EUCALC

Explore sustainable European futures

Expert consultation workshop on land, land use and carbon stock dynamics (LULUCF), biomass provision (food, energy, materials) & minerals

D 4.2

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Short Description

This report summarises the discussions and conclusions from the expert consultation workshop on land, land use and carbon stock dynamics (LULUCF), biomass provision (food, energy, materials) & minerals, held in London on 19th and 20th September 2018, within the framework of the EUCalc project. It covers the presentations given at the event by the organisers and keynote speakers as well as feedback and recommendations provided by participants on the modelling approach, key assumptions and features of the land use, water and biodiversity module of the EUCalc. The main outcomes include the refining of the set of levers and their associated modules and ambition levels, particularly in terms of scope. For most of the levers, the experts put emphasis not only on GHG emission associated issues, but also on wider sustainability issues, for example, regarding animal health and ecosystem services. The scope of the model has also been challenged. The water features have been highly acknowledged, and it will be strengthened accordingly, whereas the mining features have been considered irrelevant by most of the experts. Finally, some features will be merged, both intra and inter WPs, strengthening WP interlinkages, particularly regarding diet choices and wastes.

Aspects of the workshop related to biodiversity and water impacts of biomass provision are presented in a separate deliverable, Deliverable 4.3. The two deliverables, Deliverable 4.2 and Deliverable 4.3, are highly interlinked.

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Statement of originality:

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

EUCalc policy of personal data protection in regard to the workshop

EUCalc defined the procedures in order to reply to ethical requirements in Deliverable 12.1 (Ethics requirements – procedures and criteria to identify research participants in EUCalc – H – Requirements No. 1). All procedures in relation to the co-design process, in particular the stakeholder mapping, the implementation of the workshops and the follow-up of the workshops, follow these procedures. The informed consent procedure in relation to the workshops is based on D9.2 "Stakeholder mapping" and D9.4 "Method for implementation of EUCalc co-design process". The originals of the signed consent forms are stored at the coordinators' premises without possibility of access of externals. Scans of the informed consent forms are stored on the internal EUCalc file storing system

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Glossary

CBD: Convention on Biological Diversity
CSA: Climate Smart Agriculture
CO_2: Carbon Dioxide
EBM: Ecosystem based management
EUCalc: European Calculator
CORDEX: Coordinated Regional Climate Downscaling Experiment
ICL: Imperial College London
ILUC: Indirect Land Use Change
IPCC: Intergovernmental Panel on Climate Change
JRC: Joint Research Centre
FAO: Food and Agriculture Organization of the United Nations
GHG: Greenhouse Gas
LUC: Land Use Change
LULUCF: Land Use, Land Use Change and Forestry
ORNL: Oak Ridge National Laboratory
RED: Renewable Energy Directive
REDD+: Reducing Emissions from Deforestation and forest Degradation
RCP: Representative Concentration Pathways
RoW: Rest of the World
SFM: Sustainable Forest Management
UAA: Utilised Agricultural Area
UCO: Used Cooking Oil
UEA: University of East Anglia
WP: Work Package

1 Executive Summary

This report summarises the discussions and conclusions from the expert consultation workshop on land, land use and carbon stock dynamics (LULUCF), biomass provision (food, energy, materials) & minerals, held in London on 19th and 20th September 2018, within the framework of the EUCalc project.

Each day of the workshop started with a series of presentations. Jeremy Woods from Imperial College London (ICL) and Garret Patrick Kelly from SEE Change Net gave introductory presentations on the logic of the project and the concept of the EUCalc model. Subsequently, in his key note address, Tom Heap, a BBC rural affairs reporter, underscored the multifaceted nature of challenges caused by land use change and at the same time the importance of communicating and making these understandable to the wider public. He went on to challenge and motivate the workshop participants to bear in mind both of these aspects as crucial when thinking of making a success of the Calculator. Gino Baudry from ICL presented the findings of the preliminary research activities under the land use, water and biodiversity modules to the experts. On the second day of the workshop, Professor Ad de Roo from the Water and Marine Resources Unit of the Joint Research Center (JRC) of the European Commission presented their ground breaking work based on water resources modelling. This was followed by a presentation from Keith Kline, a member of the Distinguished R&D team of the Environmental Sciences Division of Oak Ridge National Laboratory (ORNL) in the US, who presented insights from the land use change research projects conducted globally, as lessons for the EUCalc project.

The largest segment of the workshop was devoted to eliciting feedback and inputs from experts to the EUCalc preliminary research results. A series of interesting suggestions were made that will shape the EUCalc development. Most of the levers were considered relevant, not only for GHG emission associated issues, but also to track wider sustainability issues. Typically, the agricultural, fishery, livestock and forestry issues have to be included with a broader perspective to include sustainability impacts on biodiversity, water-use, fertilizer-use, livestock health, ecosystem services among others. Another key finding was the need to aggregate some features, both inside and outside the work package. In view of this, it was strongly - but not unanimously - suggested to use 'umbrella' levers such as climate smart agriculture to drive multiple but explicit parameters (e.g. agroforestry), rather than proposing a range of possible agricultural practices. One advantage of taking this measure is that climate smart agriculture is contextual, which fits with the lever approach. It was also strongly suggested, but again not unanimously, that organic farming should be driven by the lifestyle choices rather than through the agriculture practices. Finally, the relevance of water management and mineral mining levers was challenged by the experts. The water-management was foreseen as a module to track water-impacts, hence it was suggested that this ought to be a lever on its own. On the contrary, the mineral mining associated lever was considered irrelevant as impacts are mostly from the rest of the world (RoW) with the EU having no control of sustainability mining standards outside its jurisdiction. It must be emphasised that the workshop enabled us collate critical and useful feedback that will help shape the different modules of the EUCalc.

This workshop was an important milestone in the research and design of the land use, water and biodiversity modules, providing contributions from a sizeable set of experts from the fields covering wide ranges of expertise from agriculture, forestry, waste and residues, biomass uses, etc. The experts' inputs are being assessed and used for the improvement of the EUCalc tool. The project will continue to interact with the experts, those who attended the workshop as well as those who, although unable to attend the workshop, expressed their interest to be involved.

Note: This report covers land, land use and carbon stock dynamics (LULUCF), biomass provision (food, energy, materials), and minerals, whilst the Deliverable 4.3 covers biodiversity and water impacts of biomass provision. The two deliverables are highly interlinked.

2 Introduction

The EUCalc addresses multi-dimensional and inter-disciplinary issues, and the development of the tool requires a wide range of expertise, from fundamental research to application and use[1]. In this context, the EUCalc embeds a co-design process with stakeholders who are leading experts in their field, organised through a series of workshops, one for each main module (see Figure 1). Through this approach, external experts are part of the designing process which enables them to shape and calibrate the EUCalc tool by helping co-design the determinants and the scope of the scenarios.

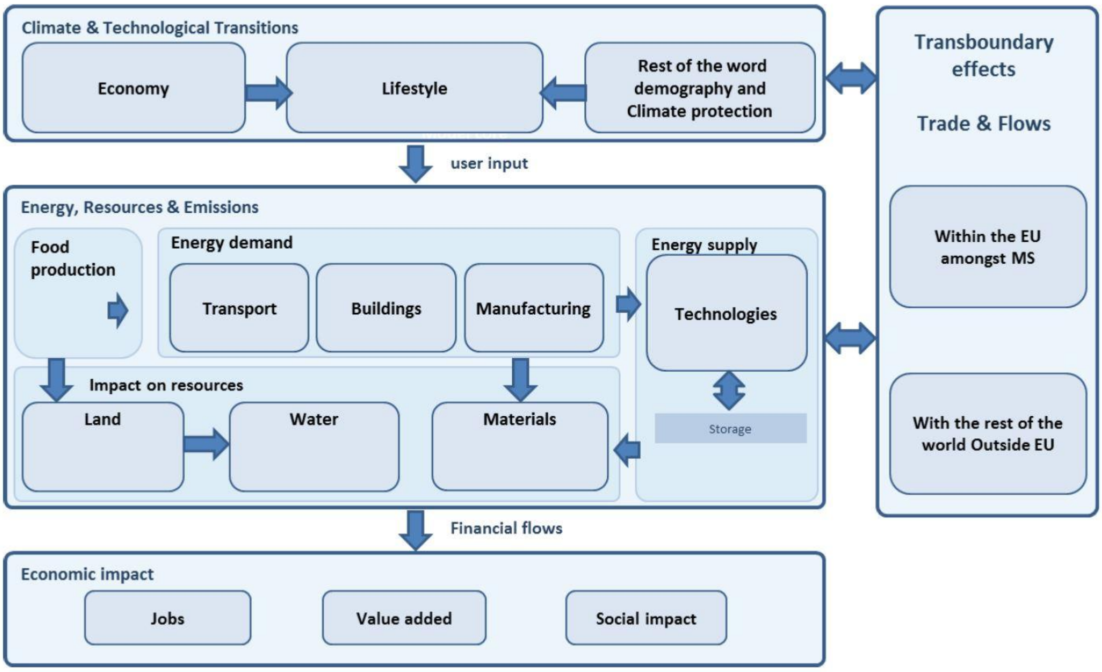


Figure 1 – Overview of the EUCalc structure and modules integration

Imperial College London (ICL) is leading the Land use, Water and Biodiversity aspects of the EUCalc project in collaboration with University of East Anglia (UEA), PIK-Potsdam, Climact, T6ECO, TU Delft, SEE Change Net and Climate Media Factory.

In the land use, water and biodiversity modules, end-users will control a set of levers that drive land use change, with four levels of ambition for climate change mitigation for each lever. These four levels enable end-users to create broad variation of mitigation choices and sustainability impacts in Europe by 2050 (Section 3.2.4). Consequently, the model can provide a wide range of land use and climate trajectories arising from combinatorics of all levers and levels that can be chosen by the end user.

The EUCalc expert engagement workshop devoted to land-use, water and biodiversity washeldat Imperial College London on 19th and 20th September 2018.

The ICL team identified, defined and evaluated beforehand potential decarbonization options based on literature review. In order to facilitate the workshop deliberations,

[1]For more information please see EUCalc's Deliverable 9.2 on *Stakeholder mapping*

background information was provided to participants in advance. This comprised of relevant data, levers and underlying assumptions and the derivation of possible ambition levels (Section 3.2).

Twenty-five experts from civil society, academia, public and private sector with relevant expert background and experience to critic whilst providing evidence-based quantitative input regarding the future of land use, water and biodiversity in Europe, attended and contributed their input at the workshop. Participants list is annexed to this report (Section 6.2)

The workshop was professionally designed and facilitated. It was composed of three distinct components:

- Introduction of the EUCalc project in a plenary scene setting, supported by a keynote speaker[2] (Sections 3.1. and 6.3.);
- Presentation of the EUCalc model and the specific components of the land use, water and biodiversity modules (Section 3.2.);
- Break-out group discussions in which experts reviewed and reported back on key questions and topics (Section 3.3.).

Over the two days, the workshop followed a "top down" process, covering three levels of depth and complexity in the land use, water and biodiversity modules. Day 1 focused on the definition and identification of levers (depth 1) and practices (depth 2), whereas, Day 2 focused on the definition of the ambition levels (depth 3). Table 1 illustrates the definition of the three levels that were investigated, using agricultural practices lever as an example.

Table 1 – Overview on the workshop process

Day 1		Day 2
Levers *Depth 1*	**Practices** *Depth 2*	**Ambition levels** *Depth 3*
Identify the relevant determinants to mitigate GHG emissions	Identify the practices or actions (if relevant)	Define the potential by 2050 through 4 ambition levels for each practice
E.g. agricultural practices	*E.g. organic farming, agroforestry, and so on.*	*E.g. organic farming by 2050 could be set at 100% as level 4.*

[2]The keynote speakers for the workshop contributed for three distinct purposes: a) to set the overall context for the workshop through description of future-oriented, inspirational best practices; b) to attract the interest of potential participants to join the eventdue to the reputation and profile of the speaker; and c) given their high profile, to help with the social media profile of the EUCalc by linking the keynote speaker to the EUCalc tweeter account (#EUCalc). However, these keynote speakers were not necessarily expected to give critical scientific input to the workshop and the development of the specific modules, but instead to inspire and enthuse the participants, whilst also participating in the group discussion afterwards as an ordinary participants

2.1 Objectives of the expert consultation workshop

This facilitated workshop introduced the philosophy of the EUCalc tool to a set of experts. It also presented preliminary results and assumptions of the EUCalc sub-model for land use, water and biodiversity, based on a literature review of the modelling work. The workshop provided a venue for experts to validate and/or to critically examine the underlying methodology, the modelling levers for carbon mitigation and their respective ambition levels within the land-use, water and biodiversity modules. The following are examples of questions that the workshop aimed to address:

- Is the selection of levers appropriate and are the levels defined adequate? Is the scope of analysis complete? Is the choice of lever coherent and comprehensive? Other suggestions?
- What are the critical trade-offs and synergies to consider in terms of land use change and emissions? How can multiple competing uses for land (e.g., biodiversity, food production, energy provision, production of bio-materials, water use, urbanization, mitigation, adaptation) be prioritised and parameterised in the Calculator?
- What are the key practices[3] to consider in terms of agricultural, fishery and forestry practices (e.g. agroforestry, multiple cropping, aquaculture)? To what extent these practices may affect bioenergy and biomaterial potentials, land-use, water and biodiversity and GHG emissions?
- What are the main trends for the deployment of the identified technologies, behavioral changes and practices for improving the levers' accuracy? What deployment pace, namely the ambition levels, should be considered for these technological, behavioral and practices changes from now up to 2050?

3 Workshop description

3.1 Setting the scene

The expert consultation workshop was opened with a welcome speech given by Jeremy Woods from Imperial College London, who also gave an overview presentation on the EUCalc project. He outlined the history, philosophy and the logic of the Calculator's approach and how it allows users, particularly, decision makers, to interactively navigate and visualize the results of each selected scenario. He was then followed by Garret Patrick Kelly from SEE Change Net, who also addressed the experts, highlighting the role and importance of the co-design process for the EUCalc development. Their introductory presentations were followed by a motivational speech by Tom Heap, the invited keynote speaker, a BBC rural affairs, environment and science reporter.

In their opening address on Day 2, Onesmus Mwabonje from the ICL and Jeff Price from UEA provided a summary of key takeaways from the previous day. This was followed by

[3]Practices in the EUCalc model mean variables that can be assessed in greater detail as part of a certain lever choice in order to give additional options for the EUCalc's user and, hence, increasing the accuracy of the simulations. For example, if a lever is about per capita meat consumption (in terms of calories or weight), a practice could be the types of meat consumed (e.g. beef, mutton, goat meat, chicken, pork and fish) and so forth.

presentations of Professor Ad de Roo from the Water and Marine Resources Unit of the Joint Research Center (JRC) of the European Commission and Keith Kline, a member of the Distinguished R&D team of the Environmental Sciences Division of ORNL(Oak Ridge National Laboratory, US).The entire workshop was facilitated and moderated by Jonathan Buhl (4Sing).

Summary of presentations delivered by invited speakers is annexed to this report (Section 6.3).

3.2 Description of the land use, water and biodiversity module of the EUCalc

On Day 1, the land use, water and biodiversity module of the EUCalc was introduced by Gino Baudry from the ICL, providing an overview of the modeling approach and illustrating levers, practices and ambition levels considered in the Calculator through several examples.

Baudry also emphasized that nothing has been written in stone and encouraged workshop participants to critically review and challenge the proposed levers, practices and levels, by considering time and spatial dimensions for Europe, the EU Member States (plus Switzerland) and the Rest of the World (RoW). Key elements presented to experts are summarized in the following sub-sections.

3.2.1 Modelling approach

The land-use, water & biodiversity module computes the impacts associated with the production and supply of food, bioenergy, biomaterials and minerals as they relate to GHG emissions from now to 2050. The extent of these impacts will depend on the choices' that the EUCalc users make when designing their own decarbonisation pathways through the setting of levels of ambition for the different levers available in the module.

The land-use, water and biodiversity modules consist of a dozen sub-sectors that enable the computing of the impacts associated with the supply of food, bioenergy, biomaterials, and minerals (illustrated in Figure 2).

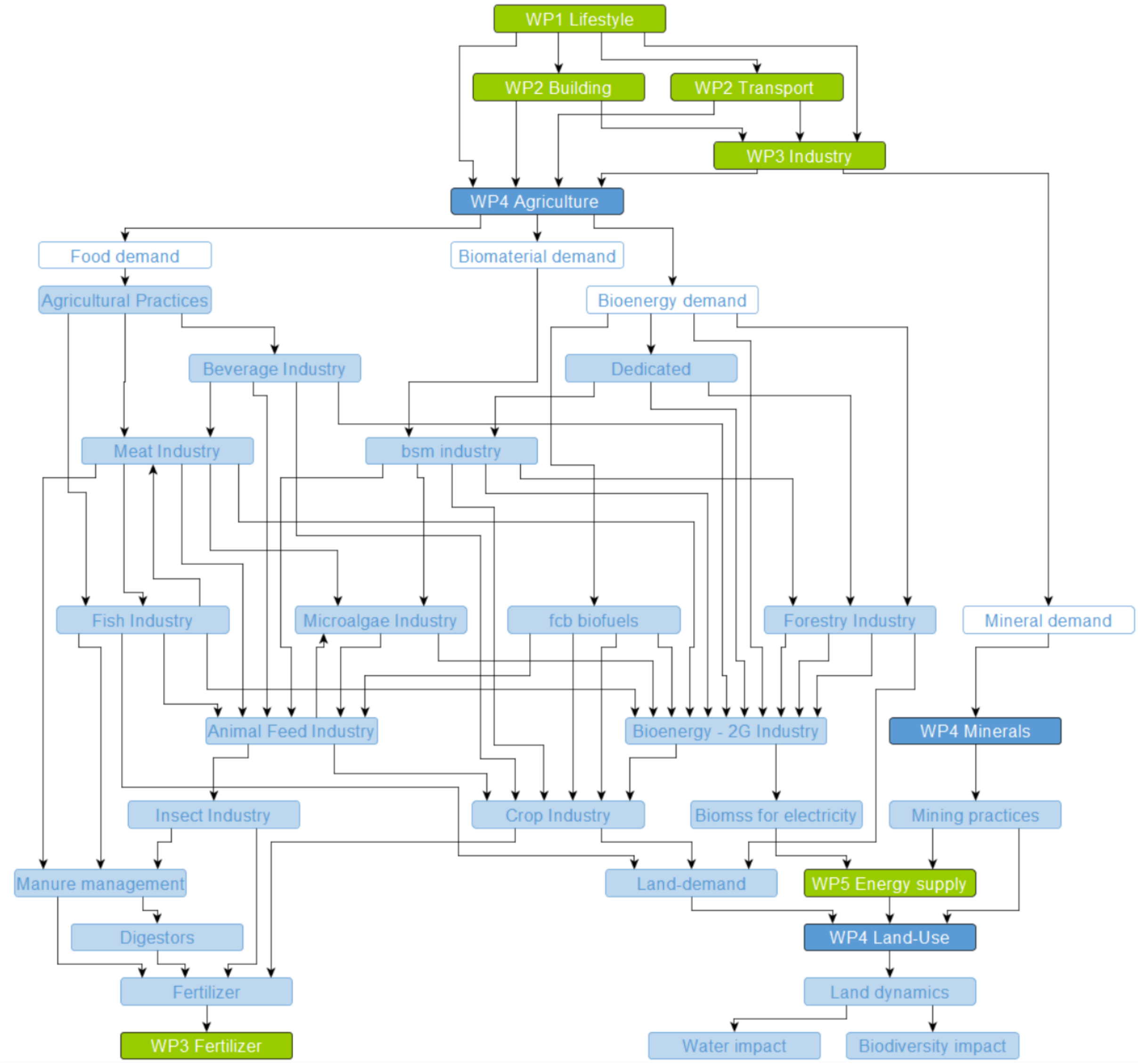


Figure 2 – Overview of the land-use, water & biodiversity module structure

Figure 2 illustrates the three main demand streams, namely, the demand for food, bioenergy and biomaterials, and the interlinkages that are driven by these demand streams. Dark blue and green represent the modules associated with WP4 (e.g. agriculture) and the other work packages (WPs) respectively (e.g. transport). The light blue represents the set of modules that are composing the land-use, water & biodiversity WP (e.g. insect industry), and the white boxes only illustrate the main flows (e.g. food, bioenergy). Arrows depict the connections between the modules and flows.

In the EUCalc, the demand for agricultural commodities drives the demand for agricultural inputs at farm level, such as energy, water, fertilisers and land-use. Consequently, this generates environmental impacts, particularly, in terms of GHG emissions, water and biodiversity.

3.2.2 Module's scope & granularity

Table 2 presents the main sectors, inputs and outputs of the land-use, water and biodiversity modules. The variables presented in the modules rely mainly on FAOSTAT, FishStat J (FAO), World Bank and EUROSTAT statistical database.

Table 2 – Scope of the land-use, water & biodiversity module

Sectors	Inputs	Outputs
Meat & livestock	Demand for Bovine, Mutton & Goat, Pig, Poultry meat; Offal; Animal Fats; Eggs; Milk products	Cattle by type; meat volume by type; manure volume; animal fats by type; meat, bone & blood meals; pasture demand; feed demand by type; energy demand; water demand.
Fishery & aquaculture	Demand for Freshwater Fish; Demersal Fish; Pelagic Fish; Other aquatic animals; Demand for fish-based meals (feed)	Fishery volumes (human food & animal feed); inland water demand; feed demand by type; energy demand; water demand.
Beverage industry	Demand for Wine; Beer; Fermented Beverages; Distilled beverages; Coffee and Tea.	Beverage volumes, crop demand by type; supply of cereal-meals, grape marc, coffee marc; energy demand; water demand.
Insect farming	Demand for insect-based meals; Organic waste supply.	Insect-meal's volume, land-demand, energy demand; water demand; feed demand (possibly); manure/fertiliser supply.
Crop-based bioenergy	Demand for bioenergy (dedicated crops)	Production volumes; energy-demand; water-demand; land-demand; feed meal supply.
Animal feeding & diets	Feed demand by type (cereals, grains, roughage, meat-meals, sugar-meals, oilseeds meals, insect-based meals, microalgae-based meals)	Feed volumes, crop demand by type of crop used as a feedstock for animal feed.
Biomaterials	Demand for biomaterial by type (wood, oil, ethanol, hemp, microalgae, fibre crops)	Production volumes; crop-demand by type; wood demand by type; microalgae biomass demand.
Forestry	Demand for wood products by type	Commercial forest demand; supply of wood residues.
Waste & residues bioenergy	Demand for bioenergy; supply of wastes & residues (from feed, food, biomaterial demand) and collection ratio.	Production volumes; energy-demand; water-demand.
Microalgae biorefinery	Demand for microalgae-based meals, microalgae biomass (biomaterial), and possibly microalgae bioenergy	Microalgae-meal volume, land-demand, energy demand; water demand; fertilizer demand/supply; energy supply by-type.
Crop production	Demand for food crops by types (from feed, food, bioenergy, biomaterial demand): cereals, oil crops, pulses (legumes), starchy roots, sugar & sweeteners, fruits, vegetables and vegetable oils.	Production volumes (including wastes); supply of agricultural residues; demands of fertilisers, energy and water.

Sectors	Inputs	Outputs
Manure management	Supply of manure (livestock, aquaculture, insects)	Production volumes; manure disposed; GHG emissions; manure applied in soil (fertilizer); manure supply for digestors.
Digestors	Manure supply; waste supply (food, urban, agriculture)	Production volumes; fertilizer supply; energy-supply; water-demand.
Organic Fertiliser	Fertiliser demand; Fertiliser supply (agro-food industry by-products, digestate)	Production volumes; nitrogen fertilizer demand.
Mineral	Mineral demand by type (iron-ore, aluminium, cement, limestone, sand, clay, gypsum, rare earth materials)	Production volumes; energy-demand; water-demand; land-use demand.
Land-use	Land-demand by type/use	Land-use & dynamics; Land multiple-cropping (e.g. double cropping), allocation of surplus land (freed-up areas); land integration (e.g. agro-forestry), soil carbon dynamics.
Biodiversity & Water	Ambition based on Aichi Objectives and other UN CDB commitments, as well as UN Sustainable Development Goals (e.g. SDGs 6, 14 and 15).	Degraded lands; protected lands & inland water; fish stocks; water management (e.g. irrigation, animal and human consumption, cooling in the energy and industrial sector).

3.2.3 Levers

Varying degrees of GHG emissions in the modules can be obtained by following possible mitigation actions and strategies. Each of these actions constitutes a lever in the land use module that can help to reduce GHG emissions, as presented in Table 3. The magnitude of this reduction is expressed through the 4 levels of ambition that ranges from a minimal abatement effort to an extraordinarily ambitious effort to mitigate climate change, offering a broad variation of mitigation choices, including intermediate levels (Section 3.2.4).

For water and biodiversity, trade-offs may occur in regard to GHG emissions, which is why an alternative lever setting was proposed: the level A, B, C, D. These levels reflect different potential scenarios in which the link to GHG emissions is not always straightforward to establish. Accordingly, the levers still provide the user with 4 levels of ambition, but without a ranking regarding GHG emissions.

Table 3 – Scope of levers and related practices

Levers	Units	Short description
Agricultural practices	%	Agricultural practices affect meat and crop supply, and the extent of land, water, fertiliser, energy demand, biodiversity impacts and their associated GHG emissions. *Share of Agricultural Practices (%), e.g.:* Organic farming, integrated agriculture (e.g. agroforestry, agro-livestock, livestock-forestry, agro-livestock-forestry), urban agriculture, conservation agriculture, precision agriculture, multiple cropping, crop yields, animal density, use of feed-lot systems (confined or semi-confined livestock systems).
Fishery Practices	%	Fishery practices affect fisheries and aquaculture, and the extent of inland, water, fertiliser, energy demand, biodiversity impacts and their associated GHG emissions. *Share of Fisheries and Aquaculture Practices (%) e.g.:* Aquaculture/wild catches, bycatches, discards, ghost fishing, fuel mix.
Forestry practices	%	Forestry management practices affect the supply of woody biomass for several purposes (e.g. building, furniture, pulp and paper, bioenergy), and the extent of the harvesting intensity, fertiliser-demand, land-demand, energy demand, carbon sequestration, and the biodiversity impacts. *Share of forestry practices (%), e.g.:* Sustainable Forest Management, Ecosystem-based Management.
Type of animal feed (diet)	%	Animal feeding practices affect the diets of livestock and fish from aquaculture. The feed types (e.g. grains, grasses, organic residues) affect the extent of the associated impacts in terms of land-use, water-use, energy-demand and the by-products types. *Split of Animal typical ration (%):* Cereal meals, grain meals, fodder, roughage, insect meals, microalgae meals, animal fats, meat & bone meals, fish meals, oil fish meals.
Biomass availability	hierarchy	Biomass availability is setting a hierarchy to prioritise the use of biomass and by-products for bioenergy and for biomaterials for papers products, building materials, etc. compared with the other uses (e.g., food, feed, pet-food, fertiliser, compost). *Hierarchy (cascading biomass prioritisation uses):* GHG emissions efficiency, energy efficiency, economic efficiency, enabling or disabling dedicated crops for non-food biomass.
Waste & residues	%	The lever sets the waste generation and waste and residues collection rates for the module (agriculture, fishery, forestry, food industry). *Parameters:* ambition in terms of waste mitigation and collection rates (%) by waste types, particularly on-farm residues (e.g., crop leaves and straws).
Mining Practices	%	Consistent with the previous levers, the mineral module sets the mining practices to supply minerals, and thus, the extent

Levers	Units	Short description
		of the associated impacts in terms of land-use, water-demand, energy-demand, possible deforestation & reforestation. _Share of mining practices (%), e.g.:_ Conventional, precision mining, among several other issues, which affects energy-use & mix, water-use, land-use, wastes, chemical-use, mine site restoration.
Land management practices	%	This lever sets the land management practices including the allocation of potential surplus land (freed-up land once all other land uses are matched up), e.g. afforestation/reforestation and/or energy crops. In addition, this lever addresses the potential increase or decrease in land-degradation, for example, erosion, soil fertility decline, salinization, increase in arid lands due to potential climate change effects (e.g., changes in rainfall patterns and fire occurrences). _Share of land-management practices (%), e.g.:_ Ambition regarding land degradation mitigation; afforestation, reforestation, protecting soil from wind and water erosion, green walls.

3.2.4 Levels of ambition

The EUCalc, as in the existing Calculators, for each lever, four levels of ambitions can be set to express the extent of the emission reduction effort that could be achieved from 2015 until 2050. In order to be consistent across the different sectors of the EUCalc, Table 4 presents how the lever settings reflect the four levels of ambition within the land, water and biodiversity module. This Table is illustrated by the "*bioenergy yield lever"*, extracted from the Global Calculator. Yield gains are mainly the result of an increased share of higher energy efficiency feedstock.

Table 4– Levels of ambition in the EUCalc framework

Level 1	**Business as usual** This level contains projections that are aligned and coherent with the observed trends. *Bioenergy yield lever illustration [unit: tonnes/ha]:* *Low yield increase. Total increase by 20% by 2050.*
Level 2	**Ambitious but achievable** This level is an intermediate scenario, more ambitious than business as usual but not reaching the full potential of available solutions. *Bioenergy yield lever illustration [unit: tonnes/ha]:* *Moderate yield increase. Total increase by 50% by 2050*
Level	**Very ambitious but achievable** This level is considered very ambitious but still realistic, given the current

3	technology evolutions and the best practices observed in some geographical areas. *Bioenergy yield lever illustration [unit: tonnes/ha]:* *High yield increase. Total increase by 120% by 2050*
Level 4	**Transformational breakthrough** This level is considered as transformational and requires additional breakthrough and efforts such as a very fast market uptake of deep measures, an extended deployment of infrastructures, major technological advances, or strong societal changes, etc. *Bioenergy yield lever illustration [unit: tonnes/ha]:* *Extreme yield increase. Total increase by 200% by 2050*

A preliminary list (first draft) of the proposed ambition levels for each lever had been defined beforehand based on literature review and provided to the experts for critical review and discussion (Section 3.3).

3.3 Discussion & recommendations

The third and largest segment of the workshop was dedicated to eliciting input from experts. Participants were invited to work in small groupsand to collect their thoughts individually and collectively in order to discuss the scope of levers, practices involved, ambition levels, the relevance and reasoning in terms of complexity of the real world versus simplicity for the users who will use the EUCalc tool. In addition to the EUCalc presentations (Section 2.2) during the workshop, handouts and guiding questions were provided to help start the discussions. Small groups worked using a World Café process[4], so that each group rotated through a set of discussion topics that aligned with practices represented in the tool.

3.3.1 Discussion topics and depth

Participants were self-organized into six small groups and rotated through six café stations (roundtables). Discussions at each station aimed to cross-examine reasoning and to provide evidence and quantitative input to the subsequent plenary sessions creating a space for aggregation of provided estimates and technical judgments. To support small-group discussions, the workshop engaged the assistance of designated rapporteurs made up of members of the consortium, as well as researchers and students from ICL.

The discussion topics:

- Topic1: Forestry management (Section 3.3.2.) and Biodiversity (the latter is covered in the document "Deliverable 4.3")
- Topic2: Biomass hierarchy (Section 3.3.3.) & Wastes and residues (Section 3.3.4.)
- Topic3: Animal feeding practices (Section 3.3.5.) & Fishery practices (Section 3.3.6.)
- Topic4: Mineral /mining practices (Section 3.3.7.) & Land management (Section 3.3.8.)
- Topic5: Agricultural practices (Section 3.3.9.)
- Topic 6: Water management (covered in "Deliverable 4.3")

The workshop followed a “top down” process, covering three levels of depth and complexity in the land use, water and biodiversity modules. Day 1 focused on the definition and identification of levers (depth 1) and practices (depth 2). Day 2 focused on the definition of the ambition levels (depth 3).

Day 1 - What levers and practices will help us to move towards a more sustainable society?

Small-group discussions during Day 1 focused on levers and associated practices for each topic area. The results of discussions during Day 1 were used to inform subsequent Day 2 discussions around ambition levels for the different practices. Examples of framing questions used to catalyse discussions around levers and practices are listed below.

[4][4]A World Café or Knowledge Café is a structured conversational process for knowledge sharing in which groups of people discuss a topic at several tables, with individuals switching tables periodically and getting introduced to the previous discussion at their new table by a "table host".

Levers (Depth 1)

- Do you agree with the selection of proposed levers? Do you think our choice of levers is coherent and comprehensive enough?
- Are there any other important levers missing on the list? Are there irrelevant levers you think we should remove from the list? Please note that EU-Calc will have several levers for the other sectors (e.g. energy, transport, buildings etc.), too, and we expect that the maximum number of levers should not be more than approximately 40 levers in total (all sectors); otherwise, the calculator may sound too difficult or confusing for an ordinary user.

Practices & their associated impacts (Depth 2)

- Do you agree with the selection of practices?
- Are there any other important practices missing on the list? Are there irrelevant practices you think we should remove from the list?
- Are the scope and range of the practice impacts well covered?
- Is there an innovative practice/solution that you think would make a positive change or a major disruption?

Day 2 – How fast can we move towards a more sustainable society?

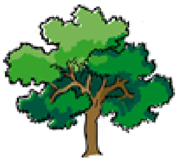
Levers and practices descriptions (discussed on Day 1) represent 'How' we can move towards a low carbon future, but not the pace of the transition. This was discussed on Day 2, which was focused on the ambition levels (Depth 3) that set the speed of transition. To support small group discussions, we proposed a set of ambition levels for each lever, and offered initial discussion questions such as:

- Do you agree with the proposed pace of the transition?
- What are the main trends for the different practices by 2050? Does the model allow enough flexibility to take them into account?
- What is the pace of technological, behavioural and practices change?

Discussions during both days made use of a World Café approach in which small groups rotated among tables that focused on specific discussion topic areas. At the end of each workshop day, comments were summarized and presented to the plenary. In the subsequent sections 3.3.2 to 3.3.9, we report the results from each topic of discussion. These results include the following aspects:

- A summary of the rationale for different levers included in the discussion;
- A summary of specific practices proposed to expert stakeholders;
- A summary of small group discussions during Day 1, including any proposed changes from group members;
- A discussion of ambition levels associated with different practices;
- Any additional comments, suggestions or insights from the participants.

3.3.2 Forestry management



Topic discussion animated and reported by:
Jeff Price (UEA) and Alexandre Bouchet (EPFL)

Lever rationale:

According to Searle and Malins (2015), the forestry potential is still underexploited in Europe. For instance, only 10% of the forestry residues in Finland are currently used, mainly for energy purposes. Nevertheless, this does not mean that 90% of the resource is available. Searle and Malins (2015), for example, suggested that 55% of the residues should remain to ensure soil quality in Finland. The rate of retention for soil quality depends on the forest characteristics, but national averages can be used as an approximation to estimate the sustainable resource in each country. In other words, the forest management lever will enable the user to set practices that will set the level of multiple parameters (e.g. harvesting rates, use of fertiliser, etc.), which in turn will affect biodiversity, biomass availability, and so on. Wood demand is driven by the Industry, which the subject of another work package (WP3) within the EUCalc project. When the demand exceeds the sustainable availability of resource, wood would be automatically imported through the EUCalc model in order to meet the proposed wood demand by the user, which in contrast may cause carbon leakages that will be tracked in the model as well.

Levers & practices (Day 1)

Box 1 – Short description of the forestry management lever proposed to experts

This lever will set the forest management practices. It will mainly affect the yields of biomass and harvesting/collection rates and will be strongly linked to biodiversity issues. It will also affect the jobs and costs in the forestry sector.

In order to facilitate the discussion, possible management practices and their definition were proposed:

> *Sustainable forest management (SFM):* as defined by the Helsinki resolution H1 (1993), SFM consists of "stewardship and use of forest lands in a way, and at a rate that maintains its biodiversity, productivity, regeneration capacity, vitality alongside its potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national and global levels and that does not cause damage to other ecosystems".
>
> *Ecosystem-based management (EBM):* as defined by the Secretariat of the Convention on Biological Diversity (CBD guidelines, 2004), EBM is "a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way".

Several exploitation practices have also been presented[5]:

> *Forest establishment or regeneration:* Establishing or regenerating a forest can

[5]The following definitions are based on the 'Growing forest trees' technical document proposed by the Georgia Forestry Commission (GFC) and the forest management 101: A handbook to forest management in the North Central Region, developed by the North Central Research Station (USDA Forest Service).

be achieved by either artificial means - primarily planting trees - or by natural methods - which rely on seed, sprouts and/or naturally occurring seedlings.

Intermediate stand management practices: Managing established intermediate stands includes manipulating: the stocking (number of trees per acre); species composition; and competition levels.

Harvest systems: For tree harvesting, several options can be used that relate to forest regeneration planning strategy. Among other producing management regimes, the following types have been considered: these are, clear cutting; conventional selective logging; selection & retention systems; andor shelter-wood systems.

At the overall level, the forestry management practices were considered unclear, and no consensus was found. Two alternatives were proposed and discussed with the experts.

One proposal has been to focus on 3 parameters, including the protected forest share, the harvesting intensity, and the collection rate of forestry residues, which would enable the framework to cover forest type (commercial or protected), biomass availability for bioenergy and biomaterial, and the biodiversity impacts. The drawback is that assumptions will have to be made on other inputs, such as growing mono or multi-species trees for commercial forest, or else, on how the trees are planted. The latter may include: tree type (fast/short growing), continuous forest cover, harvest cycle length (e.g. short rotation coppice), tree diversity (species), and use of fertilisers (especially N fertiliser, which may affect N_2O emissions from soils).

The second proposal would be to set a REDD+ lever, referring to the United Nation (UN) programme. REDD+ stands for countries' efforts to Reduce Emissions from Deforestation and forest Degradation, and aims to foster conservation, sustainable management of forests, and enhancement of forest carbon stocks. The lever strength is its linkage to existing programmes and may facilitate policy design as REDD+ packages are included in the Paris Agreement. REDD+ is mostly focused on developing countries which will address carbon leakage issues. The drawback is that this narrows the scope of the forestry lever and the set of options available for expert audience in the tool. As a compromise, REDD+ may be an additional sub-lever (i.e. a “practice”).

An additional comment was that protected forest issues should be included in the biodiversity module/lever, which would possibly limit the forest lever to focus on biomass harvesting and residues collection rates.

Proposal for the forestry management lever

The first proposal may require a large set of levers for which the impact at the overall level might be limited. At the opposite, using a unique lever through well identified standards such as SFM and EBM enables covering a wider range of parameters. The users will not be able to set the harvesting rate directly, but the later will be considered through the choice of management practices, which enable users balancing ecosystems or commercial priorities regarding forest management. The following approach echoes with the experts’ comments collected in the land management and agricultural practices groups’ discussions.

The second proposal (REDD+) might be appropriate to consider leakages beyond the European Union, associated with forest management (mainly deforestation, biodiversity). Nevertheless, such an approach may be consistent with the scenarios drawn for the rest of the World, which still require further research. The Global Calculator may be considered to this end, among other possibilities.

Ambition levels (Day 2)

Based on the comments collected Day 1, the levels of ambition were discussed for residues collection rates, round-wood harvest intensity and protected areas (Table 5).

Table 5 – Ambition levels for forestry management(based on Levers et al. (2014), and expert inputs)

Management practices	Current	Level A	Level B	Level C	Level D
Forest residues	10%	20%	30%	40%	60%
Roundwood harvest intensity	62%	62%	50%	40%	30%
Protected area	13%	13%	20%	30%	50%

These ambition levels have not been discussed at the level of each member state as harvesting intensity and timber volumes differ substantially in Europe. The objective was to discuss these variables for Europe as a whole, while putting emphasis on the fact that the modelling framework will consider this heterogeneity across the EU Member States. For instance, forestry residues average collection rate is currently low in Europe, and four ambition levels were proposed ranging from 20% to 60% from the least to the most ambition levels (i.e. 40% to 80% remain on soil).

These levels were considered in the good range by most of the participants. It was suggested to carefully consider the trade-offs between forest ecosystems and residues collection rates. In other words, forestry residues should be considered in the forestry lever(s), not in a specific 'wastes and residues' lever. The later comment also echoes with the agriculture discussion concerning the agricultural residues, that should be considered through the agriculture practices, not through the waste and residues lever.

Additional comments

It was suggested that the cost of management options in forestry should be mentioned to the user. As explained during the workshop by the EUCalc team, costs will be covered in collaboration with the EPFL (Ecole Polytechnique Fédérale de Lausanne), in line with WP6[6] set of activities. Nevertheless, economics should not be a criterion to set ambition levels, given that the Calculator philosophy is to explore what is technically possible to achieve and not what is probable. Costs are an important output in the model, but it should not be an input.

It was also mentioned that afforestation can be bad for biodiversity in some cases (e.g. not using native species and appropriate biodiversity balance), depending on the land use dynamics as well.

Finally, some participants pointed out that forest management ought to consider the split between private/public forests.

[6]EUCalc's Work Package 6: Social and Socio-economic impacts.

3.3.3 Biomass hierarchy

Topic discussion reported by:
Lorenzo Di Lucia and Timo Rossberg (ICL)

Lever rationale:

The biomass hierarchy is a novelty in the Calculator (compared to other existing versions for other countries and regions). It has been designed to allow the user to choose the allocation priority of different biomass uses (e.g., biofuels, biochemicals, etc.). The EUCalc claims to be neutral, leaving to the user to decide the best strategy. In a world constrained by biomass resources, one may explore the impact of prioritising the use of biomass in different sectors, whilst also considering technical constraints and rationales (e.g., manure is relevant for digestors to produce biogas, but not for jet fuel). Given the nature of this lever, the discussion approach was slightly different compared to the other levers. The relevance of having this type of lever was discussed, the alternative being to let the model driving the biomass towards the different markets, such as the previous Calculators. Second, the type of hierarchy that would be interesting at the level of the user was discussed. For example, one may consider efficiency as a criterion to drive the biomass towards different markets. Case GHG mitigation efficiency may then drive the biomass towards transport sector which is highly relying on fossil fuels, whereas energy efficiency, at the opposite, will prioritise co-generation that can yield heat and electricity.

Levers & practices (Day 1)

Box 2 – Short description of the biomass hierarchy lever proposed to the experts

This is a novel type of lever that will enable setting priority between the different use of biomass. For example, one may consider efficiency as a criterion to drive the biomass towards different markets. For instance, GHG mitigation efficiency will drive the biomass towards transport sector which is highly relying on fossil fuels, whereas, energy efficiency, at the opposite, will prioritise co-generation that can yield heat and electricity.

As a basis for discussion, multiple ways of setting hierarchy between biomass were proposed. The following suggestions were based on a previous work in which a wide range of stakeholders was involved (Baudry et al., 2017, 2018):

> *GHG efficiency hierarchy:* will prioritise biomass use that enables to mitigate the largest amount of GHG emissions, which may lead to prioritising substitute for fuels in the most fossil depended sectors (typically, air transport for which alternative to fossil fuels are very limited).
>
> *Energy efficiency hierarchy:* will prioritise biomass use that offer the best Energy Returned On Energy Invested (EROEI), (typically, cogeneration and district heating have high energy efficiency).
>
> *Economics efficiency hierarchy:* will prioritise the use of biomass in technologies that enable mitigating GHG emissions, but with the lower price in terms of Euros € invested for each GHG tonne avoided.

Sector hierarchy: will prioritise the use of biomass within pre-determined sectors of economy through different scenarios. For instance, one may prioritise transport sector, buildings or industry.

Technology hierarchy: will directly set priorities between technologies that utilises biomass as feedstock. For instance, one may focus on liquid biofuels when another may prefer to focus on biogas and cogeneration.

At the beginning of the workshop, there was no agreement on the relevance of this lever for the model. Arguments against the lever were that allowing the users to change the destination of the biomass will allow the clouding of important dynamics in the model. Nevertheless, the fact that each expert stakeholder had its own insights about how biomass should be allocated, confirmed the relevance of this issue. For instance, some experts claimed that using biomass for jet fuels was highly irrelevant because of economics, as jet-fuels are the cheapest fuel and tax-free, while biofuels are the most expensive and highly subsidised. At the opposite, other experts stated that liquid biofuel is the only technology available to decarbonise substantially the air transport and, as such, biomass should be driven to air transport first. As a matter of fact, the most important biorefinery in Europe (La Mède, France, 500 ktoe y^{-1}) was initially developed to produced jet-fuels produced from vegetable oils. However, there is still no-binding commitment from air transport industry; although, the International Air Transport Agency committed to decrease GHG emission by 50% by 2050.

Ultimately, it was acknowledged that the model output that displays the results of multiple hierarchy scenario is an important element of the learning functionality since it would allow users to explore alternative biomass allocation approaches and their impacts on GHG emissions. Some experts also reinforced the proposed hypothesis, which is that biomaterial ought to be considered using a hierarchical approach within the EUCalc project.

Ambition levels (Day 2)

Building on the Day 1 discussion, possible hierarchies were submitted to participants to trigger the discussion (Table 6):

Table 6 - Setting the priorities for the biomass allocation

Level	Efficiency	Sectors	Technology	Type
Level A	Economics	Transport	Biofuels	Biofuel
Level B	Energy	Residential	Co-generation	Biomaterial
Level C	GHG emissions	Industry	Heating	Bioheat
Level D	-	Power	Biogas	Bioelectricity

The Efficiency hierarchy was debated but discarded because it can be challenging to compare the GHG saving efficiency of alternative products/processes due to efficiency factors changing over time and space, not to mention leakages issues. Sector hierarchy appeared to be the most supported option because its application would be most the straightforward way to implement and be easily grasped by the users.

Proposal for the biomass hierarchy lever & levels

The group eventually came to an agreement with the type of hierarchy and the scenarios to be considered. The type of hierarchy suggested was an alternative to the options provided initially. The suggestion considered scenarios based on a mixture of products and uses. Some experts proposed to include scenarios that they considered interesting for the users in terms of learning purposes:

- Level A: Business as usual (keeping the current mix);
- Level B: Bioenergy (for transport, heat and electricity);
- Level C: Readily consumed biomaterial and chemicals;
- Level D: Long lasting biomaterials and chemicals.

As an example, Level D would mean prioritizing long lasting biomaterials over readily consumed biomaterials; and then bioenergy. Non-available biomass would result in imports or fossil fuels substitution. It is worth mentioning that land demand leakages would be tracked (e.g. import of bioenergy).

Additional comments

The biomass hierarchy setting proposal assumes that no more than 4 scenarios can be included. Nevertheless, if an additional scenario was to be considered, it would be along the lines of either removing transport from bioenergy (Level B), or choosing whether transport is prioritised in the context of heat and electricity production.

3.3.4 Wastes and residues

Topic discussion reported by:
Lorenzo Di Lucia and Timo Rossberg (ICL)

Lever rationales:

The lever has two main purposes, the first being to set the range of biomass which is available, the second being to set the collection rate of wastes and residues. The EUCalc philosophy is to be 'agnostic' (non-biased, leaving the decision to the user), thus we want to let the users to choose whether they allow the use of biomass from wastes and residues for biomaterial, animal feed or bioenergy use. Thus, the lever aims at defining the range and amount of biomass that would be available for bioenergy purposes against other possible uses.

Levers &practices(Day 1)

Box 3 – Short description of the waste and residues lever proposed to experts

This lever describes the use /collection of on-farm waste and residues. It does not include post-farm residues up to the consumer's level, given that this has been modelled in another sector of the EU-Calculator. For the on-farm residues, there may be a trade-off between the quantity of residues collected and used (e.g. as animal feed or bioenergy) and the quantity left on soil, increasing soil carbon and nutrient recycling. The lever will mainly affect the availability of waste and residues that can be used for livestock, aquaculture, bioenergy, biomaterial, fertilizer and pet food.

The following feedstocks were foreseen to be controlled by the lever and have been submitted to participants:

Crop residues: are the non-edible part of the crop that can be used, for instance, for livestock bedding or bio-energy production. Typically, the amount of residue/waste on farm per food produced is 1:1 (ton per ton)[7] as a broad average for different crops;

Animal wastes: are generated by the meat & fish industry and are classified in different categories that allow or forbid their use in different market (e.g. edible or non-edible, drives the biomass towards food/feed/pet-food and bioenergy/compost/fertilizer respectively).

Used Cooking Oil (UCO): Although UCO is not an on-farm waste, it will be considered as a possible feedstock for biodiesel. It consists of recycling used cooking oil from restaurants for instance.

Manure: is an output of meat, fish and insect production. Manure can be disposed in the soil (pasture) or collected to be used as fertilizer or as a feedstock for digestors, which will generate biogas for electricity or heating as well as digestate (organic fertilizer).

[7] Based on the Global Calculator numbers: www.globalcalculator.org

This level of granularity in the Calculator is a novelty that was considered important and valuable by the experts. Nevertheless, the scope of the lever has been highly challenged in various aspects. First, it was suggested that Used Cooking Oil ought to be removed, as this cannot be grouped as on-farm waste/residues. It should therefore be considered in the post-farm section within the lifestyle sector.

Emphasis was also put on the terminology for the lever, as it was not aligned with definitions of the Renewable Energy Directive (RED): "residues" should be clarified as "crop residues" given the broader scope of the term in the RED. In addition, it was suggested that UCO has been primarily used for animal feed rather than biofuel and that it represent a by-product rather than a waste product. Such a statement also strengthened the need for the biomass-use hierarchy lever. Imports would be tracked through the interaction between the food net-import lever and the waste lever, in collaboration with the lifestyle WP1.

Many experts suggested that agricultural residues should not to be included as proposed for this lever, but instead, they should be embedded in the agricultural practices levers. Thus, it was suggested that this lever was somewhat unbalanced relative to others in terms of its scope and impact. Instead, the waste and residue dynamics could be integrated into other levers (e.g. agricultural residues with agricultural practices, such as the forestry residue setting).

The experts agreed with the original proposal, in which the users should be enabled to choose a pathway for bioenergy being exclusively produced from waste and residues, i.e. not from dedicated energy crops. In other words, giving the opportunity to rule out food-crop based bioenergy

Proposal for the biomass availability lever

Building on the experts' comments, the scope of the lever will be adapted. First, the collection rate of residues will be excluded and associated with agricultural practices. Moreover, the UCO will no longer be considered in the land-use modules but in the Lifestyle one, most probably as a feature associated with wastes (see Deliverable 1.3). Second, the lever will enable users setting whether biomass can be used for non-food purposes, i.e. for bioenergy and/or biomaterials verses organic residue left on (or incorporated in) the soil, hence increasing soil carbon. Thus, the lever will be renamed 'biomass availability', as it will allow or forbid the use of biomass for bioenergy or biomaterials purposes. As another alternative, one of the biomass-use hierarchy lever setting may implicitly rule out food-crop based bioenergy/biomaterial, which may reduce the number of levers without reducing the users' choices.

Nevertheless, critical issues remain. For some scenarios, large amount of rapeseed meals may be produced for livestock, for instance for self-sufficiency issues (which has also been claimed by experts). In such setting, large amount of vegetable oil will be generated as a by-product. When this oil is not turned into biofuels or biomaterial (including biochemicals) and not consumed domestically (national level) for either food or feed, then its exportation ought to be considered. However, it implies assuming a demand abroad, and also that exported oil will not be used for non-food uses. Consequently, in such scenarios, two main options can be considered: (1) A warning can be used to inform the user about possible inconsistency; (2) an indicator can inform about the oil exportation volumes.

Ambition levels (Day 2)

The levels of ambition for residues were discussed on day 2 (Table 7), whilst keeping in mind that they may be triggered through the agricultural practices lever, as previously mentioned.

Table 7 - Level of ambition for waste collection (based on France Agri-Mer, 2013; Searle and Chris Malins, 2013)

On-farm collection rate	Current	Level 1	Level 2	Level 3	Level 4
Crop residues (average)	10%	10%	20%	30%	50%
Animal wastes (average)	30%	30%	50%	70%	90%

There was a discussion around the levels for crop residue use. Some experts mentioned that 50% as the maximum was very low (80-90% may be more accurate in many cases), while others mentioned that this may be high for many crops. There is significant variation between countries and crops, which must be reflected in the average removal values used as levels. According to one of the experts, UCO needs to be considered a limited option (2-3 Mtons for Europe) because it is mainly used as animal feed, which echoed again the need for the biomass-use hierarchy.

Proposal for the biomass availability levels

Complementary to the hierarchy lever, which will drive biomass, both dedicated and waste/residue biomass, towards different markets, the biomass availability lever will enable the user to choose whether they allow dedicated crops to produce bioenergy and/ or biomaterials (including biochemicals). Table 8a shows an option for this lever's levels.

Table 8a - Level of ambition for biomass availability (option 1)

Availability	Current	Level A	Level B	Level C	Level D
Biomass for bioenergy	1 (yes)	1 (yes)	1 (yes)	0 (no)	0 (no)
Biomass for biomaterial	1 (yes)	1 (yes)	0 (no)	1 (yes)	0 (no)

The lever will consist in enabling or disabling biomass-use for non-food uses. For instance, level A will allow the use of biomass for both bioenergy and biomaterials, while level D will disable it. The demand for bioenergy and biomaterial will come from other WPs. The lever setting will thus affect the net-import balance of biomass.

An alternative is also suggested in Table 8b:

Table 8b - Level of ambition for biomass availability (option 2)

Level	Description
Level A	No dedicated crops
Level B	By-products can be used (typically vegetable oil as rapeseed meals by-products)
Level C	Dedicated crops are allowed when there are freed lands (but priority is given to ecosystems)
Level D	Dedicated crops are allowed (priority is given to commercial uses, against ecosystems)

Given the biomass-use hierarchy lever, Table 8b offers a suitable compromise and enable the user to explore pathways for which dedicated crops can be set at different level of priority, but which also are dependent on other lever setting. Such an approach may offer better insights for the users, but may imply challenges in modelling the biodiversity and ecosystems related levers.

Additional comments

Several experts mentioned the potential importance of the diversity in residue sources (e.g. non-agricultural non-woody biomass) and use (e.g. textile industry) pathways besides biomass for biofuel, and that this ought to be considered in the model design, which is actually the objective of the hierarchy lever.

3.3.5 Animal feeding practices

Topic discussion reported by:
John Pasada (TU Delft) and Mathilde Fajardy (ICL)

Lever rationales:

In 2015, feed demand for livestock in Europe represented 480 Mtons, including forages, industrial compounds, and various meals (FEFAC, 2016). As another novelty, the type of animal diet will be considered in EUCalc. The users will be able to choose alternative diets for livestock, which have high impacts on land-use, energy and water demand, biomass supply for bioenergy and biomaterials, and so on. For instance, microalgae biorefinery may yield 30 tons of algae meals per hectare against 2 tons for rapeseed meals (Baudry et al., 2017).

Levers & practices (Day 1)

Box 4 – Short description of the animal feeding practices lever proposed to the experts

Animal feeding practices set the typical diets for animals by type for both aquaculture and livestock. The diets will affect the extent of the associated impacts in terms of land-use, water-use, energy-demand and the by-products types that will feed other industries. The feed types will also be calibrated depending on the animal healthy diets and the agricultural practices (e.g. organic farming requires at least 60% local roughage). The demand for feed will also be a driver of oil availability for biofuels, as a by-product of crop-based meals (e.g. rapeseed) or microalgae meals. The lever will mainly affect the crop demand, land-use, the biomass available for biomaterial & bioenergy, the Feed Conversion Ratio (FCR), the microalgae meals demand, the insect meals demand, as well as jobs & costs.

The typical feed meals that we aim to consider in the model were presented to the experts to inform them about the scope and granularity that are foreseen:

Crop-based meals & roughage: are dedicated crops that are used to feed livestock and fish in aquaculture. Crops can be used as meals (e.g. processed soybean meals), or as forage (i.e. the whole plant is given to the livestock).

Animal based meals: are by-products of the meat industry that can be used to feed livestock or fish. Typically, animal meals consist of fats, bone, blood and visceral parts (non-exhaustive). The amount of waste available will be set by the waste and residues lever.

By-products of industry: can be used to feed livestock and fish, such as cereal meals produced out of beer. Biomaterial/biochemical may also generate feed by-products, such as those from ethanol produced for pharmaceutics or cosmetic industry, and biofuel (e.g. yeast from fermentation process, and biomass bagasse).

Microalgae based meals: consists of processed meals, derived from microalgae production, which can be consumed by ruminants, poultry, pigs and aquaculture.

Insect based meals: consists of processed meals produced through insect farming. Insect can be grown using wastes and residues or using dedicated crops.

Experts acknowledged the consideration for biofuel/feed interlinkages, i.e. feed demand triggers supply for bioenergy feedstock, such as discussed in the concurrent session for the biomass availability lever. Nevertheless, various aspects of the Animal Feeding practices lever were challenged. On the one hand, some experts recommended to combine it with the Agricultural practices lever. However, other experts during the deliberations showed concerns about the possibility of double accounting of GHG emissions. They also pointed out that the contributions from imports versus domestic production of animal feed should be clearly accounted for in the calculator.

One suggestion was that the 'Animal Feeding practices' lever should be renamed 'Alternative Protein Sources', and that its focus should be on replacing foreign grown soybean meals with European alternatives, e.g. fungus (mainly yeasts used for fermentation processes), oil seed rape, algae, etc. According to some experts, this has the advantage that it fits with existing EU policy.

Another suggestion was to consider a lever for protein transformation efficiency, but such a scope might be too limited in terms of total GHG impacts at European level. It may be considered through efficiency parameters, but not through a dedicated lever.

Proposal for the alternative protein source (livestock) lever

Building on these suggestions, we propose to rename the lever 'Alternative Protein Sources'. The lever will set the share of the animal diet that will be replaced by novel protein sources (e.g., yeasts, algae and insects). Nevertheless, the share of imported animal feed products will be considered in another lever, namely the food net-import lever, that enables users to choose the level of self-sufficiency regarding food products (including for feed purposes). Possibly, the later mentioned lever may put more emphasis on bioeconomy issues.

Currently, the granularity of the animal diets is set as follows: fodder, cereal-meals, oil-cake meals, other meals (including for example, blood and meat meals) and grazing (on pasture land, or forage supply).

Ambition levels (Day 2)

A first set of ambition levels were proposed to experts to critic the share of alternative feedstock that can be expected by 2050, considering possible healthy diets for animals. In other words, level 4 corresponds to the ideal share of alternative meals to sustain a healthy diet for animals and meat quality (Table 9).

Table 9-Level of ambition for algae and insect diets by animal types (Makkaret al., 2014; Madeira and al., 2017)

Animal type /Algae meals	Level 1	Level 2	Level 3	Level 4
Ruminants	0%	3%	5%	10%
Pigs	0%	5%	15%	25%
Poultry	0%	1%	3%	5%
Aquaculture	0%	10%	20%	30%
Animal type / Insect meals	**Level 1**	**Level 2**	**Level 3**	**Level 4**

Pigs	0%	10%	20%	33%
Poultry	0%	10%	20%	30%
Aquaculture (carnivore)	0%	10%	20%	30%

The experts regarded the levels to be relevant (although without discussing the calibration in greater detail), but they put more emphasis on the fact that high ambition levels may also consider opportunities for smart integration between aquaculture and agricultural practices. For instance, waste of aquaculture can be an input for agriculture and vice et versa. Some participants considered that yeasts may be more important than algae and insects as alternative sources of protein for animal feed.

Given the lack of fishery and aquaculture expertise in the workshop's audience, further research and expert face to face meetings will be conducted to calibrate the model for aquaculture more accurately.

Proposal for the 'Alternative Protein Sources' levels

The present numbers were based on literature and may be kept in the model for the most part. Nevertheless, literature is still weak when it comes to the testing of mixed meals (e.g. partly algae, partly insects, and so on), which may occur for instance for pigs. Two alternatives will be further investigated with experts: (1) we may consider that insects, that are natural feed for poultry or fishes for instance, will not have negative impacts on meat quality or animal health when algae meals are substitute of oil-cakes (e.g. soybean or rapeseed); (2) we may consider using only one protein alternative source by animal, as a preliminary modelling approach.

Additional comments

Discussion also led to explore the opportunity to use alternative proteins sources for humans, due to the increasing consumption of non-animal proteins (e.g. mycoprotein burgers already available in many supermarkets). Experts suggested to develop similar pattern for alternative protein sources for humans in the Lifestyle sector, which includes the percentage of non-animal proteins consumed, such as insects or synthetic meat (via stem cells). Vegetal protein may also be included to consider "flexitarian" diet. Consequently, further research and discussion will be conducted with the Lifestyle WP to identify whether we should include an additional protein source lever for human consumption or not.

3.3.6 Fishery and Aquaculture practices

Topic discussion reported by:
John Pasada (TU Delft) and Mathilde Fajardy (ICL)

Lever rationales:

As a new feature, the fishery & aquaculture module will be developed specifically, but not exhaustively, to address biodiversity, ecosystems and air pollutant emissions impacts. Indeed, marine resources are being depleted and some fishery practices are destroying the marine ecosystems. Covering biodiversity properly thus requires developing a dedicated module for fishery and aquaculture.

Levers & practices (Day 1)

Box 5 – Short description of the animal feeding practices lever proposed to the experts

This lever sets the practices for the fishing sector, including aquaculture systems and wild catching methods/techniques. The practices will drive the fleet and fishery methods characteristics as well as their associated impacts. It will mainly affect the yields & efficiency (fishery effort), the feed demand & supply (incl. plant-based products, demanding additional land use for their production, apart from residues), fish stock impacts, inland water demand and coastal water demand, energy demand by type, jobs & costs, fertilizer demand & supply.

Specific practices, based on consultations with experts, are related to major drivers for GHG emissions, biodiversity, and air pollutant emissions in the sector:

- *Aquaculture*[8]*:* is the farming of aquatic organisms, including fish, mollusks, crustaceans and aquatic plants. Main practices include:
    - *Extensive aquaculture:* is a long-established farming method that consists of maintaining ponds (natural or artificial) in such a way that they foster the development of aquatic fauna.
    - *Semi-extensive aquaculture:* consists of adding supplementary feed, to integrate the feed naturally available in the pond, allowing for higher stocking density and production per water surface area.
    - *Intensive aquaculture:* is generally composed of several open-air concrete tanks, metal tanks, net tanks (fish enclosures in river or seawater), raceways or earth ponds (often using impermeable plastic films too) of different sizes and depths suited to the different stages of growth of the fish.
- *Artisanal fisheries*[9]*:* use relatively small amounts of capital and energy, relatively small fishing vessels, and make short fishing trips that are close to shore. Artisanal fisheries can be subsistence or commercial fisheries, providing for local consumption or export. They are sometimes referred to as small-scale fisheries.

[8] Aquaculture definitions from: https://ec.europa.eu/fisheries/cfp/aquaculture/aquaculture_methods_en
[9] Definition extracted from: http://www.fao.org/family-farming/detail/fr/c/335263/

Commercial fisheries: consist of catching fish and other seafood for commercial profit, usually using industrial sized fleet.

Fuel-mix: currently the fishery sector is mainly consuming heavy fossil fuels, but a move towards hydrogen and biofuels can help reducing GHG and air pollutants emissions.

In discussions, the relevance of having a Fishery lever, given their small contribution in terms of the GHG emissionsat the European level (including all other sectors)was questioned. Nevertheless, given the feed demand for livestock(fish meals, and fish oil meals) and biodiversity discussions, the relevance of having this lever was acknowledged as necessary. It was suggested that the lever should be broken up into two components to separate the wild-catches and the fish farming practices. When comparing intensive and extensive aquaculture, other sustainability aspects/criteria than GHG emissions should also be considered: e.g. ecosystem services, and risks on nutrients limitation, pollution, uncontrolled antibiotics, human health, invasive aqua-species, etc. In other words, the experts confirmed the relevance and importance of this new module and lever. As mentioned previously, it has been suggested that high ambition levels should account for smart integration between aquaculture and agricultural practices.

Ambition levels (Day 2)

Given the lack of fishery expertise among workshop participants, the calibration of ambition levels for the Fishery module was not challenged, except for the share of renewable energy consumption in this sector.

Table 10 - Level of ambition for fishery sector (EU, 2018; Connolly, D., Mathiesen, B. V., & Lund, H. 2015) – preliminary values

Fuel mix	Current	Level 1	Level 2	Level 3	Level 4
Renewable energy (aquaculture)	n.s.	5%	20%	50%	100%
Renewable energy (wild-catches)	n.s.	5%	20%	50%	100%

Although the numbers provided were not criticized, we will continue the discussion with Fishery/Aquaculture experts to ensure the relevance of the presented scenarios, as well as to address the levels' calibrations related to fish production practices. It is worth mentioning that the main driver for level 4 was associated with the workshop organised by WP3 (Industry), in which experts suggested considering a 100% renewable scenario by 2050 as a level 4.

Additional comments

Although we could not gather as much information as required regarding the setting and calibration of the fishery module, our confidence was strengthened by the experts regarding the need of developing such a module. Additional interviews are currently being performed to develop the fishery module, especially with the University of Nantes and the IFREMER[10].Building on the agriculture practices discussion (see Section 3.3.9), we may develop a “climate smart fisheries and aquaculture” lever (FAO, 2013).

[10]IFREMER is a French institute that undertakes research and expert assessments to advance knowledge on the oceans and their resources, monitor the marine environment and foster the sustainable development of maritime activities (see: https://wwz.ifremer.fr/en/The-Institute).

3.3.7 Mineral mining practices

Topic discussion reported by:
Judit Kockat (BPIE)

Lever rationales:

Although some European countries are major producers of specific minerals, such as Poland, which represented 5% of the worldwide production of silver in 2014, most of the European countries rely on mineral imports from other countries (British Geological Survey, 2016). Nevertheless, the footprint in terms of energy, water, land and GHG emissions is critical, and ranges depending on the practices and location. For example, the range of GHG emissions for copper production is estimated between 1 and 9 t CO_2 per tonne (Northey*et al*., 2012), with an average of 2.6. In China, each tonne of gold may generate 55 000 tCO_2 (Chen *et al*., 2018). In other words, the mining industry generates significant amounts of GHG emissions, and a wide range of environmental impacts outside the European borders for the most part, which is why the lever has been highly challenged.

Levers & practices (Day 1)

Box 6 – Short description of the mineral mining practices lever proposed to the experts

The lever will enable the users to set mineral mining practices such as the use of renewable energy to substitute fossil fuels or the rehabilitation of mining sites. It will affect the yields & efficiency, the waste generation/treatment, the energy demand by type, the land-use and the jobs & costs. The key practices associated with the mining practices lever were presented to the experts:

*Renewable energy:*GHG emissions in the mineral sector is mostly caused by the use of fossil fuels to crush rocks. One of the good practices is to deploy renewable energy and hybrid systems to limit GHG emissions.

Energy efficient technology: can help in reducing energy consumption. A typical example is the mine ventilation systems which consume large amount of power.

Reforestation/Rehabilitation of habitats of mine sites: can help reduce the GHG emissions and biodiversity burden of mines. It maybe even considered compensation in other areas when the on-site rehabilitation is not possible.

Renewable energy units: dedicated renewable energy can be developed to address the needs of the mining process, which can be left to local communities following the end-life of the mine.

The experts mentioned that minerals, rare earth minerals and sand/aggregate (construction materials for buildings, transport infrastructure etc.) do not emit a substantial amount of GHG emissions compared to other energy intensive processes and most of these materials are not extracted in Europe. Moreover, the high-quality sand for construction is getting rare in the EU, although this is the only mining practice that may be relevant.

On the other hand, the effects of mining can have a huge impact on landscape, water contamination and soil damage leading to degradation of land. The industries have the means to explore remote locations and built infrastructure that enables people to work in mines and in the surrounding areas. Water and resource efficiency are substantial in such processes. Water consumption during mining and extraction can be very large and, if taken away from other uses in locations with water scarcity, may lead to degradation of land. This can potentially affect agricultural production and have an impact on social aspects as well. However, a direct link or impulse from the EU through the markets cannot be made.

One suggestion was to put a carbon price on the carbon at the point of extraction of fuels and not at the point of use. From a market perspective this makes sense, because of the value of the fuel product is closely linked to its combustion use. This would encourage fuel savings and discourage their extraction and indirectly encourage alternatives. On the other hand, energy-intensive mining may keep moving towards developing countries, as have been occurring in past decades worldwide and, therefore, increasing GHG emissions and other environmental impacts outside the EU.

Proposal for the mining practices lever

Given the experts' comments, two alternatives are foreseen. The first, suggested by the experts, would be to remove the lever as it is not significant enough for Europe in terms of total GHG emissions, which is the focus of the EUCalc. The second may be to consider that EU may impose sustainability standards for mineral imports, which may increase the costs but decrease the negative environmental impacts. Nevertheless, experts mentioned that Europe is not strong enough to raise up international mineral mining sustainability standards on its own and, besides, the EU has to comply with the international trade rules established by the World Trade Organisation (WTO).

Ambition levels (Day 2)

Although the relevance of having a lever associated with mining practices was questioned, the ambition levels were presented to the experts (Table 11):

Table 11- Level of ambition for mining practices (Based on Connolly, D., Mathiesen, B. V., & Lund, H. 2015; H2020-SIMS project; FP7-I²Mine project)

Energy	**Current**	**Level 1**	**Level 2**	**Level 3**	**Level 4**
Renewable energy	5%	10%	30%	60%	100%
Energy efficiency	100	100	80	70	50

Precision mining	**Brief description**
Level 1	By 2050, mining standards remain the same as the base year.
Level 2	*By 2020, 10% of the new mines* committed to these standards, growing to 50% by 2050
Level 3	*By 2020, 20% of the new mines* committed to these standards, growing to 80% by 2050

Level 4	By 2020, all new mines are committed to these standards

According to ongoing research projects, mineral mines may become invisible, safe, and have reduced impact on the environment. This is precision mining (see Table 11). Precision mining consists of using new sensor technologies to enable autonomous and highly selective extraction. After the separation process, waste rock and backfill will be stored underground and only the ore and by-products will be transported to the surface (see for example FP7 - I²Mine project).

Proposal for the mining practices ambition levels

It has been suggested that EUCalc should consider the influence and utilisation of European standards to the rest of the World in calibrating the levels of the mineral mining practices. Nevertheless, this was not a consensual position at all among the experts. Thus, we decided to conduct further consultations with mineral mining specialists to take a final decision whether or not the lever should be kept, and in such a case, to challenge further the ambition level calibration that was preliminary proposed in Table 11. At least, the model will consider the impact of mineral mining, and we may inform users of the "exported impacts".

Additional comments

Comments have been made about Oil, Coal, Gas extraction that may not be as relevant in Europe as worldwide (e.g. OPEC countries, the USA, Australia and South Africa). Experts stated that the mining practices should be considered in the Industry Sector of the EUCalc. The interlinkages between offshore mining, including oil and gas, and biodiversity should be taken into consideration. It was also mentioned that mine can be rehabilitated to storage CO_2 via carbon capture and storage (CCS) systems or capture it via enhanced weathering. Finally, the experts reiterated the importance of considering water quality issues associated with the mining processes.

3.3.8 Land management

Topic discussion reported by:
Judit Kockat (BPIE)

Lever rationales:

The land management lever was expected to gather in a unique lever: the ambition regarding the allocation of surplus land (freed up lands) for a/reforestation and/or energy crops; and practices to prevent land degradation (e.g. soil compacting and erosion control, crop rotation, no tillage systems, use of integrated schemes such as agroforestry, etc.) and rehabilitate degraded land (e.g. production of energy crops, including grasses and short rotation coppice for second-generation fuels, which are one of the subjects of REDII). The lever is mainly inspired by the Global Calculator, and land-use future levers, namely the land degradation and land-surplus levers (Strapasson *et al*., 2016).

Levers & practices (Day 1)

Box 7 – Short description of the mineral mining practices lever proposed to the experts

The land management lever will set a key variable of the model, which is the allocation of land surplus (e.g. reforestation, afforestation, bioenergy crops, and natural grasslands). It will also set ambition for addressing the land degradation (e.g. addressing land desertification through reforestation or afforestation). The lever will thus mainly affect the land surplus dynamics as well as the land availability. Definitions of practices were provided to the experts in order to present the scope of the lever as well as to facilitate the discussion:

Land-surplus allocation: In the model, the demand for products will affect the land-use. For instance, a high meat consumption may induce a land-demand that one cannot reach without deforestation. At the opposite, a lower meat consumption may free up some lands for which the users will be allowed to set uses priority.

Re/Afforestation: consists of reforesting or afforesting the freed-up land, which will contribute to mitigate GHG emissions, whilst also increasing biodiversity. It can also be used as a way to prevent desertification and erosion.

Crops for biomaterials and bioenergy: enables using the freed land to produce biomaterials and bioenergy, which will also yield by-products for other sectors (e.g. bioenergy, animal feed);

Natural grassland: will cover the freed-up land and help mitigate GHG emissions;

Land degradation: negatively affects the land availability and yields. Good practices may help in reducing the land degradation or to valorise the degraded lands.

Energy valorisation: degraded land can be used to produce energy (e.g. PVand energy crop).

The land-surplus lever enables users to set how the land-use change will occur in the scenarios that enable land to be freed up (remaining land), for example though the decrease of meat production. Some experts criticized the lever by pointing out that the concept of 'land-surplus' is theoretical, in other words, that land-surplus only exist in theory. Thus, it was suggested by some experts to remove this lever, even though many European countries have been presented a growing area of abandoned lands from agriculture in past decades

Other experts pointed out that using surplus land for bioenergy will lead to less CO_2 savings than afforestation (although this usually not the case in the Global Calculator pathways, in terms of GHG life cycle assessment), and that biomaterial and bioenergy are the only market relevant options. It was also discussed that possibly, land may simply be abandoned, but some biomass may be naturally regenerated, which may be considered as forest or grassland over time anyway. The suggestion was illustrated through an example: farmers in the US choose to rather increase their yield on a smaller part of their property and leave land abandoned instead. Due to low agriculture prices in some countries, farmers leave their land for good. Farmers consider it more rewarding to send their children to town to study something else than farming.

Proposal for the land management lever

As a compromise, experts suggested to allocate freed-up land between ecosystems (forest, grassland) and commercial use (biomaterial, bioenergy). The latter would include a mix of biomaterial and bioenergy use that will be driven by the other levers (namely the biomass-use hierarchy and availability). The GHG emission savings will include the CO_2 sequestration and enable the substitution of fossil fuels. The use for the ecosystem would result from a rehabilitation/restoration or "laissez-faire". In addition, the mix of grassland and non-commercial forest would depend on the location. This mix will then determine the GHG emission savings from sequestration. We may also consider a share of abandoned lands as suggested, but additional research may be conducted in this regard.

Ambition levels(Day 2)

The ambition levels proposed to experts were based on the Global Calculator setting (Table 12).

Table 12-Level of ambition forland-surplus allocation

Land-surplus	Current	Level A	Level B	Level C	Level D
Re/Afforestation	-	80%	48%	32%	16%
Biomaterials & bioenergy	-	20%	40%	60%	80%
Natural grassland	-	0%	12%	8%	4%

The numbers provided were debated which resulted in the suggestion that 80% afforestation is too high for Europe. Also, it cannot be determined if – with respect to

GHG emission reduction - the afforestation or the growing of biomass will lead to increase in the level of ambition. An expert also mentioned that afforestation cannot be performed everywhere, and that in some cases, it could be bad for biodiversity depending on the setting (e.g. replacing grassland by forest, using fertilizer for afforestation or using non-native species). In order to make the EUCalc more acceptable to parties of different interests – it was encouraged to change the ambition levels to A, B, C, D instead of 1, 2, 3, 4. Some proposals were made by individual participants, including land allocation for leisure(e.g. parks) and for food exports. Land allocation for leisure may be investigated even if it seems out of the scope of EUCalc for now.

Land multi-use considerations have also been discussed, whether it should be considered through land management or agricultural practices. No clear consensus emerged for that matter but to avoid risks of overlaps and double counting (e.g. land-multiuse, agroforestry practices, land management).

Proposal for the land management levels

Building on the experts' comments, the land management will be designed to propose 4 levels, ranging from more commercial-uses to more ecosystem rehabilitation. The lever will affect land-surplus allocation (land prioritization) and other features such as agriculture practices; Land multiuse may also be triggered through agricultural practices, however, it may be considered through, for example, climate smart agriculture (Section 3.3.9). Nevertheless, given the inputs collected, further research will be required to calibrate the lever and the model. For example, we may consider a share of non-valorised lands such as suggested.

3.3.9 Agricultural practices

Topic discussion reported by:
Prajal Pradhan (PIK Potsdam)

Lever rationales:

The EU28+Switzerland total Utilised Agricultural Area (UAA) is about 180 Million hectares (Mha), in other words, nearly 40% of land use (EUROSTAT). Depending on the agricultural practices, land productivity and sustainability impacts may change in terms of agricultural yields, use of water, energy, fertiliser, etc. For instance, organic farming areas currently represents from 1 to 22% of UAA depending on the country (EUROSTAT), and continue to increase over the years, which may affect yields, fertiliser's demand, and so on. According to AGFORWARD, the current area of agroforestry is estimated around 8.8% of the UAA (den Herder *et al.*, 2017), and there is a potential to reach at least 90% by 2050 (Mosquera-Losada*et al.*, 2016), which may impact yields, biodiversity and so on. Agriculture practices lever will thus enable users to set different ambition levels.

Levers & practices (Day 1)

Box 8 – Short description of the agricultural practices lever proposed to experts

This lever will enable setting the choice for multiple agricultural practices (e.g. agroforestry, crop-livestock, multiple cropping). Agricultural practices will mainly affect the extent of land-demand, crop yields, efficiency, water demand, fertiliser's use, energy demand, biodiversity impacts, livestock 'intensity' (animal density on pasturelands, and feed conversion ratio of different animals), feed demand and supply by type, animal lifetime, and GHG emissions.

> *Organic farming:* according to the FAO definition[11], organic farming is a 'holistic production management system, which promotes and enhances agro-ecosystem health, including biodiversity, biological cycles, and soil biological activity'.
>
> *Agroforestry:* according to the FAO definition[12], agroforestry can be defined as: 'a collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, bamboos, etc.) are deliberately used on the same land-management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence'.
>
> *Agroecology[13]:* according to the FAO, agroforestry can be defined as: 'the application of ecological principles to the interactions between human beings and their environment, as well as to their consequences, with the goal of minimising

[11] See: http://www.fao.org/organicag/oa-faq/oa-faq1/en/
[12] See: http://www.fao.org/forestry/agroforestry/80338/en/
[13] See: http://www.fao.org/family-farming/detail/en/c/415959/

the negative effects of certain human activities'.

Urban farming [14] *:* (UA) can be defined as 'the growing, processing, and distribution of food and other products through plant cultivation and seldom raising livestock in and around cities for feeding local populations.

Precision agriculture: is the practice of managing variability in space and time and consists of a spatial management that can result in the more appropriate use of inputs that benefits the profitability of the enterprise and natural resource management (extracted from Leonard, 2015)

The agricultural practices lever was considered relevant and useful to track sustainability impacts of the different practices. Experts validated that the GHG emission focused lever setting (i.e. 1-4 ambition level setting) was clearly not suited for agriculture, and that a branch of sustainability outputs is required using the A-D ambition level approach.

The set of the possible practices was challenged by the experts. The terminology of practices was discussed and there was no clear consensus among experts regarding the meaning that each of the proposed practices entails (e.g. for farmers, for environment, or for consumers). For instance, precision farming was challenged by some experts, who consider it more as a set of technologies to make farming more productive, without some substantial changes in the ways people farm. It is rather about investment and opportunity costs. The agroecology was considered by some experts more as an ethos or mind-set that can be applied to various practices. Building on this comment, it was suggested that the lever may command the balance intensification and extensification of agricultural practices.

Having a specific lever for organic farming was also highly debated. As a European policy target, some experts considered the lever useful whereas others believed organic farming should be triggered through lifestyle choices, or else that 'organic farming practice' was too blur and overlapping with agroecology. Nevertheless, both are characterized by concrete production standards (IDDRI, 2018).

It was also suggested that the lever on urban farming may be extended to both urban and peri-urban agriculture (UPA). Urban farming should not only consider vegetables, but also crops and livestock. It was also suggested that specific targets should be considered for vertical farming within the urban farming ambition levels.

Rather than detailing the different practices, it was suggested by some experts to use a unique lever as an umbrella for multiple practices which would embrace common mind-set, for instance: 'Climate Smart Agriculture'. According to the FAO, Climate Smart Agriculture is defined as[15]:

> *'an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate. CSA aims to tackle three main objectives: sustainably increasing agricultural productivity and incomes; adapting and building resilience*

[14] See: https://sustainabledevelopment.un.org/content/documents/5764Urban%20Agriculture.pdf
[15] See: http://www.fao.org/climate-smart-agriculture/en/

to climate change; and reducing and/or removing greenhouse gas emissions, where possible. CSA provides the means to help stakeholders from local to national and international levels identify agricultural strategies suitable to their local conditions. It is in line with FAO's vision for Sustainable Food and Agriculture and supports FAO's goal to make agriculture, forestry and fisheries more productive and more sustainable'.

It was also pointed out that issues regarding global versus regional food production systems should be explicitly addressed, echoing the possible net-import or self-sufficiency lever for food, feed, and bioenergy within the transboundary effect Work package (WP7).

Ambition levels (Day 2)

Based on the discussion of Day 1, possible levels based on the literature were proposed by the EUCalc team and given to experts for review and validation (Table 13).

Table 13- Level of ambition for the different practices (IDDRI, 2018; European Parliament, 2016; EUROSTAT; AGFORWARD, 2016)

Practices	Current	Level A	Level B	Level C	Level D
Organic farming	6%	30%	50%	75%	100%
Agroforestry	30%	30%	50%	70%	90%
Agroecology	*n.s.*	0%	50%	75%	100%
Conservation agriculture	25%	25%	50%	75%	100%
Urban farming (vegetable)	*n.s.*	0%	12%	25%	50%
Precision agriculture	*n.s.*	*tbd*	*tbd*	*tbd*	*tbd*
Land-multi-use	*~10%*	*10%*	*20%*	*50%*	*100%*

Experts mainly challenged the 100% numbers that were considered too hypothetical and non-feasible (e.g. producing 100% of the food organic). Nevertheless, the point of EUCalc is to explore the highest ambition levels that are technically feasible as level 4 (or D). Although it was mentioned that the potential, for instance, of organic farming, needs to consider upcoming behavior and lifestyle patterns, for the worse but also for the best, such as meat production decrease, enabling to feed Europe though extensive agriculture. Such views also highlight the difficulty of changing people mindset regarding food patterns, which is precisely echoing the interlinkages between culture and food pointed out by Tom Heap's presentation during the first day of the workshop.

Multiple cropping levels were suggested, and divided into two scenarios, one being double-cropping, and the other triple cropping when technically possible for example, in regions with favourable climate conditions in winter season.

Proposal for the Agricultural practices' lever and levels

The experts positions were mixed, and no clear consensus emerged concerning the agricultural practices lever. On the one hand, high granularity was supported to explore the sustainability impacts of specific practices such as organic farming, also in line with the European policy. At the same time, overlaps between the different practices (agroecology and organic farming) led experts to suggest aggregating sustainable intensification methods (e.g., precision agriculture), and more extensive approaches (e.g., organic farming, permaculture and other agroecology concepts). Given the modelling constraints (number of levers), we may choose to use the latter option.

Building on the experts' comments and based on the Climate Smart Agriculture report developed by the FAO (2013), we suggest developing two levers called: (1) "climate-smart crop production system"; and (2) "climate-smart livestock". As recommended by experts, livestock and crop issues should be distinguished; and considered in separate levers.

Concerning Climate Smart Agriculture, the use of this concept requires further investigation, given that the concept needs to be adapted for the different local contexts in Europe, which may result in a flexible lever that may adapt the multiple possible lever settings. For example, climate smart agriculture can be reached through sustainable intensification or extensive agricultural practices. Rather than dedicating an additional lever for this specific parameter, we may assume that the land-management lever will set the split between sustainable intensification and extensive practices (e.g., land-based or feedlot-based livestock systems). In other words, the land-management lever will set priorities between commercial uses, and ecosystems purposes. We will assume that commercial uses favours sustainable intensification whereas ecosystems favours extensive practices.

The climate smart levers, for crops and livestock, will affect (non-exhaustively) the feed conversion ratio (FCR), the grazing management, manure collection rates, the agroforestry deployment, the urban farming deployment, and so on (for a review, see FAO, 2013). Consistently with livestock and crop, a climate smart fisheries and aquaculture lever may be developed.

Finally, to address experts' comment, a net-import lever will enable setting the net-import balance for food and feed, as one or separate levers.

Additional comments

Experts stated that mono-culture, multiple cropping, inter cropping, crop rotations, and so on need to be treated and explicitly explained in the agricultural practices lever. In addition, some experts were interested and keen to see the Calculator consider and explicitly inform users about livestock health (associated with the practices), including in the context of growing concerns on animal welfare. Additionally, some experts emphasised that the motivations and reasons for choosing the different levers need to be transparent.

It was suggested that lifestyles could drive the quality standards (e.g., organic). Moreover, it was suggested to include a lever for seasonal consumption behavioural patterns. The opportunity to deal with these aspects through lifestyle levers, and especially 'sustainable lifestyle' will be further investigated.

4 Conclusions

In general, experts' insights were mixed between the need for more levers to enable more settings, and the need to limit the set of levers to simplify the model. This suggests that two levels of complexity should be developed to comply with both expert and non-expert audiences.

The lever settings were based on a literature review and were discussed during the expert consultation workshop. Following the expert consultation, additional review of the model will be carried out. This additional review is necessary in order to clarify and refine the ambition levels based on suggestions/feedback raised during the workshop and in order to assess its scientific underpinning in relation to the modelling requirements. The beta version of the EUCalc model will be developed by building on the experts' comments and will address the identified issues as much as possible. In summary, here are the main outcomes of the workshop:

(1) Experts supported a modelling conceptualization focused on sustainability impacts rather than only GHG emissions. This was considered as relevant, particularly for agriculture, forestry, fishery and land-management levers;
(2) It was suggested by the experts to use an umbrella sub-lever to cover multiple practices, rather than developing a sub-lever for each agricultural practice. Therefore, a climate smart intensification system may be implemented that will set ambition for the multiple practices, rather than providing a sub-lever for organic farming, agroforestry etc. The team may consider the possibility of incorporating a sub-tab to enable users who require testing for each practice as a compromise, so as to offer two different levels of complexity;
(3) Based on the expert advice, the share of organic farming in agriculture should be defined as a lifestyle choice rather than an agriculture practise. Consequently, an additional lever, or additional features may need to be developed in WP1;
(4) Due to massive importation of minerals in Europe, the relevance of the mineral mining lever was strongly challenged. The experts suggested not to develop a mining lever, but to keep a track on the impact of leakages outside Europe;
(5) The development of a water focused lever was strongly supported, rather than just keeping track of water consumption, withdrawal and footprint. Consequently, the scope of the water module will need to be extended, and the lever will be developed to this effect with an objective of e.g. limiting water stress in Europe;
(6) Although the relevance of the biomass hierarchy-use lever had been initially challenged, the robust discussion with experts about how to use biomass led to the conclusion that such a lever would be beneficial to the model;
(7) The experts considered developing a lever for on-farm wastes irrelevant. It was suggested to connect these features to the levers associated to a given sector such as through the climate smart crop intensification system;
(8) The experts' emphasis was on placing a toggle switch regarding the use of food crops for non-food uses. The users will thus be allowed to enable or disable food crop use for non-food uses through a dedicated lever or through the above-mentioned hierarchy lever;
(9) The scope of the land management lever was challenged by the experts. It was suggested to provide ambition levels that would put emphasis on the balance

between commercial uses and ecosystems purposes. The lever may also be connected to other levers (e.g. sustainable intensification versus extensification).

Beyond the scope of the resource's modules, the experts made several suggestions that will feed the internal debate and foster further research to improve the EUCalc:

a) It was suggested to add a lever that would set how the EU trajectory would impact/ influence the RoW;
b) Such as for the choice to use biomass for non-food purposes, experts suggested to enable the users to choose whether they wanted to enable/disable some types of technologies, such as, for resource extraction (e.g. fracking technology);
c) A question also arose on how the model will take into consideration waste and landfills emissions alongside biochar production and utilisation;

Given the wide range of expertise input required for the land, water and biodiversity modules, further research will be conducted as highlighted throughout this report (deliverable 4.2). In addition, face-to-face follow on meetings will be performed to refine the inputs and fill some gaps that were not able to be covered during the workshop (e.g. for fishery and aquaculture). Moreover, additional refinement of the model are expected to follow after the planned Call for Evidence. The Call for Evidence will be based on an online consultation process to evaluate a preliminary version of the EUCalc webtool (beta version) before its final publication.

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6 Annexes

6.1 Participants list

Participants – Experts:

First Name	Last Name	Organization
Ad	de Roo	Joint Research Centre, European Commission
Tom	Heap	BBC
Keith	Kline	Oak Ridge National Laboratory
Ana	Kojaković	Energy Insitute Hrvoje Požar
Eric	Sievers	Ethanol Europe
Christian	Davies	Shell
Pam	Berry	Environmental Change Institute, University of Oxford
Cary Yungmee	Hendrickson	FAO, University of Rome
Nicole	Kalas	ETH Zürich
Grahame	Buss	LCAworks
Elliot	Buss	Cambridge University
Alex	Mason	WWF European Policy Office
Prajal	Pradhan	Potsdam Institute for Climate Impact Research (PIK)
Kathy	Ryan	Global Green Investments
Sarah	Wynn	ADAS
Steven	Peterson	Thayer School of Engineering at Darthmouth
Richard	Murphy	University of Surrey
James	Millington	King's College London
Ramon	Bicudo	UNICAMP
Luc	Bas	IUCN Europe
Frank	Rosillo-Calle	Imperial College London
Sagar	Sumaria	*Sow Grow* and *Reap*
Lorenzo	DiLucia	Imperial College London
Alexandra	Collins	Imperial College London
Mathilde	Fajardy	Imperial College London

Participants – European Calculator Project:

First Name	Last Name	Organization
Onesmus	Mwabonje	Imperial College London
Jeremy	Woods	Imperial College London

Gino	Baudry	Imperial College London
Alexandre	Strapasson	Imperial College London
Rachel	Warren	University of East Anglia
Jeff	Price	University of East Anglia
Ana	Ranković	SEE Change Net
Garret	Kelly	SEE Change Net
Alex	Bouchet	École polytechnique fédérale de Lausanne (EPFL)
John	Posada	TUDelft
Judit	Kockat	Buildings Performance Institute Europe (BPIE)

Facilitator:

First Name	**Last Name**	**Organization**
Jonathan	Buhl	4Sing

6.2 Workshop agenda

Day 1: Wednesday, September 19, 2018 Imperial College London | South Kensington Campus | London | United Kingdom **Royal School of Mines (RSM): Room G01**	
Time	**Activity**
12:00 – 12.30	**Registration and light lunch**
12.30 – 12:50	**Opening & welcome -** *Workshop agenda, objectives, participants introduction* Dr.Jeremy Woods, Imperial College London Jonathan Buhl, 4sing (facilitator)
12:50-13:10	**Presentation of the EUCalc project**- *Short overview presentation followed by clarifying questions and brief discussion* Dr.Jeremy Woods, Imperial College London Garret Kelly, SEE Change Net
13:10 – 13:50	**Reflections on food security, land use and climate change challenge -** *keynote presentation followed by questions and discussion* Tom Heap, BBC Rural Affairs Correspondent
13:50– 14:05	**Coffee/tea break**
14:05 – 14:40	**Background to Land use, water and biodiversity module of the EUCalc**- *Short overview presentation on the methodology, assumptions and levers* Dr. Gino Baudry and Dr. Onesmus Mwabonje, Imperial College London Prof.Rachel Warren and Dr. Jeff Price, University of East Anglia
14.40 – 16.00	**Interactive dialogue and discussion on critical questions**

16:00– 16:15	**Coffee/tea break**
16.15 – 17.10	**Interactive dialogue (continued)**
17:10 - 17:30	**Closing -** *Summary and key takeaways*
19.00 - 21.00	**Dinner** *(optional)*

Day 2:Thursday, September 20, 2018 Imperial College London | South Kensington Campus | London | United Kingdom **Royal School of Mines (RSM): Room G41**	
Time	**Activity**
10:00 – 10.30	**Welcome coffee/Registration**
10.30 – 10:45	**Opening -** *1st day takeaways, objectives of the 2nd day* Dr.Onesmus Mwabonje, Imperial College London Prof.Rachel Warren, University of East Anglia Jonathan Buhl, 4sing (facilitator)
10:45-11:30	**European and global perspective on Land use, water and biodiversity impacts**- *keynote presentations followed by questions and discussion* Prof.Dr. Ad De Roo, European Commission, Joint Research Centre, Directorate D – Sustainable Resources, D2 - Water and Marine Resources Unit Dr. Keith Kline, ORNL - Oak Ridge National Laboratory
11:30 – 11:45	**Levels of ambition and scenarios of the Land use, water and biodiversity module of the EUCalc** - *Short overview presentation* Prof.Rachel Warren and Dr. Jeff Price, University of East Anglia Dr. Gino Baudry and Dr. Onesmus Mwabonje, Imperial College London
11:45– 12:00	**Coffee/tea break**
12:00 – 13:50	**Interactive dialogue and discussion on the levels of ambition and scenarios**
13:50 - 14:00	**Closing -** *Summary and conclusion, final reflections* *and outline of next steps by the EUCalc team*
14.00 - 15.00	**Lunch and departure**

This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement no. 730459

6.3 Contributions from invited speakers

Tom Heap - BBC

Tom Heap was the keynote speaker on Day 1. His talk was entitled *"Reflections on food security, land use and climate change challenge".* He is a well-known BBC reporter on rural affairs, environment and science. He is the producer and reporter of the television program *Country file*[16] broadcasted every Sunday night in the UK and also of the radio program *Costing the Earth*, an international environmental radio program. In his address, Heap underscored the multifaceted nature of challenges caused by land use change and the importance of communicating and making these understandable to the wider public. Both of these issues strongly relate to the current narrative of the EUCalc. In addition, Heap also brought to the attention of the participants late Professor David McKay's rational approach to climate and energy debate and his admirable legacy in relation to the UK 2050 Calculator, a precursor to the 20-30 Calculators that have emerged around the world. This approach embraced by the late Professor McKay has brought the idea of inescapable solidity of numbers to public debate and government policy making in a way that is accessible and easy to fathom.

By placing land use change in a wider Calculator context (including major issues such as energy, commerce, lifestyle and manufacturing, etc.), Heap highlighted *land use* as a particularly difficult section of a wicked climate change problem. In his comments, land use is strongly tied up with multiple biological and cultural influences on the human identity, among other issues he discussed as following described.

- While rising GHG is an existential threat, it is a very distant one compared to not eating. Although overconsumption or poor distribution of food is more of a problem today than absolute levels of production, memory of not having enough food in Europe is not very distant, and in parts of the world it is still prevalent. Food matters.
- Culturally, food is memory, community, joy, and comfort to people. As an old phrase says: "*There is nothing better than getting around a decent meal*". It is deeply embedded issue and a matter of national identity (German sausage, Spanish paella, French cheese, American burgers). Over the years IPCC has said very little about diet and it is possible that this is because diet is potentially an alienating topic. It is difficult enough to get people out of cars or to reduce size of massive pick up, let alone to eat less meat. Diet and culture are strongly connected.
- Landscape and culture are also very connected. If we look at the history of art, photography, film, our connection and our identification with landscape is very strong. From an environmental perspective, for example, there are landscapes in Britain that are barren in the sense that they have low biodiversity, inefficient food production or low levels of flood protection. However, people love them and would not be happy to re-wild them and turn them into scrub and then real forest. Unlike other sections of economy, there is also a strong preservation and protection movement involved with landscape.

[16]*Country file* programme spends an hour every Sunday night celebrating British countryside. While it may sound like a marginal programme it is Britain's most watched factual programme, with half urban, half rural audience.

- Unlike energy or transport where GHG impact is readily comprehensible, for instance car driving or tuning the heating up, GHG implications of land use change are not readily apparent to most people.
- Currently land use and agriculture are responsible for 10% of UK's GHG. Since 1990, there has been a 41% drop in GHG overall emissions, but only 16% drop from land which, after an initially steep drop, has slowed down recently. Some of the low hanging fruits has been probably gathered, but also according to the research made by the UK's Committee on Climate Change around 50% of farmers said they didn't consider climate change when they were making decisions, 47% believed it is not necessary to take it into account. While soil carbon increase by 0.4% is very prominent in some parts of Europe, especially in France, methods for improving soil carbon have little traction in the UK.

According to Heap, for all of these reasons, public acceptance of changes in areas of food and land use could be difficult to deliver. There is a strong need to make the GHG and land use story more visual and more apparent, and there is probably much that we can learn from the energy community in terms of explaining various benefits (financial, air quality, etc.).

Voluntary approaches to reducing GHG emission from farming and land use has failed. It is also alarming that in public discussions touching on land use change, GHG is almost not mentioned at all. At the same time however, there is no other area of economy where governments command so many policy levers. It is an opportunity waiting to be grasped, to steer the land use change in a more sustainable direction. It takes a political bravery to do so to create a positive impact on land use. Common Agricultural Policy (CAP) has not delivered its promises in terms of environment. Reflecting on the agricultural bill in the UK, while it identifies many of the issues such as lower GHG, higher biodiversity, better use of water, etc., there are currently very few mechanisms that can address societal costs and very little practicality in terms of how this is going to be done. With effective right policies, support schemes and reward systems (e.g. carbon sequestration) one can shape what farmers do on the land, whether UK stays or leaves the EU. What is required is high level of clarity for people to understand the inter-linkages between lands and impact on our climate.

Finally, looking at the Calculator, one of the biggest dangers is that we end up exporting environmental costs and impacts of our production abroad. Being transparent about this is important and ought to be clearly understood by the wider public. For example, importing oil-cakes to feed European livestock may lead to export the environmental burden, which is why it is critical to keep track of such trajectories.

Heap affirmed that the idea of the EUCalc is an admirable and empowering one:*"what I've seen so far in the European Calculator, the split into levers, practices and ambitions, I find readily comprehensible, which is surprising when one approaches academic things for the first time."* He added that the group discussions during the workshop on the balance between complexity and accessibility, and accessibility side of this spectrum are incredibly important when we think of making a success of the Calculator being developed. He then finished his address by saying that the Calculator should provide great clarity, great examples and simplicity.

On Day 2, two short presentations stimulated the discussions with insights from research projects conducted by the **Joint Research Center (JRC) of the European Commission and ORNL (Oak Ridge National Laboratory, US).** As a result, the EUCalc partners will have a follow up interaction with JRC to study the opportunity to collaborate concerning water and land-use issues.

Professor Ad de Roo – JRC

Professor de Roo presented their brand-new work based on water resources modelling, the development of which started in the 1990s. This work began as a flood simulation and flood prediction model and has been modified and extended since then.

LISFLOOD is a hydrological rainfall-runoff model including the simulation of water abstraction and consumption (irrigation, rain-fed agriculture, cooling for energy production, manufacturing industry, livestock, public water usage and environmental flow). It simulates the detailed hydrological cycle, including human water consumption, irrigation, lakes and reservoirs, and river flow routing. LISFLOOD is used for operational flood (EFAS, GloFAS) and drought (EDO) forecasting, as well as river basin (Meuse, Oder, Elbe, Danube, Toce), European, African and Global water resource studies.

Since 2003 JRC has been providing information to European Water Authority as an early warning model. Globally, results are used by the world food programme and other rescue organisations. Recently, JRC has endeavoured to link irrigation with agriculture to better estimate crop yields. The next development step is to include crop yield directly in the model.

Various assessments have been done, by using this model, to explore climate change scenarios for Europe. These use the CORDEX for historic control simulations and they apply various CO_2 scenarios through the end of the century. According to the model, a2-degreescenario will result in different effects across Europe. For example, Scandinavia is likely to see a more severe impact than the UK, in terms of water balance. Other model-based implications for Europe's water resources up to 2050 under the 2-degree scenario include:

- Climate change causes wetter conditions in north and central Europe, and drier conditions in the Mediterranean;
- Mediterranean gets increasing issues of less water for rainfed agriculture and less surface and groundwater for irrigation and other activities;
- Water scarcity is exacerbated in areas where it is already an issue. An extreme warming scenario (IPPC's RCP8.5 by end of 21st century) projects increased water scarcity problems in central Europe and England, especially during summer;
- Changes in land use and water demand play a role, but the climate change effects in Europe is likely to be dominating changes in water resources;
- River floods are likely to become an increasing problem, even in autumn months in the Mediterranean;
- Urban excess water is a growing issue in central European countries including UK.

Professor de Roo noted that impact assessment under the 1.5 degrees scenario is being developed by JRC.

Keith Kline - ORNL

Keith Kline is a Senior Research Staff at the Climate Change Science Institute and Center for Bioenergy Sustainability, Oak Ridge National Laboratory (ORNL), in the United States. He delivered a presentation[17] in which he highlighted the need to challenge some of the conventionally held assumptions about land use and to deploy science-based approaches and causal analysis to better understand relationships among drivers of land use change (LUC).

According to Kline, there is a number of studies looking at 2050 and projecting that with increase in population and higher per capita incomes, there will be a need for "more food" and more arable land. These projections are based on how we do things today and are based on extrapolation of historical trends. Nevertheless, is that a good way to make projections? Empirical studies say that we have overproduction of food, with food prices going down persistently for over 100 years. About a third of the world's agricultural area is lost or wasted. Conventionally, LUC and indirect LUC (ILUC) are determined by the selected land classes, and models rely on many underlying (and often unstated) assumptions. Hence, there is a need to look for the empirical data to test these assumptions.

In this context, findings from some recent analyses include the following:

- Land area & commodity output do not limit global food or bioenergy production (Kline et al., 2009, 2011, 2017; SCOPE 72 (Souza et al. eds.), 2015; Thurow and Kilman, 2009);
- Land scams, tenure issues, poverty, & market distortions cause land clearing (Kline et al., 2009, 2011, 2017; SCOPE 72 (Souza et al. eds.), 2015.;Efroymson;et al. 2013);
- Agricultural system responses to demand are quick and rely on existing production systems (e.g., intensification) rather than new land clearing (Kline et al., 2009, 2011, 2017);
- "Growing more" is not the solution when 40% of production is wasted & commodity stocks are at historic highs (FAO and others, 2013, 2014, 2015).

Kline's perspective is that there is shortage of good land management and not shortage of land, but as long as deforestation persists, concerns about "limited land" and biodiversity will continue to prevail. It is therefore critical to understand actual causal drivers and a confluence of circumstances and opportunities in a given place and time that leads to deforestation.

Inter-disciplinary research on biofuels and biodiversity across the Americas suggests that concerns for biodiversity and ecosystem protection are high and prompting: agroecological zoning (e.g., Brazil), increased monitoring, certification schemes, legal and regulatory reforms, pressures to improve enforcement and rule of law, research on making bioenergy systems more harmonious with conservation goals. As an example cited by Kline, some positive impacts can be observed in the last 10 years in the State of São Paolo (Brazil) in terms of water quality, forestry and return of jaguars. This is quite

[17] The presentation is based upon work supported by the US Department of Energy under the Bioenergy Technologies Office (BETO), and performed at Oak Ridge National Laboratory under contract number DE-AC05-00OR22725. The views and opinions expressed do not necessarily state or reflect those of the United States Government or any agency thereof.

different to the land use effects in Guatemala's national park, which is linked to petroleum extraction.

The EUCalc project can help these discussions by engaging with multitudes of stakeholders and perspectives to critically examine effects of various levers, what causes some of the changes that we are seeing and what tools we have at disposal for a better land management.