

Figure 2. Screenshot of the Miro board used to collect feedback for the FeliX ISE. It is split into three columns with panels aligned to the three key feedback areas – *Usability, Accessibility* and *Engagement Appeal*.

3.2.2 Feedback on FeliX ISE

(0) High-level Observations

Users still do not have a fully clear idea of how they might use the ISE; however, there is noticeable progress compared to an earlier demo session held during the Vienna Meeting in November 2024.

Even by the end of the feedback session, participants contributed more actively to the *accessibility* and *engagement appeal* categories than to the *usefulness* column. Most of the open-ended feedback came from a small subset of participants, primarily modellers, technical implementers (ISE collaborators), or researchers with prior experience working with IAMs.

(1) Usefulness

Fit-for-Purpose. Users generally find the ISE to be useful to some extent and have expressed ideas about how they might use it. This is reflected in Figure 3, which shows active engagement around questions such as how they would apply the ISE, and which scenarios are most relevant to them.

However, the perceived relevance appears to be skewed toward specific functional use cases and particular scenario inputs (see Section 2.1.2 Conceptual Design for FeliX ISE), In particular, the use cases of *Educational Use* and *Comparing Scenarios*, as well as scenario inputs related to *Diet Change*, were found to receive the most attention. This observation asks for further investigation to determine whether it reflects a true design limitation or is the result of survey bias, possibly due to the shared interests of the workshop participants.

Trustworthiness. Perceptions of trustworthiness were more polarised. While some users found the ISE to be highly trustworthy, others rated it only moderately so (see Figure 4). Suggestions for improvement included enabling users to test for sensitivity and uncertainty, incorporating historical data visualisations, allowing comparison with other IAM outputs, and providing more scientific references and documentation. Although trust in the current version of the ISE is limited, there are clear—and in some cases, straightforward—opportunities to enhance its credibility.

Data Relevance. As shown in Figure 5, the decision to focus on scenario outputs that represent environmental indicators was received positively. When prompted for suggestions on specific variables to improve, participants did not provide any, suggesting that the current selection of variables across environmental domains is generally considered appropriate.

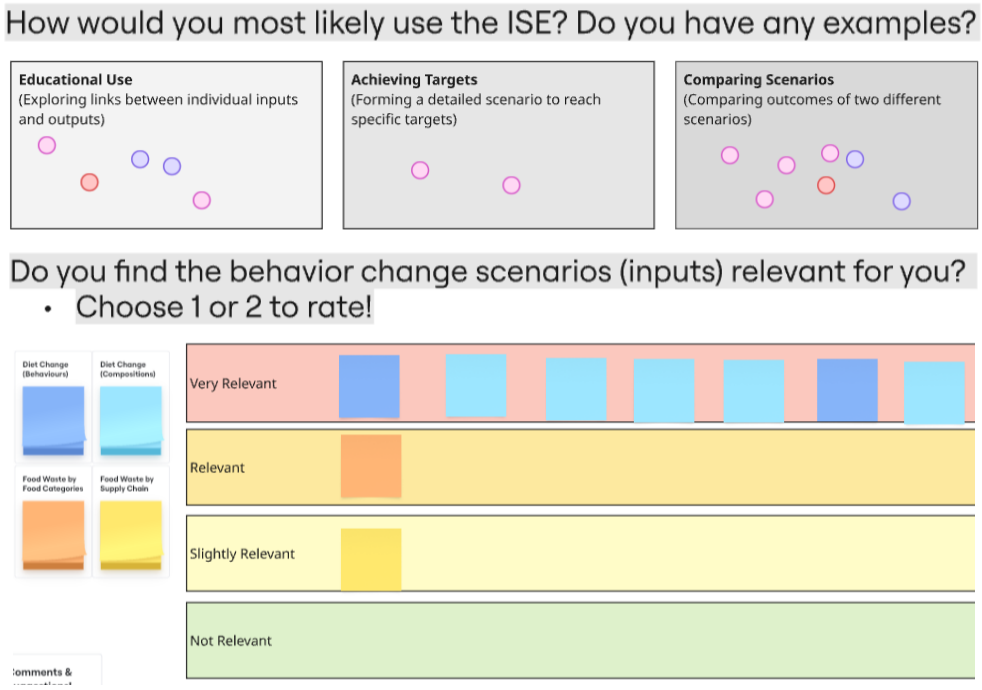

Figure 3. Screenshots of questions relating to the fit-for-purpose of the ISE

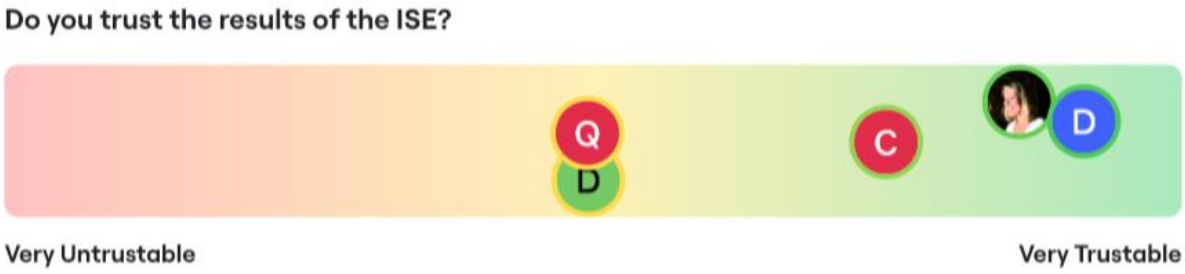

Figure 4. Screenshots of questions relating to the trustworthiness of the ISE

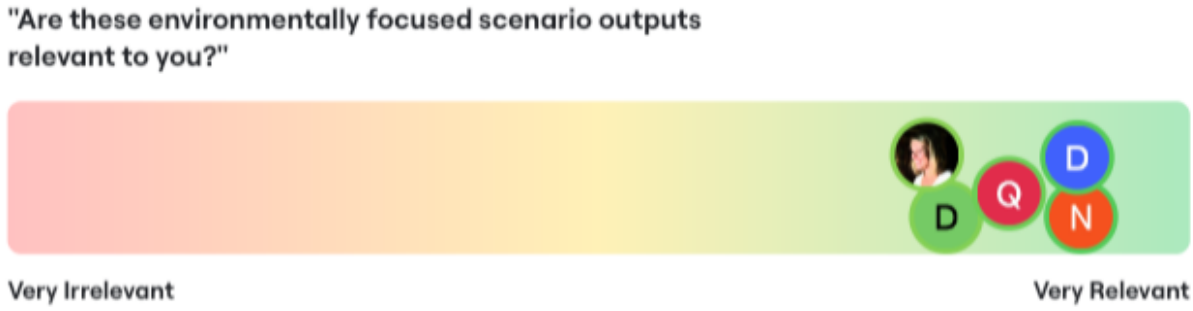

Figure 5. Screenshots of questions relating to the data relevance of the ISE

(2) Accessibility

The Miro board asked users to rate each accessibility metric on a scale from strongly disagree to strongly agree, and the results are presented in Figure 6.

Based on all accessibility metrics, the ISE demonstrates at least average overall accessibility. Among the various metrics assessed, *intuitiveness* and *readability* received the highest ratings, followed by *navigation*. The areas with the greatest potential for improvement are *cognitive load* and *clarity*.

Specific design-related pain points contributing to reduced accessibility were also identified. For *clarity*, two users highlighted difficulties in interpreting the quantification of sliders—particularly those related to behavioural factors. For example, they found it unclear what a 20% increase in self-efficacy means on an individual level. Regarding *cognitive load*, one user expressed challenges in keeping up with the terminology used throughout the interface. In terms of *intuitiveness*, users suggested ways to improve the functionality related to scenario comparison, likely in response to the currently incomplete design of this feature. There were no specific comments related to *navigation*. As for *readability*, users proposed exploring alternative input mechanisms beyond sliders.

Participants were also invited to rate some of our suggestions on general features that could improve ease-of-use. The most prominent ones were user guides, saving and loading scenario Inputs, and non-English language options.

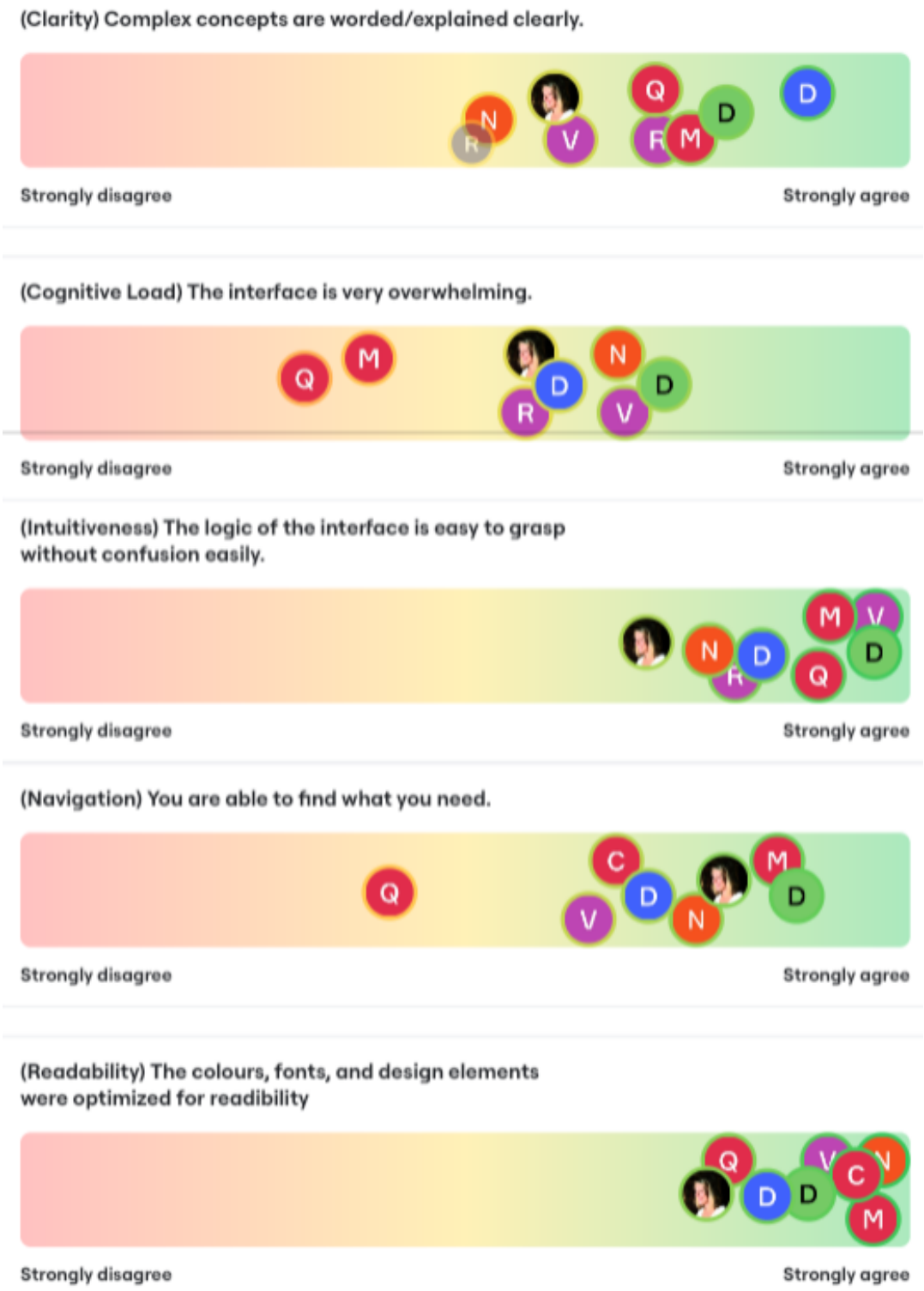

Figure 6. Screenshot of a panel in the Miro board where participants rate the Clarity, Cognitive Load, Intuitiveness, Navigation, and Readability.

(3) Engagement Appeal

On the Miro board, we asked the participants to rate the overall engagement appeal of the ISE. Results in Figure 7 show that it is generally positive. Users are prompted with more engaging images and texts to explain information. In general, because engagement appeal can be quite hard to conceptualise because it is quite subjective, the following questions were focused on how our design can be more interactive:

Input Design. Users agree on having more graphic content in our tool tip that stores most of the meta information. There are also agreements on exploring a wider range of input designs than sliders, also having the possibility to key in numbers directly. Finally, interactive labels to enable value ranges to be more relatable are supported.

Output Design. The main design suggestion was supporting the scenario comparisons better, e.g. combining both scenario outputs on a single graph than putting it on two separate graphs. There was also a comment about how we should order the tabs on the output panels as a better way to introduce the app to the user initially. Another feedback was on how to organise the functional usage of the ISE better by splitting it into two explicit modes, with a single scenario mode and a multi-scenario mode.

Interactive Elements. Two main interactive elements supported were having more popup instructions and graphs, and also better interactive features on output graphs, e.g. ability to mark specific timestamps and points was encouraged.

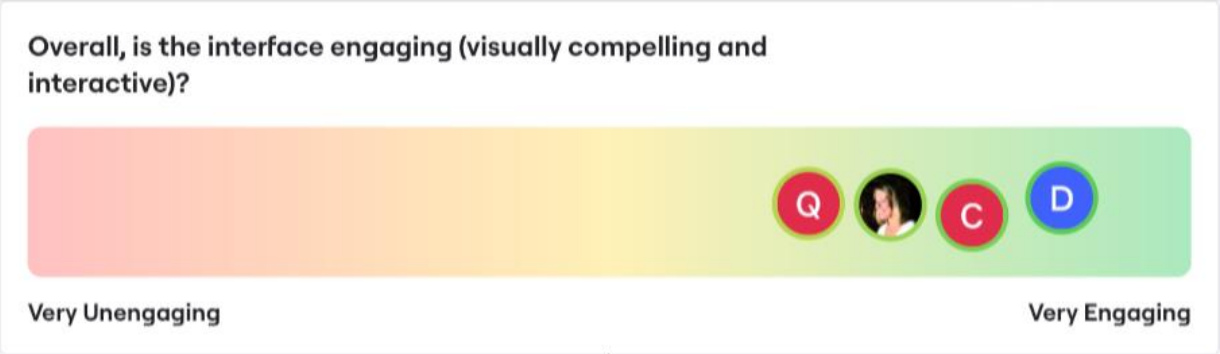

Figure 7. Screenshots of questions relating to the overall *Engagement Appeal* of the ISE

3.3 FABLE Calculator ISE

3.3.1 FABLE Calculator Workshop Settings

At the beginning of the FABLE Calculator ISE session, a live demonstration of FABLE Calculator ISE was presented to the users, offering them an overview of its key features. The demonstration started with a detailed explanation of how users can configure a scenario and trigger an assessment, followed by an overview of the dashboard that displays the outputs. Next, sample use cases were provided, allowing users to follow along on their computers and gain a deeper understanding of the FABLE Calculator ISE's functionalities. The session concluded with a feedback segment, where a questionnaire was shared via a link, followed by an interactive discussion with the participants.

The questionnaire was designed to gather user feedback on the *usefulness, accessibility* and *engagement appeal* of the FABLE Calculator ISE. It is divided into three subsections, as outlined below:

- **(1) Usefulness.** This section focuses on evaluating the usefulness of the FABLE Calculator ISE. It assesses the scenario input parameters, the outputs, and whether the insights provided are actionable and meaningful.
- **(2) Accessibility.** This section examines its accessibility, specifically how easy it is to use and navigate the tool.
- **(3) Engagement Appeal.** This section evaluates the engagement appeal of the user interface, assessing how interactive, intuitive, and engaging the UI is.

The questions and the responses collected are described in detail in the following paragraphs.

3.3.2 Feedback on FABLE Calculator ISE

The feedback collected during the FABLE Calculator ISE session provides valuable insights into the tool's *usefulness, accessibility,* and *engagement appeal*. The following sections outline the responses gathered from the participants and the main findings.

(1) Usefulness

In this section, the responses collected from questions 1-4 that assess the usefulness of the FABLE Calculator ISE in various contexts, are presented.

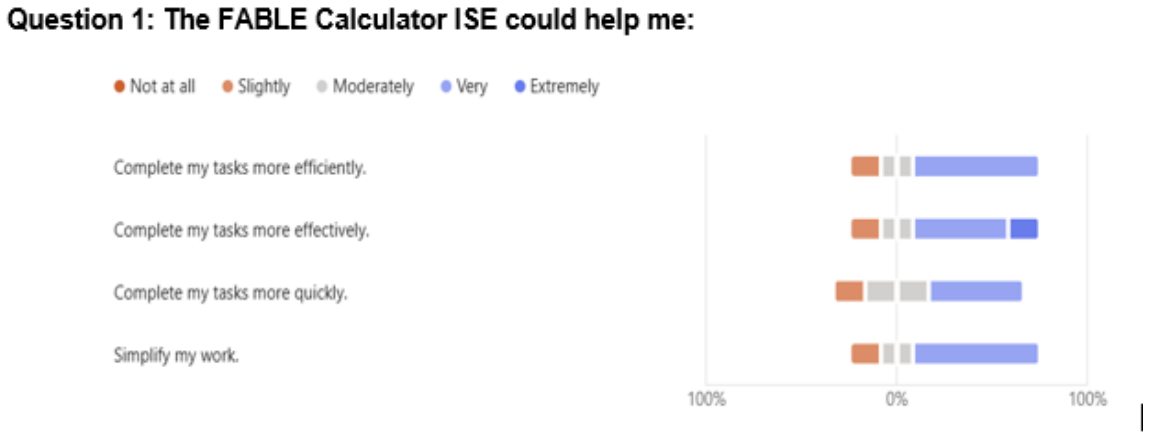

Figure 8. Question 1

Based on the responses that were received from Question 1, it can be concluded that the majority of the participants found the FABLE Calculator ISE to be useful and efficient. However, a small percentage of users felt that it offers them minimal assistance in completing their tasks.

Question 2: The FABLE Calculator ISE scenario (e.g., GDP, population, diets, evolution of exports, etc.):

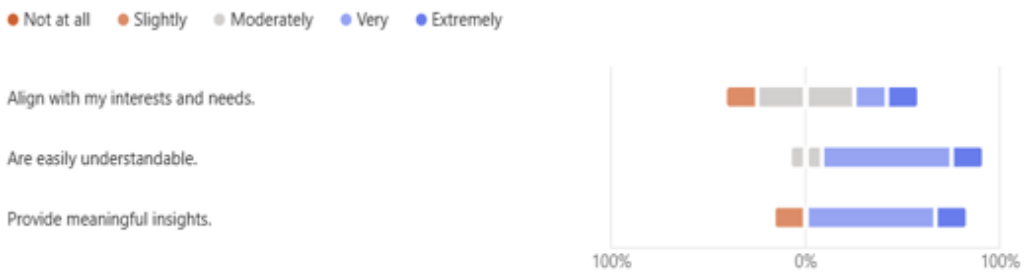

Figure 9. Question 2

Question 3: The FABLE Calculator ISE's output (food, production, jobs, trade, biodiversity, lands, GHG and water):

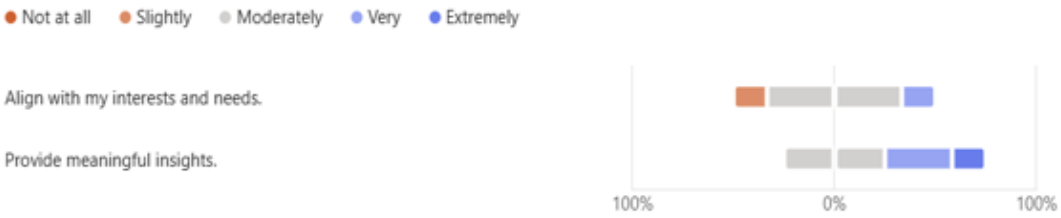

Figure 10. Question 3

According to the answers for Questions 2 and 3, most participants considered the FABLE Calculator ISE scenarios and FABLE Calculator ISE's outputs relevant to their interests and needs. In addition, the majority agreed that the tool provides meaningful insights.

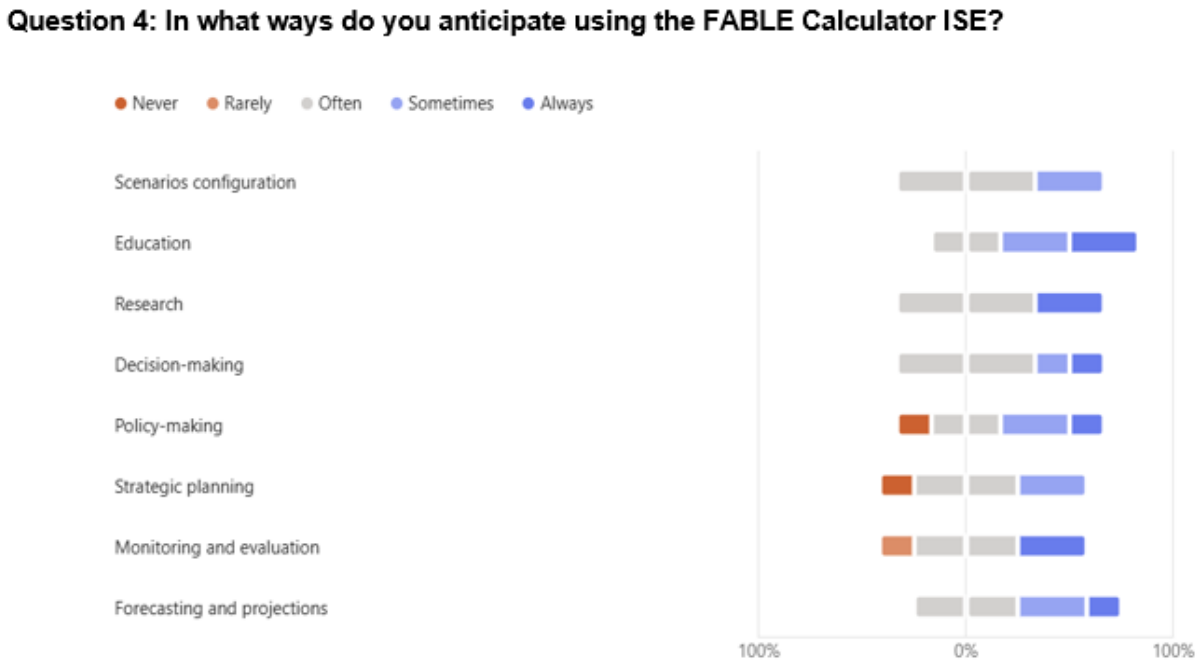

Figure 11. Question 4

Many users indicated that they found the FABLE Calculator ISE suitable for scenarios configuration, educational and research purposes, forecasting and projections. However, a few users expressed no intention to use it for policymaking, strategic planning, monitoring and evaluation.

(2) Accessibility

The second section of the questionnaire focused on evaluating the accessibility of the FABLE Calculator ISE. This section aimed to assess how easy it is for users to navigate and use the tool. The responses highlight the users' experience in performing tasks with the application and their overall satisfaction with its ease of use.

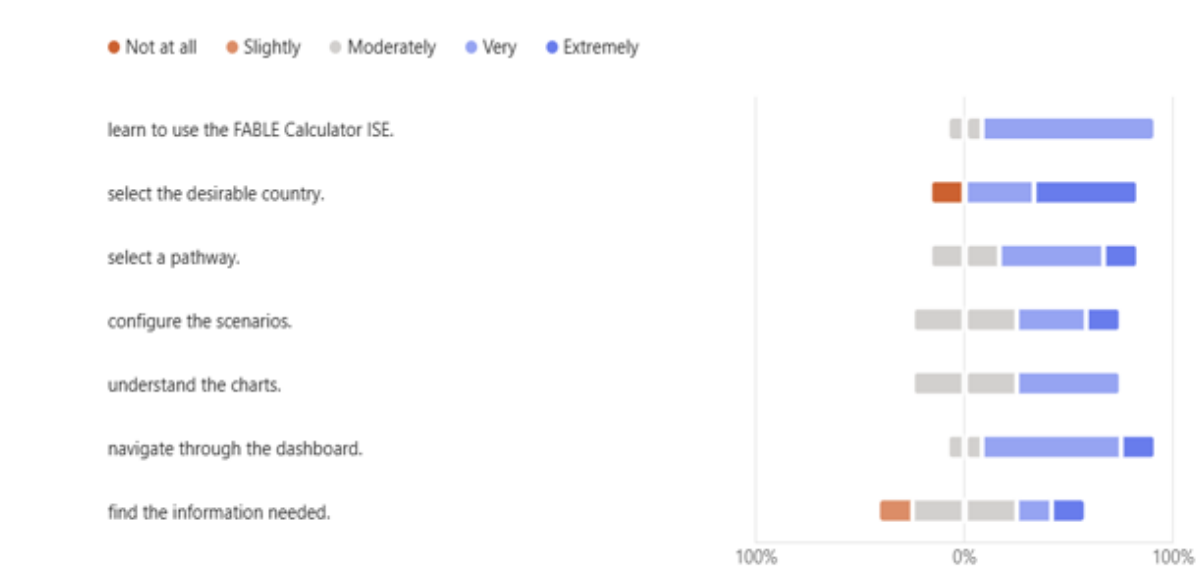

Figure 12. Question 5

Question 6: How much effort did it take to:

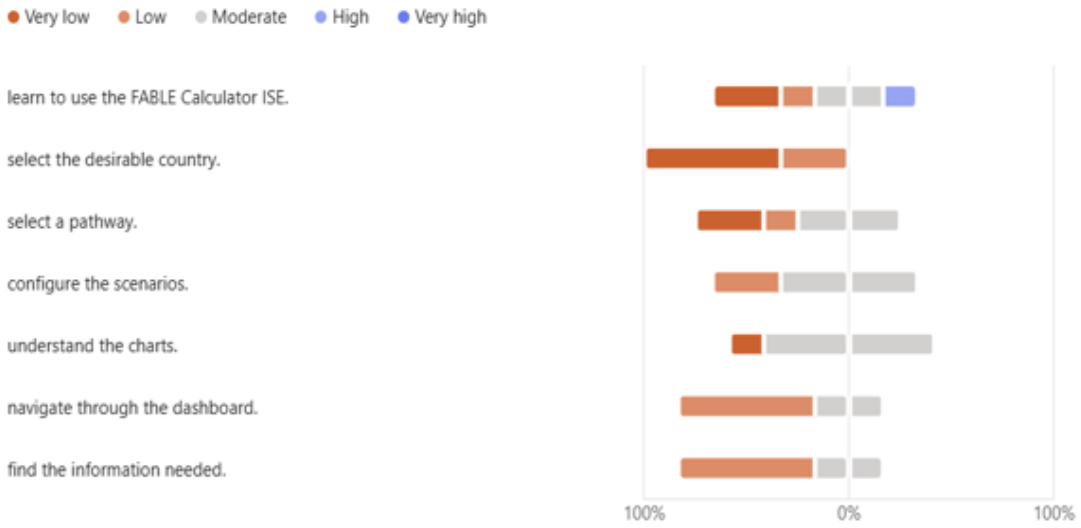

Figure 13. Question 6

Question 7: I made mistakes while trying to:

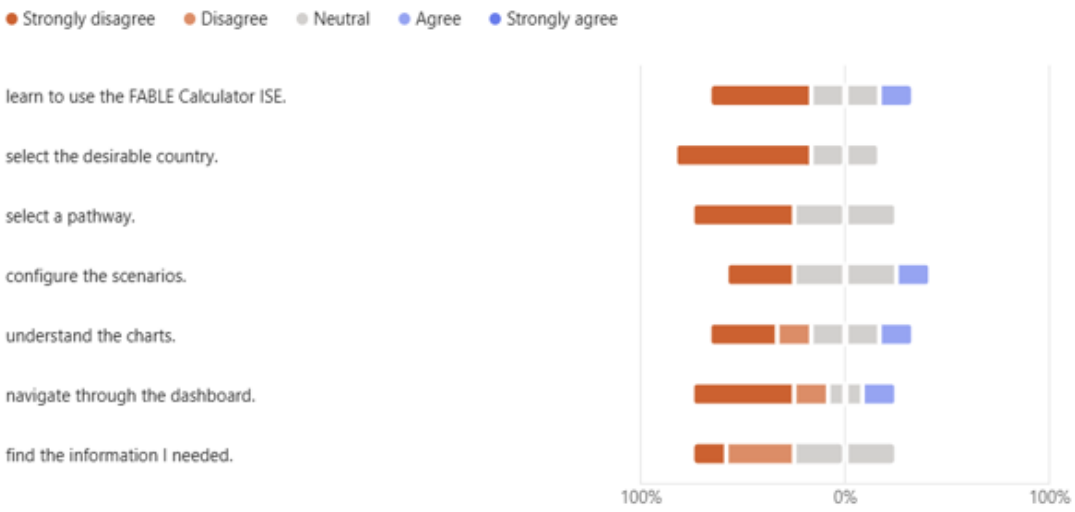

Figure 14. Question 7

Based on the responses to Questions 5, 6, and 7, it is clear that users found it relatively easy to complete tasks with the FABLE Calculator ISE. The majority indicated that minimal effort was required to perform tasks such as selecting the desired country, configuring scenarios, and navigating through the dashboard. Additionally, users reported making very few errors while exploring the tool's functionalities.

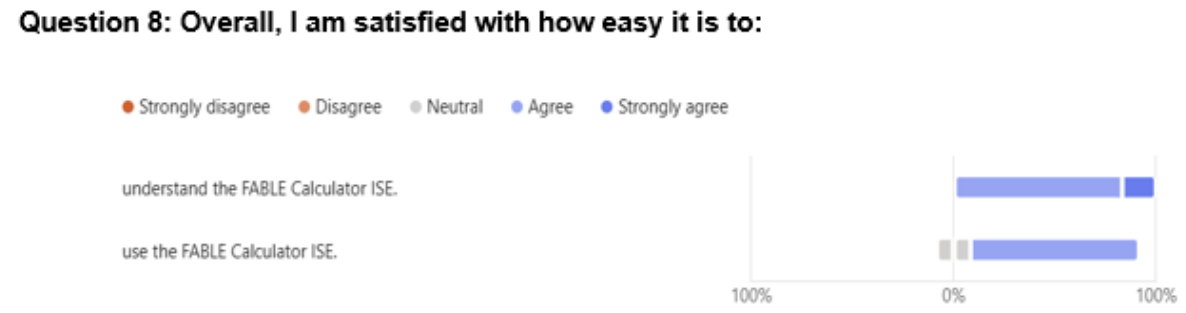

Figure 15. Question 8

Additionally, participants evaluated positively the overall easiness of the FABLE Calculator ISE, by replying that they are satisfied with how easy it was to understand and use it.

(3) Engagement Appeal

The third section of the questionnaire focused on evaluating the engagement appeal of the FABLE Calculator ISE. This part aimed to assess how intuitive, visually appealing, and interactive users found the interface, as well as their overall experience with the platform. Understanding user perceptions of the UI is essential for ensuring that the tool remains not only functional but also enjoyable and accessible for a wide range of users.

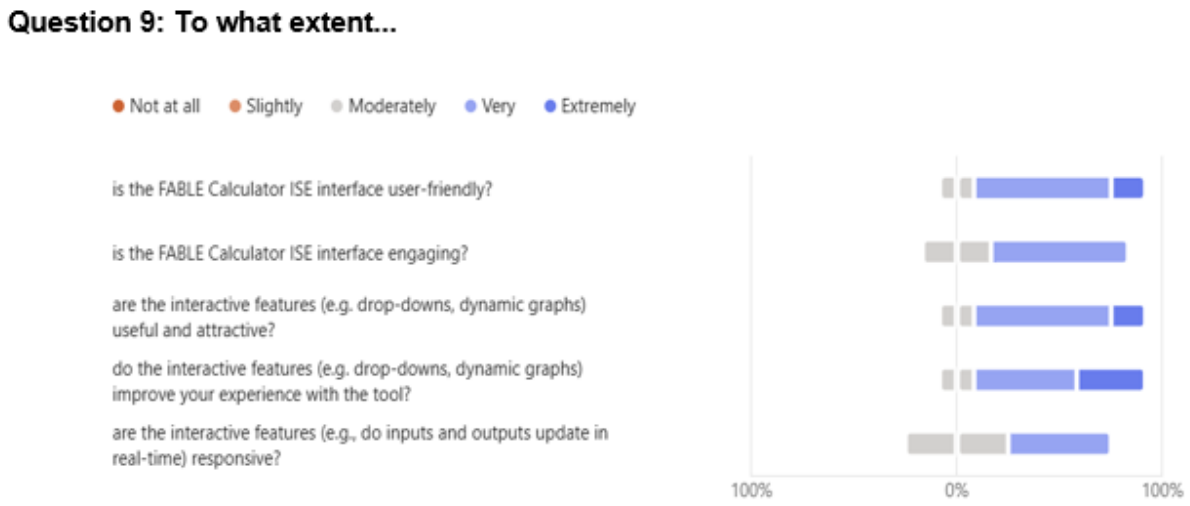

Figure 16. Question 9

Most users described the UI as user-friendly, engaging, and visually appealing. They emphasised that features such as dynamic graphs and interactive elements significantly enhanced their experience, making it easier to explore data and derive insights.

Question 10: What interactive features could we add to make FABLE Calculator ISE more interactive?

Maybe comparing before and after could be useful

it would be nice if you can change an input and see the updated output without hitting recalculate button.

Perhaps show an indicator that you are currently changing the inputs and haven't pressed "Calculate results" yet.

Figure 17. Question 10

This open-ended question encouraged participants to provide suggestions for future improvements. Several users proposed ideas such as enhanced tooltips, guided tours for new users, additional customisation options for graphs, and the ability to compare multiple scenarios side by side. These responses offer valuable input for improving the interactivity and usability of the tool in future versions.

Question 11: Does the FABLE Calculator ISE

Figure 18. Question 11

Most participants agreed that the data and results were meaningful, clear and well structured. Moreover, users could effectively understand the key insights of the output graphs. Although, there were some participants who had difficulties in understanding some complex concepts, implying that some complicated scenarios and trends should be simplified.

Question 12: Would you ...

Figure 19. Question 12

The majority of participants responded positively, expressing that they would continue using the FABLE Calculator ISE and recommend it to colleagues. Only a small number of users indicated that they were unlikely to use the tool long-term, suggesting opportunities for further refinement.

Overall, the feedback indicated that the FABLE Calculator ISE meets users' expectations in terms of functionality, usability, and design. While most users had a positive experience, the input collected also highlighted specific areas for future enhancement. These insights will be invaluable in shaping the next iterations of the tool, ensuring it evolves in alignment with user needs and preferences.

4. Conclusions

The workshop gathered valuable feedback from attendees who could potentially be among the first users of the tool. Both the FeliX and FABLE Calculator ISEs received generally positive feedback, but several key flaws and weaknesses emerged during the feedback sessions.

Limitations

There were limitations in the workshop, including a limited number of participants, most of whom were at the higher end of the "non-expert" knowledge spectrum. Additionally, some participants were particularly interested in applying the ISEs to their stakeholder workshops, narrowing the focus of feedback to specific use cases rather than exploring the broader potential of the tool.

General Findings for Both ISEs

A key finding for both ISEs is that identifying a target audience and a clear purpose remains challenging, largely due to the tool's essence is on the IAMs in which the model scopes constraints what purposes it may take. Despite this, it is crucial for the ISE to be clear about its capabilities, as users may either assume it can perform any task or become confused about how to use it.

Furthermore, there will likely be tension between the mental models of modellers and users, as users' natural understanding of variables and their relationships does not always align with how these elements are represented in the models. There must be many means within the ISEs to guide users at each step that could be essential for ensuring its adoption and effective use.

4.1 Next steps for the FeliX ISE

The key points for improvement, summarised in the feedback, are listed below. Rather than taking the suggestions and comments literally as specific objectives to be fulfilled, we have interpreted them based on the core arguments of what could be enhanced. As such, the following list of improvements can be framed both as general recommendations and as more specific targets, depending on how we interpret the most important aspects of the feedback received.

Aligning Purpose, Audience, and Scenario Inputs *[Usefulness]*.

The purpose and intended audience of the tool should be reflected more deeply on, to further guide the selection and design of scenario inputs. Future development of the FeliX IAM should support a broader range of scenario types, especially since the current implementation tends to emphasise certain aspects of the model over others. The current set of outputs appears to be tentatively adequate and understandable, but ongoing refinement may be needed as the tool evolves and is applied to more diverse use cases.

Enhancing *Comparing Scenarios* Functionality *[Usefulness & Accessibility].*

Scenario comparison was one of the most frequently requested features but remains underdeveloped. Improving this aspect will require the ISE backend to manage multiple scenarios more efficiently. Enhancements could include allowing users to save and load scenarios, rename them, and visualise multiple scenarios within the same graph rather than across separate ones. Introducing clearly distinguished modes—such as a Single Scenario mode and a Multi-Scenario mode—could also help structure the experience in a more intuitive way that aligns with diverse user needs.

Improving the Organisation of Meta-Information *[Usefulness & Accessibility].*

Users emphasised the importance of building trust in the tool, which could be achieved by visualising historical data to provide grounding without adding to cognitive overload. Meta-information could be presented in more engaging and accessible formats—moving beyond static text to include visual elements that communicate the same information more intuitively.

Managing Cognitive Load and Improving Clarity *[Accessibility].*

Concerns around cognitive load were central to feedback on the ISE's accessibility. Given that the interface is designed to "push" information to users, this information must be clear and digestible. Simplifying terminology wherever feasible would make the interface more user-friendly. Additionally, restructuring the input and output panels to prioritise key information, and hiding less critical details until needed, could help reduce users' cognitive burden and improve the overall experience.

Increasing Interactivity and Engagement *[Engagement Appeal].*

The current iteration of the ISE offers limited interactive features as it was more focused on exploring purpose-driven design choices, and this leaves significant room for growth in future iterations. Users expressed a preference for more diverse input designs, as sliders are not always suitable for all variable types. On the output side, interactive features that allow users to explore data dynamically, e.g. selecting specific time points or drilling down into specific variables, would greatly enhance its engagement appeal. There is also potential to design interface elements that actively support different functional use cases, such as highlighting tabs or graph features when key changes occur in the data.

4.2 Next steps for the FABLE Calculator ISE

Based on the questionnaire responses, several improvements have been identified to enhance the FABLE Calculator ISE and better meet user expectations. One of the main areas of focus will be simplifying complex concepts and outputs. This includes making scenario definitions and graphical results easier to understand by integrating contextual explanations, more tooltips, and a glossary of key terms directly within the interface. The list of scenarios available to select will be refined to only the most relevant ones following the feedback received. The graphs displayed will also be adapted to the new list of scenarios to facilitate the interpretation of impact of scenario selection.

Another priority is to enhance interactivity and customisation. Users expressed interest in features such as scenario comparison views, more flexible filtering and sorting options, and the ability to personalise graphs and dashboards. In response, future updates will explore the integration of these features to create a more engaging and tailored user experience. Moreover, giving the option to easily export and import custom pathways through the UI, namely scenario configurations that users have made, to use them again in the future, is another feature that will be integrated into the next versions of FABLE Calculator ISE. This functionality aims to increase the tool's usability and simplify the scenario configuration process.

Considering the feedback collected, the current version of FABLE Calculator ISE offers users overall a user-friendly and intuitive UI, which helps them to use it in an effective way. Although various improvements and updates are intended to be included in the next versions. Incorporating the feedback gathered during the workshop into future versions and adjusting the FABLE Calculator ISE to users' needs will result in increasing user experience and engagement and will make it accessible to a broader audience, including both expert and non-expert people.

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Appendix A (Screenshots of FeliX ISE)

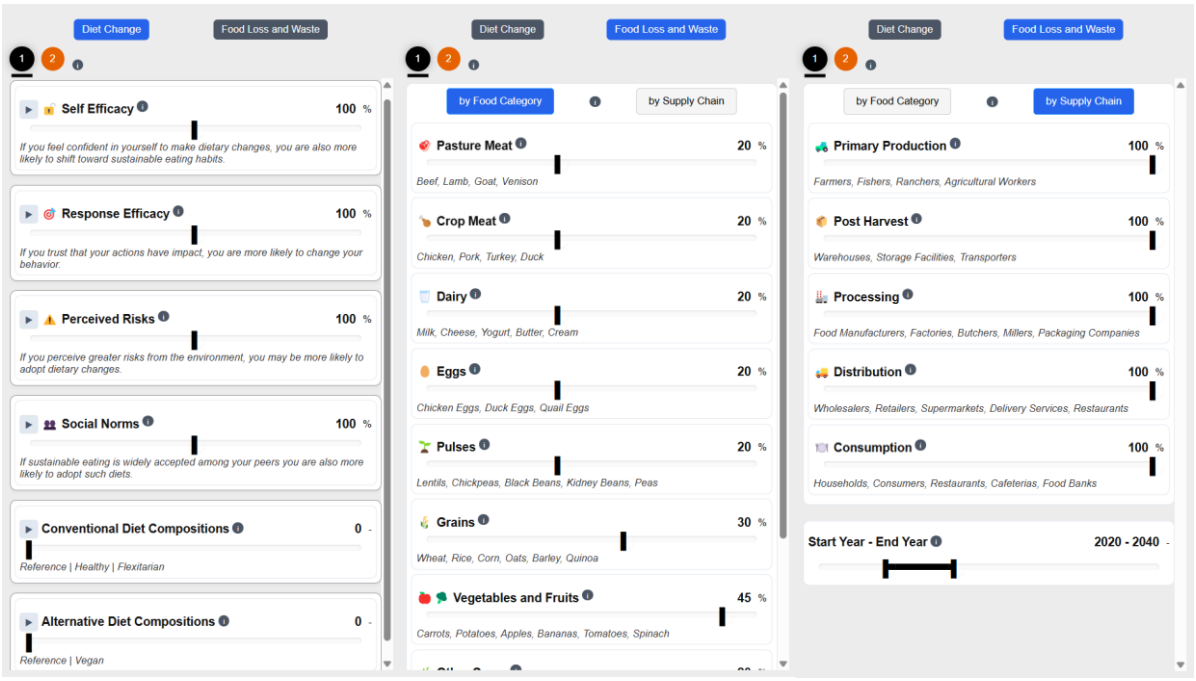


Figure A1: Screenshots of the various tabs in the scenario input panel

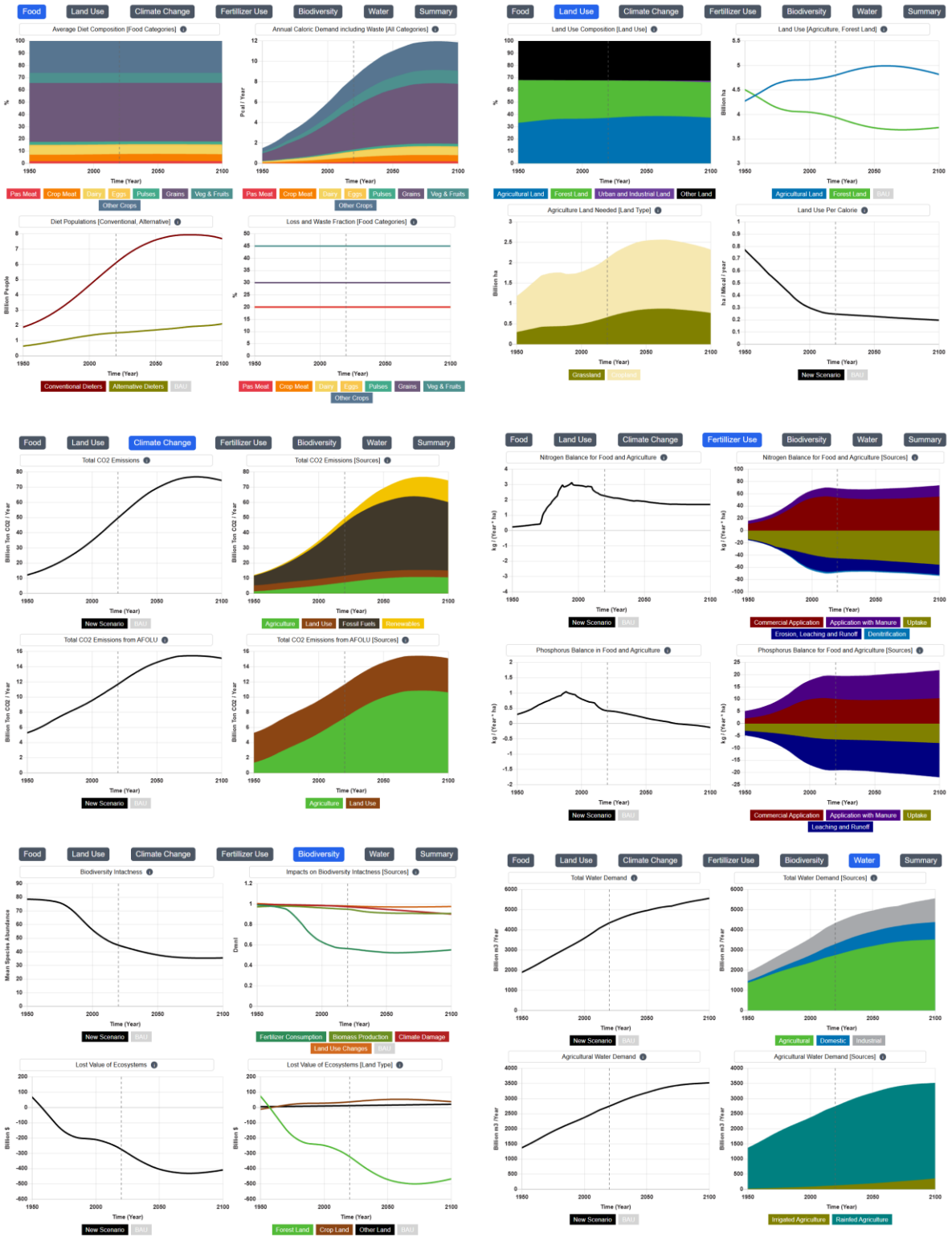


Figure A2: Screenshots of the various tabs in the scenario output panel

Appendix B (List of Input and Output Variables of FeliX ISE)

Table B1: Scenario Inputs of FeliX ISE. These variables are the main variables, excluding additional hidden variables.

Input Tabs	Variable Types	Main Variables (excl. Sub Variables)
Diet Change	Behavioural Factors	Self-Efficacy | Response Efficacy | Perceived Risk | Social Norms
	Diet Assumptions	Conventional Diet Compositions | Alternative Diet Compositions
Food Loss and Waste	By Food Categories	Pasture Meat | Crop Meat | Dairy | Eggs | Pulses | Grains | Vegetable & Fruits | Other Crops
	By Supply Chain	Primary Production | Post Harvest | Processing | Distribution | Consumption
	Assumptions	Start-End Year

Table B2: Scenario Outputs of FeliX ISE. Variables enclosed in square brackets represent graphs that display different categories, often shown as multiple lines or stacked line plots.

Systems	Variables
Food	Average Diet Composition [Food Categories] | Annual Caloric Demand including Waste [All Categories] | Diet Population Percentage [Conventional, Alternative] | Loss and Waste Fraction [Food Categories]
Land Use	Land Use Composition [Land Use] | Land Use [Agriculture, Forest Land] | Agriculture Land Needed [Land Type] | Land Use Per Calorie
Climate Change	Total CO2 Emissions* | Total CO2 Emissions [Sources] | Total CO2 Emissions from AFOLU* | Total CO2 Emissions from AFOLU [Sources]
Fertilizer Use	Nitrogen Balance for Food and Agriculture* | Nitrogen Balance for Food and Agriculture [Sources] | Phosphorus Balance in Food and Agriculture* | Phosphorus Balance for Food and Agriculture [Sources]
Biodiversity	Biodiversity Intactness* | Impacts on Biodiversity Intactness [Sources] | Lost Value of Ecosystems* | Lost Value of Ecosystems [Land Type]
Water	Total Water Demand | Total Water Demand [Sources] | Agricultural Water Demand | Agricultural Water Demand [Sources]

Appendix C (Screenshots of FABLE ISE)

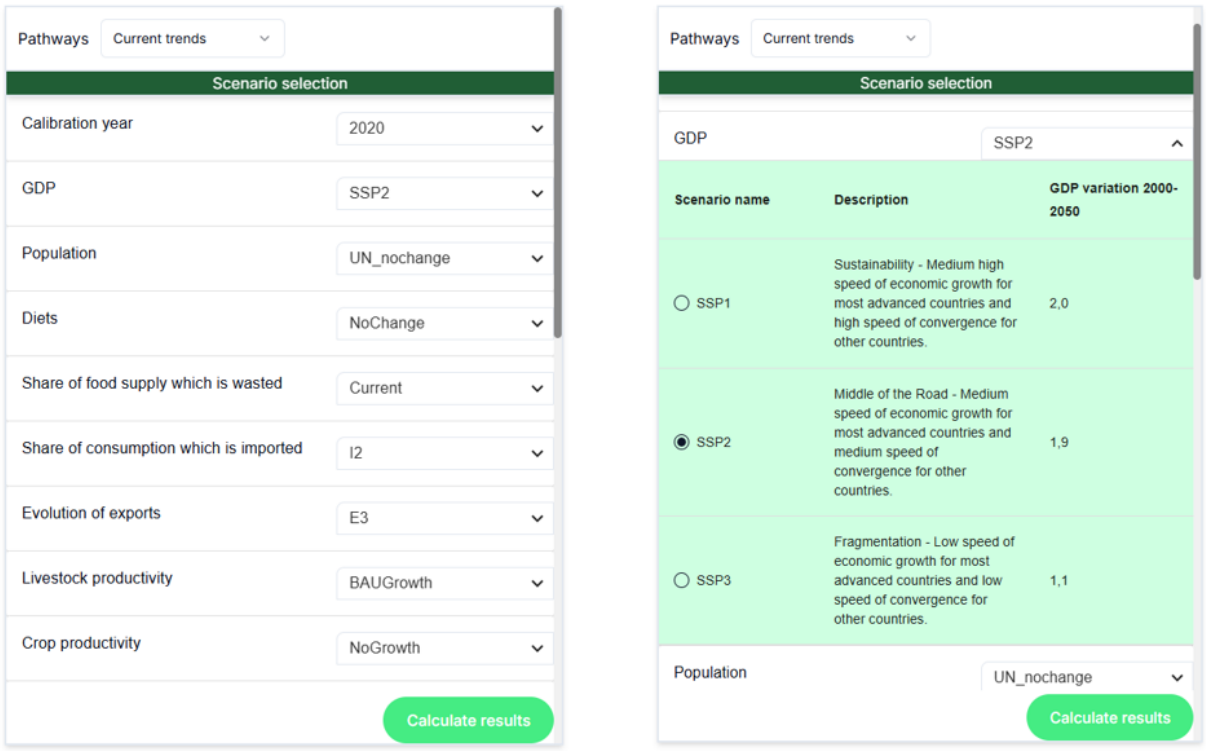


Figure C1: Screenshots of FABLE ISE input parameters

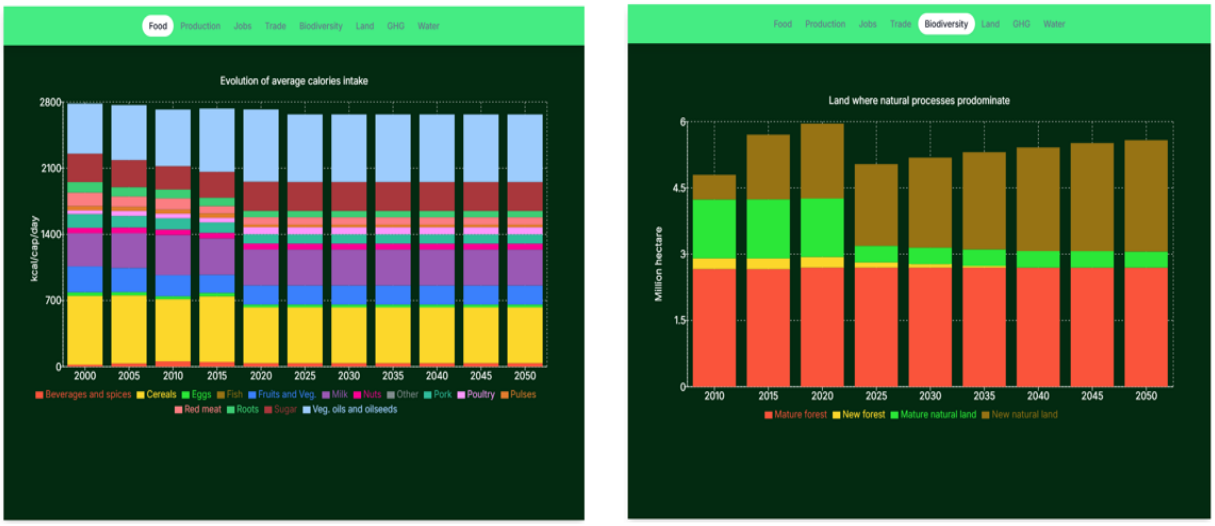
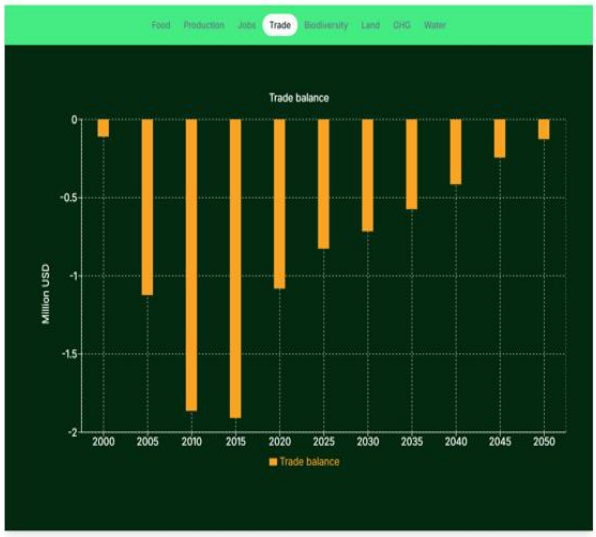


Figure C2: Screenshots of FABLE ISE outputs



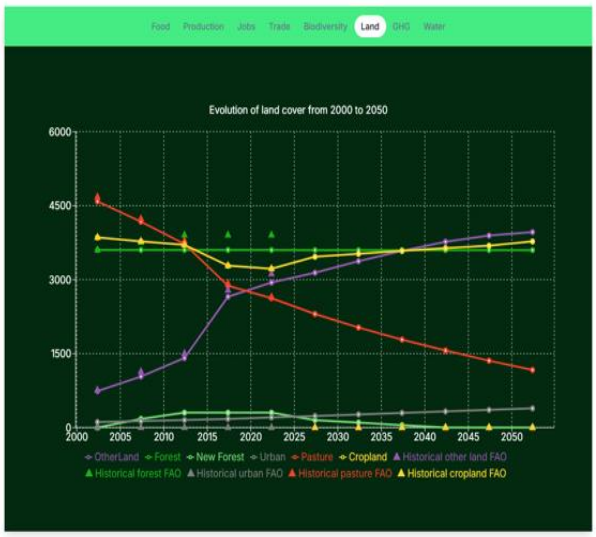


Figure C3: Screenshots of FABLE ISE outputs

Appendix D (Workshop Participant List)

Table D1: This participation is recorded by Microsoft Team's attendance function which records any user who entered the workshop meeting room. Not all participants stayed throughout the full 2.5-hour session.

#	Role	Participant Name	Organisation
1	ISE Collaborator/Presenter	TAN Ryan	IIASA
2	ISE Collaborator/Presenter	Filippos Marntirosian	ICCS/NTUA
3	ISE Collaborator/Presenter	Nikolaos Tantaroudas	ICCS
4	ISE Collaborator/Presenter	Dimitra Samara	ERRA
5	ISE Collaborator/Presenter	Clara Douzal	SDSN
6	External Visitor	Yekatherina Bobrova	ECI
7	External Visitor	Domenica Cox	ECI
8	Choice Partner	YE Quanliang	IIASA
9	Choice Partner	Beatriz Rodríguez	Bio
10	Choice Partner	Christos Giannakopoulos	NOA
11	Choice Partner	RAQUEL González	CAAND
12	Choice Partner	Kevin Reyes Otero	Tecni
13	Choice Partner	Dora Karali	RISA
14	Choice Partner	KOZICKA Marta	IIASA
15	Choice Partner	STEINHAUSER Jan	IIASA
16	Choice Partner	Myrto Gratsea	NOA
17	Choice Partner	Dora Karali	ERRA
18	Choice Partner	Viviana Narváez	Tecni
19	Choice Partner	Petros Xepapadeas	ATHENA
20	Choice Partner	DAGLIS THEODOROS	ATHENA
21	Choice Partner	Adela Itzkin	UP
22	Choice Partner	Yannis Kopsinis	LIBRA

23	Choice Partner	Evi Brousta	LIBRA
24	Choice Partner	Antonia Lorenzo	Bio
25	Choice Partner	Obdulia Parra	CAAND
26	Choice Partner	Ilias Karachalios	ICCS

Choice

Mainstreaming Integrated Assessment Models by embedding behavioural change and actor heterogeneity, and increasing their outreach to citizens, communities and industrial actors

CHOICE Consortium:

Contact

Project Coordinator: **Dr Angelos Amditis**

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