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Analysis of needs and capacity of different audiences including policy makers, expert practitioners and other modellers

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BESTMAP

Behavioural, Ecological and Socio-economic Tools for Modelling Agricultural Policy

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Preface

To be able to respond to the needs and specific requests of identified stakeholders, BESTMAP has conducted needs assessment presented in this document. BESTMAP project will produce a dashboard tailored to meet the needs of stakeholders and allow them to monitor the impacts of implementing future Common Agricultural Policy scenarios. Following chapters will present the identified needs and capacity of policy makers, expert practitioners, and the modelling community.

The objective of the Needs Analysis is to identify and understand stakeholders needs and interests to capture the initial requirements for the policy dashboard, to understand all aspects that should be considered in current and future CAP scenarios/indicators.

Summary

This document has five main sections: the first one, "Developing the needs assessment protocol" which explains how we approached to different stakeholders in order to define and analyse their needs and capacities; the second section contains the report of of the interviews conducted by RISE and present the needs of Policy Makers; section three explains the needs of expert practitioners identified during the online workshop (14th and 15th of July 2020); section four presents the needs of biophysical modeling community and section five explains the needs of ABM modellers identified from recent scholarly workshops. The results of this analysis will be taken under consideration and co-design and co-development processes.

1. Developing the needs assessment protocol

The needs assessment was conducted for the four stakeholders groups - EU policy makers, expert practitioners, biophysical modellers and agent-based modellers. For each of these groups a different approach to collecting the needs and requirements was undertaken.

To identify the needs of policy makers at EU level, 12 interviews with key stakeholders were carried out by RISE in the period between 14th of April 2020 and 18th of June 2020. Interviewees were chosen based on 3 criteria:

1. To represent a stakeholder group in the pre farm gate aspect of the agri-food value chain or are an expert analyst of the European agriculture policy.

2. To be involved in following European policy at the Brussels level

3. To be recognised as already active in the debate on the future of European agriculture

All interviewees were sent the introduction and questions with the invitation for interview. Interviews were carried out using the online meeting app, GoToMeeting, except two interviews. One that was carried out in writing form, and one company did not allow for accessing GoToMeeting and therefore the recording was taken through Skype by phone. An interviews' report is presented in section 2.

Within the BESTMAP project, a virtual workshop "Improving environmental and social capacity of EC impact assessment tools" attended by 37 DG AGRI/ENV/CLIMA and JRC representatives, was organised on 14th and 15th of July 2020, with the aim to help BESTMAP better understand the needs of modellers in the DGs and JRC, in particular in the area of environmental and social impact. The format and dates of the workshop was different than previously planned, due to COVID-19 restrictions of travelling. Workshop was composed of plenary sessions and three thematic breakout discussion groups on the topics "Agricultural impact modelling in the EC and Member States", "Post-2020 CAP and SDGs indicators" and "Macroeconomic and ecosystem services model linkages". A report of the workshop is presented in section 3.

To ascertain the needs of the biophysical modelling community for various overarching issues across the modelling arena was distilled from a series of presentations given during the 'Current status and key questions in Landscape Decision making' workshop in July 2019 and 'Progress on novel mathematics and statistics for Landscape Decisions, including priorities for further research' in July and August 2019. The conclusions could be found in section 4 of this document.

The needs and requirements of the land use ABM modelling community were raised during the discussions in a set of scholarly international workshops / conferences in the last years. The conclusions are presented in section 5.

2. Needs analysis for policy makers

With the aim of capturing the important drivers of change and possible trade offs of European agricultural policy, RISE has done a series of interviews with key policy influencers at the European level. Through the questionnaire, we tried to collect opinions of EU stakeholders on the priorities for the sustainable food system, the greatest challenges, trade-offs and what will drive the food chain and consumers to meet these objectives. The full report of the interviews is presented in the Milestone M1.

2.1. Methodology

To support holistic approach BESTMAP project is trying to embrace in developing new modelling framework, 4 groups of interview candidates were defined:

- Producers (representatives of farmer groups and sector producers)
- Input industry (fertilisers, pesticides, machinery etc.)
- Environmental NGOs working on European agricultural policy
- Think tanks (expert analysis)

These four groups of EU stakeholders are chosen to address the needs, predictions and concerns about the future of agriculture from the environmental, social and economic aspects.

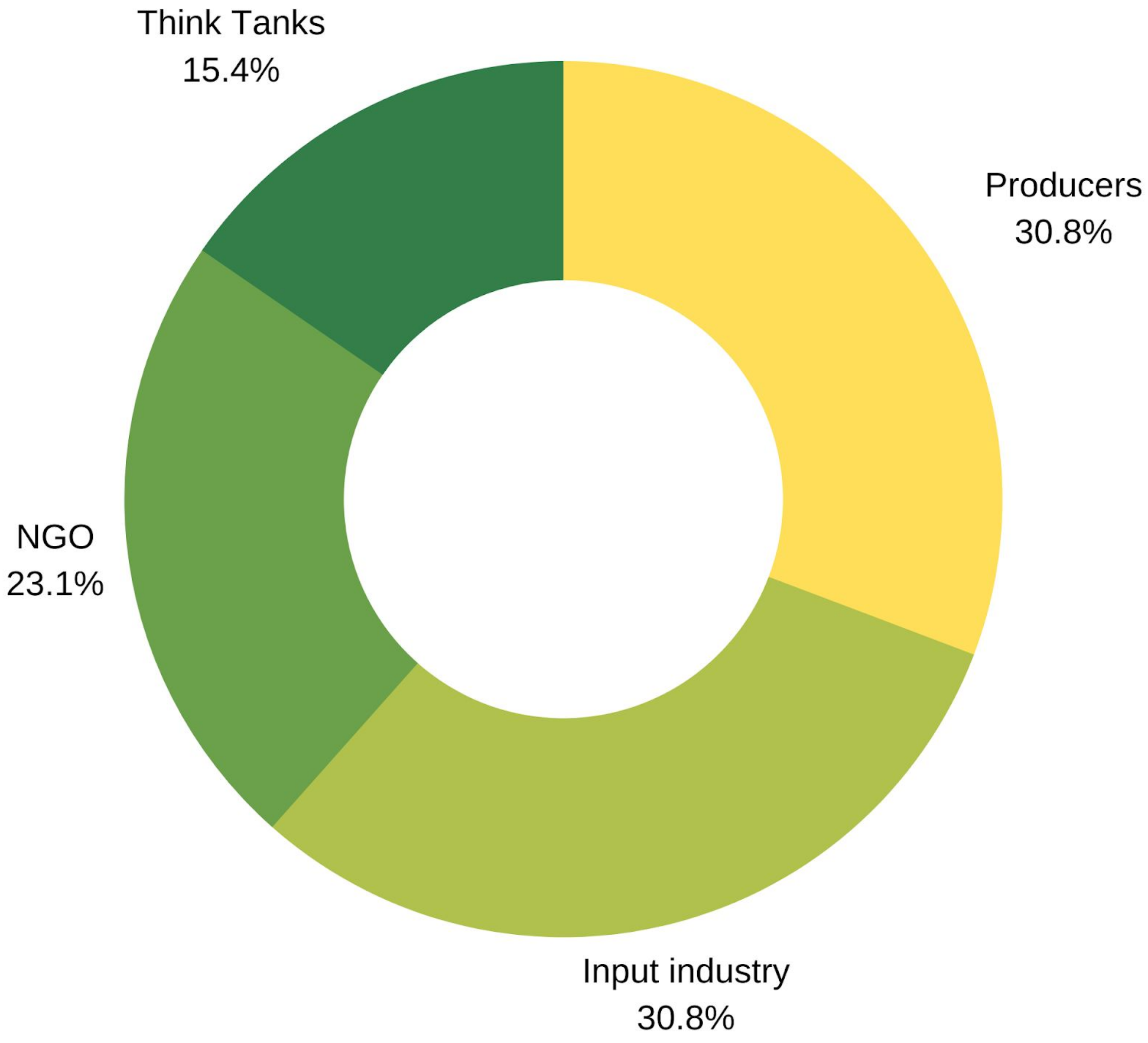

Figure1: Groups of interviewees

Upon final selection there were 6 producer groups (including landowners, farmers, young farmers, and organic farms) 4 industry groups (covering the three primary agriculture inputs + Biogas sector – due to their potential importance going forward), 3 NGOs and two expert think tanks. 3 producer groups declined to be involved or could not be contacted. The organic representative who could not be contacted was replaced by another due to the importance of the organic in the future Green Deal strategy.

This selection of interviewees is in no way a representation of the full agricultural sector in Europe and the Brussels representation level also means they cannot reflect the circumstances of individual member states. However, the selection allows for a broad overview the views of producers, the main input industries and the environmental and climate concerns of NGOs

2.2. Summary of interview responses

- **Question 1: From your perspective, what do you consider will be the most significant trend in EU agriculture and food production in the next 5, 10-15 and 30-years' time?**

To capture what stakeholders predict to happen in the field of agriculture in future, what might be important trends and what challenges future CAP scenarios will possibly have to address, they were asked following question: "From your perspective, what do you consider will be the most significant trend in EU agriculture and food production in the next 5, 10- and 30-years' time?". The summary of their answers is roughly drafted in *Figure 2* and further explained below.

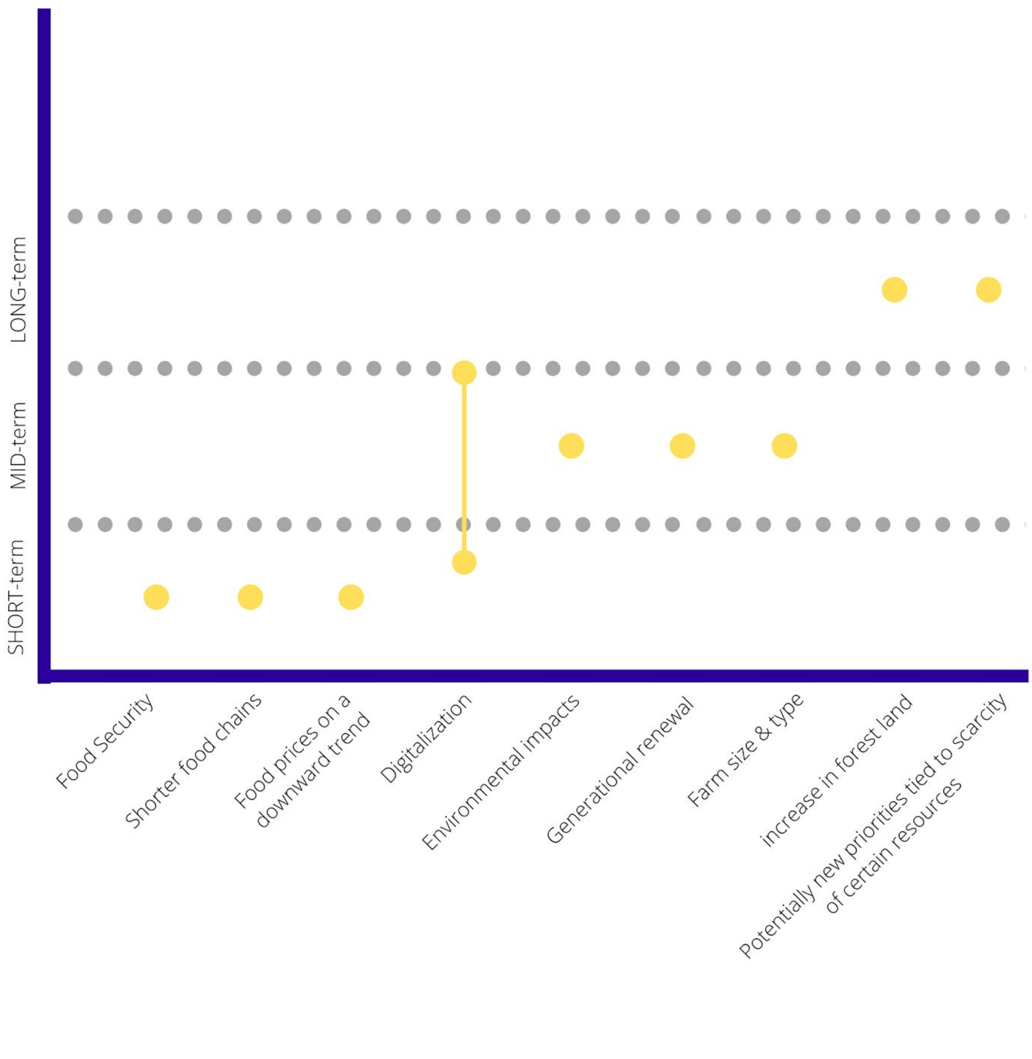

Figure 2: Short, mid and long-term trends in EU agriculture

Short term EU agriculture trends

7 out of 12 interviewees felt that the COV-19 pandemic had changed the predominant trend in European agriculture in the short term, creating a greater focus on food security and the consequences that may have. Four interviewees foresaw a refocus by consumers on shorter food chains and how food is produced. There was concern that emergence of concerns around food security could slow the momentum on environmental and climatic targets, and create greater economic drivers for protectionism. One interviewee highlighted an upcoming COVID-19 generated recession that will likely create a downward pressure on food prices.

Medium to long term EU agriculture trends

The key themes for the medium-term trends centred around digitisation, the impacts of climate change and environmental degradation, farm size and type and generational renewal.

Whilst all those interviewed predicted a real shift in how we produce our food and manage our land in the medium term, two interviewees questioned the political will to support this shift and warned that without the political will, there would be a risk that the status quo (high input agriculture, low margins, high environmental and climate impact) would remain the norm in the medium term.

Digitisation. The digitisation of agriculture was highlighted by 5 of the interviewees as a major trend going forward. Changes will include a shift towards precision agriculture (two interviewees highlighted the localisation of input precision to the plant level – spray technology and fertiliser application, would reduce input in the region of 50 to 80% and thereby reduce environmental and climate impacts). Three interviewees also highlighted the role that digitisation will likely play in the monitoring of how we farm – both for authorities, and the whole food chain. The opinions differed somewhat on the take up acceleration of the technology, with the machinery industry seeing a slower uptake in the short term and eventual high level take up in the medium to long term, whilst one of the input industries saw a continual rapid take up of technology innovation from the short term.

Environmental impacts. Two interviewees saw a continuing escalation of the impacts of environmental degradation (especially soil degradation) and climate change (a shift in precipitation and temperature patterns – leading to increased rain in winter, early summer droughts, floods and pest outbreaks) having a real effect on our ability to produce. One interviewee predicted that output would continue to decline in Europe as a result of these impacts, unless European farmers are allowed access to the tools used elsewhere by farmers, such as new breeding techniques. They argued that if Europe continues to have more restrictive laws on such technologies, then Europe's role as a net importer will continue to grow, thus affecting global food supply and prices.

Generational renewal. This was raised as a major concern by interviewees from all sectors (5 interviewees). With the average age of the farmer at 50-60 years of age, we will see the real effects of the lack of new young entrants into the sector in the next 10 years. This will play out differently across Europe. For example, two interviewees raised rural exodus, a major concern as more young leave and with them the social and structural fabric of local communities, leading to a downward spiral effect. In other areas it may lead to a rapid substituting out of labour for technology, increased reliance on hired labour and subcontracting and the collapse of some farm businesses (further aggravating the exodus of younger generations). Two environmental groups considered that in some areas the generational renewal may have a positive element as the majority of new entrants into farming are in the organic sector who are on average 10% younger than conventional farmers and younger entrants into agriculture may be more open to pursuing multifunctional farming and agroecology. However, in all cases the aging of the average age of farmers in European agriculture was seen a major concern that must be addressed.

<u>Farms - their numbers and size.</u> 5 of the interviewees mentioned farm type and size. Three interviewees predicted an increase in farm size primarily due to the price pressure on products. One interviewee predicted that the realisation during the COVID-19 crisis that small farms are less resilient and able to adapt to sudden change may accelerate this trend. However, whilst farm sizes may increase, one pointed out that field size will stay the same due to restrictions already in place on changing field boundary size.

Two interviewees foresaw a simultaneous expansion in the number of small niche farms (agroecology, veg box, community farms) and a diversification in farm incomes (additional off farm income, waste management in AD plants etc.). One producer organisation argued that larger farms will be better able to increase environmental benefits due to their ability to manage the environment over a larger area and leverage greater knowledge from a wider knowledge base.

<u>Livestock.</u> One industry member predicted a reduction in livestock due to growing pressure on climate targets. Another production sector representative also saw a possible reduction in livestock number, but with a larger reduction in monogastrics and where ruminants were better recognised as an essential element in the circular economy. This, they predicted, would lead to a higher proportion of grazing livestock becoming geographically dispersed (increasing the mixed farming structure from its current level of 10% and increasing fodder crop rotations).

<u>Other identified trends:</u>

- Increased protein independence Europe
- Decline in agricultural land due to urbanisation
- Continuing strengthening of regulations on what farmers can use on farm and massive growth in the biological crop protection and soil amendment market.

Long term EU agriculture trends

Most focused on the short and medium term, the long term having too many variables. Two points put forward for the long term were:

· Significant increase in forest land in the long term

· Potentially new priorities tied to scarcity of certain resources, changes in prices for key elements (oil, fertilisers)

- **Question 2: The multiple aims (increasing the share of land used for carbon sequestration, increasing the production of biomass for renewable energy, reduction of synthetic inputs, improving water quality, soil health and building resilient systems to mitigate and adapt to climate change) will inevitably lead to trade-offs and priorities. Are there any aspects that concern you and where do you see the major challenges and trade-offs?**

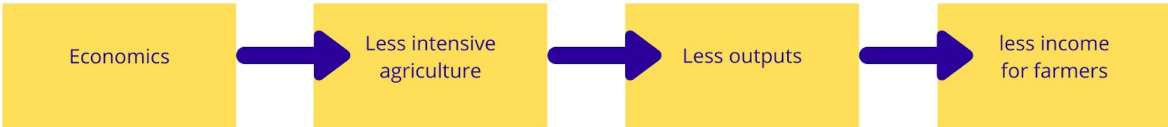

Figure 3: Less intensive farming measures - possible impacts

The Figure 3 emphasises the summary of the answers of three interviewees. Less intensive farming measures, which is the objective of the Farm to Fork (F2F) Strategy, will result in less farm output and therefore less income for the farmer. This puts into question the financial viability of moving towards low input farming. As one interviewee explained, having less intensive farming measures combined with increasing regulations might put European farmers at disadvantage against farmers who are able to produce at a lower cost.

However, an interviewee from an environmental group countered this argument, suggesting that this is a short termism view and only considers a loss of yields in the near future. In the longer term the level of production we benefit from today would not be sustainable and water shortages, pest infestation in monocultures and soil degradation will reduce yields in the future, unless we move to a lower input form of farming.

An industry interviewee also questioned whether reducing the inputs would actually reduce output, arguing that advances in precision technology will only increase productivity, allowing for a greater output to input ratio.

Regarding the F2F strategy goal of increasing the organic sector in Europe, the responses differed. One industry interviewee saw a problem with the financial viability of increasing the organic area by 25%. The interviewee stressed that this would likely increase supply to demand, thus reducing the price of organic produce and therefore obliterating the increased margin organic products can claim. This was not a concern shared by another interviewee who predicted the current growth in demand for organic products would easily match the growth in supply and thus margins would be sustained.

Three organisations highlighted what they felt was key to overcoming this trade off – the fairer distribution of value in the food chain; stronger social policies to deal with the necessary increase in food prices that will be required if farmers are asked to produce less and investment in innovation for win-win technologies – such as Anaerobic Digesters. Two environmental organisations warned against the concept of land sparing and land sharing (i.e. maintain or increase productively on one area of land and leave another part for biodiversity) saying that it was the wrong solution for biodiversity. The only way forward is to focus on a low input low carbon system where biodiversity can be improved within and between cropping systems.

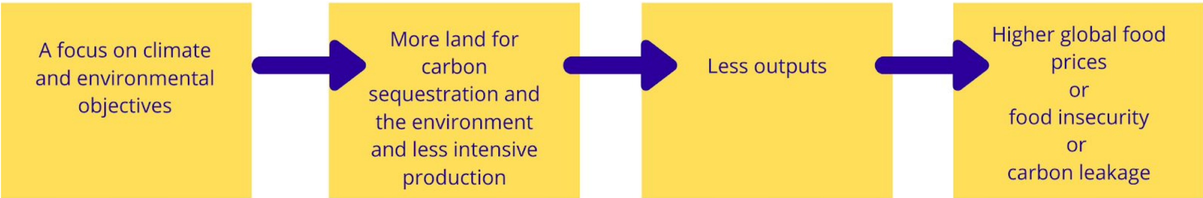

Figure 4: A focus on climate and environmental objectives - possible impacts

The arguments above were further expanded upon in relation to global trade. Three interviewees considered that less food output in Europe would mean higher imports for Europe. This, one argued, would reduce global food supply and increase global food prices. The increase in imports may have a higher ecological and carbon footprint than for the same production in Europe.

This, it was argued would be the case *unless* there is a simultaneous reduction in (over) consumption of livestock and other calories and a reduction in food waste

Meeting climate objectives at the cost of biodiversity objectives

Pressure on land competition will be high. Two interviewees questioned the use of land for biofuels to meet climate targets when compared to, for example, using the freed-up land for high storage carbon systems such as wetlands and forests which would simultaneously improve biodiversity and provide effective carbon sequestration. Although another environmental organisation pointed out the need to harness the potential dual benefits of biofuels and the greater synergies with waste and residue streams which would bring additional environmental and climate benefits. Another interviewee highlighted the potential pressure on reaching climate targets leading to rapid solutions such as large areas of quick growing crops to sequester carbon, which is, again, extremely poor for biodiversity.

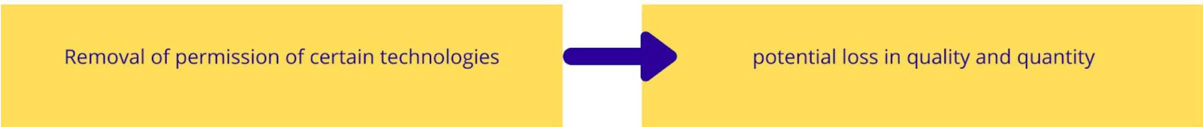

Figure 5: Trade-offs of removing access to certain technologies

Two interviewees highlighted that if Europe continues to remove access to technologies by farmers (crop protection, breeding, technology etc.) product quantity *and* quality will be reduced. This, they argue, is a trade-off that needs to be made clearer to the public, as do false promises that, for example, promising European citizens that Harmonised Risk

Indicators (HRI) will show a reduction, when increasing organic agriculture. Organic agriculture relies heavily on copper sulphate which is used in higher quantities per ha (and are not low risk) so any increase in organic agriculture will only increase the HRIs.

Livestock will be a key

Maintaining ruminants in a more spatially diverse manner will allow them to be reinserted back into mixed farming systems = better use of land for food (rotations, permanent pastures), better carbon sequestration, contributes to lower input farming, less water pollution, more sustainable nutrient cycles etc. But policy makers need to be aware of the trade-offs when reducing livestock . How do you reduce livestock but increase organic land when organic land uses manure as its fertiliser? How do you reduce beef production without affecting the dairy sector, when the two are so intrinsically linked?

Consider the technology of the future

One interviewee argued that policy makers need to consider *future* technological developments when measuring trade-offs, not only currently available innovations i.e. development of algae production in Australia for animal feed has enormous potential to reduce carbon and methane emissions.

Trade offs in policy measures have to be considered

The knock-on impact of each policy objective must be considered. For example, a carbon trading scheme in agriculture would be good for climate targets but could lead to an inadvertent increase in the price of land = less access for land for younger people. Many of the options for transitioning systems require investment in infrastructure which requires liquidity and credit, which many young people lack access to = less access to farming. A reduction in the beef sector may reduce methane emissions, will also have a direct effect on the viability of the dairy sector as both produce sectors are closely linked. Incentives for renewable energy may lead to plantations which reduce biodiversity and increase polluting inputs.

A key message that came from the majority of respondents was the need for a policy approach that considered all the objectives at the farm or regional level. By dealing with the bioeconomy, renewal energy, forestry, productive agriculture etc separately will ultimately lead to trade offs and to policy targets that may end up requiring more land than was available. In addition, 3 of the respondents advocated a food system as the only viable approach as only by simultaneously addressing over consumption and waste could enough land be freed up to address some of the trade-offs. Two respondents also pointed out that it was important that each farm was not expected to reach all targets, but rather there needs to be a recognition that some farms are better able to focus on some aspect of the objectives, and others will be better focused on other objectives.

- **Question 3: What do you envisage will be the key drivers to make the change in the Green Deal aiming to happen (at the European level and, if you have particular knowledge of certain member states, giving examples at the MS level) etc?**

Almost all interviewees identified a mix of both policy and market incentives as being the key drivers in meeting the objectives of the Green Deal.

The market as the key driver. Five of the respondents felt that without the drive by consumers to adopt more sustainable purchasing habits, little traction could be made. These interviewees considered that market pull effects would be crucial to create the incentives needed for farmers to create fewer polluting systems of production.

Policy certainty

One interviewee highlighted certainty and clarity as crucial to encourage farmers, and industry, to invest in new systems of production. Recent decades have left farmers wary of frequent changes in demands and a lack of clarity of what is expected in them and are therefore reticent to invest in restructuring production systems.

The enforcement of policy was mentioned by two environmental groups. There needs to be more emphasis on implementing the actual policy we have which has to date been poor, especially in central and southern Europe (e.g. the nitrates direction). This should be accompanied by a stick and carrots approach and one interviewee suggested an agreement between MSs for a taxation system which taxed GHG emissions equally across the farming sector (i.e. fertilisers *and* livestock).

Effective policy incentive systems. Three interviewees argued that if it doesn't make financial sense for farmers to swap out food for, for example, ecosystem services, it won't happen. This can be helped, one argued, by policy makers seeing farmers as the primary solution to our greatest global challenge i.e. farmers providing carbon sequestration to slow climate heating, and incentivising in line with this. However, policy has to be joined up.
Examples were given of farmers being reticent to allocate land to plant trees when they wouldn't see an income for 20 to 40 years time, or of installing solar panels when doing so would mean the declassification of land as productive land making it ineligible for production subsides on a permanent basis. One respondent from the production industry also questioned the focus on forestry for carbon sequestration when arable land is being shown to have more carbon sequestration potential and should be the recipient of the necessary incentives to maximise this.

Knowledge. And better investment in Agriculture, knowledge and innovation systems.

Investment support for locked in assets and investments in large infrastructure products (through the CAP and EIB)

Private and public risk management tools such as insurance schemes and mutualisation funds.

Reduction of unnecessary delays and red tape for new innovations.

Better tools to evaluate emissions at the farm level so that progress in reductions can be better followed *vis*-à-*vis* policy tools.

- **Question 4: Is our current policy framework adequate to meet these challenges? Is it a question of the better implementation of current policy, or do we need to adjust our current policy framework? If you believe we need to adjust our current policy framework, what set of policies do you believe need to be put in place? If you believe it is a matter of the more effective implementation of current policy, what do you think can enable this?**

Enforcement of environmental policies

The emphasis from the majority of the respondents (7) with regard to adjustments needed to the policy framework concerned the current failure to implement existing environmental policies. This was highlighted as the number one objective.

One interviewee argued that having clearer targets and proper mechanisms were needed to take action when targets were not met. Another advocated for the removal of loopholes in legislation to enable better implementation of environmental policy (i.e. Water Framework Directive which allows countries to justify why they cannot reach good quality water).

There was some scepticism regarding the proposed developed strategic plan approach of the new CAP. One environmental group questioned whether this would in fact hamper the implementation of environmental policy as *"it is already well known that ability of the EU to control the implementation of policy (such a directives) at the MS level, is already severely limited (i.e. nitrates directive)".* The prioritisation of objectives in these plans was deemed to be especially important so that MSs did not systematically prioritise farmer income in a trade off against environmental and climate objectives. One producer group suggested that all environmental directives and regulations need to be included in the CAP as mandatory to receive payments.

Conversely one interviewee saw the positive in the new CAP structure, and praised the new CAP and its focus on eco schemes and national strategic plans primarily because it would bring the debate back to the MS and regional level – leading to greater awareness among citizens and would be farmers and force politicians to be held accountable. By removing the 'blame' option of Brussels, real change would need to be made. This, they argued, would also allow for MSs to adapt their measures to different regions (for example in some poorer regions of Spain organic conversion or maintenance payments have more impact whereas in some wealthier areas they have little impact but investment incentives create change).

A rebalancing of the CAP

Two environmental organisations proposed that in the CAP in its current form, the system of payments should shift – from less voluntary to more mandatory payments, from pillar 1 income support, to pillar 2 environmental payments.

Greater inclusion of digitisation in the remit for the strategic plans. This was proposed by two organisations. An industry interviewee argued that evidence has shown that if policy mechanisms support digitisation, there is a greater uptake (current lack of support they said, can be seen in the difference in take up of technologies between, for example, Canada and Europe). However due to the importance of contractors in carrying out many farm activities, they proposed a 'technology voucher' that could be 'spent' by the farmer with the contractor. An environmental group supported this, arguing that digitisation would play a crucial role in the future in monitoring farming practises and impacts and improving data collection, which is currently poor, for policy adjustment.

An agriculture that needs to meet multiple objectives needs a multi-faceted policy. Six interviewees argued the importance of having policy objectives (i.e. renewable energy supply, the bioeconomy, food production etc.) matched to the current resource based and ecological limits. By focusing on each policy target individually, there is a real risk that the cumulative resource needs of these targets add up to more than the available land area in the EU.

Definition of the active farmer was brought up by three of the interviewees (one industry, two producer organisations). One producer organisation proposed a stronger active farmer definition to ensure that only *active* farmers benefit from the CAP. An industry respondent also called for a focus on subsidies going to active farmers rather than landowner-landlords or investment firms buying up vast swathes of land. In contrast to this, another producer organisation called for a clearer definition between landowner farmers and farmer tenants to benefit landowners as, according to their viewpoint, landowner farmers are often more invested in the long term value of their land (and therefore the associated ecosystem services) whereas farmer tenants are more inclined to see land merely as an input for production.

Investment and start up aid for young farmers. This is important throughout the entire budgetary period.

Remove unnecessary red tape. that Is thwarting the introduction of new innovations.

REDII Directive. More by products should be added to the annex, and this combined with an increase in support for sequential cropping would enable farmers to be more involved in the biofuel market, without impacting on food crops.

Education Environment should be included as mandatory in the curriculum of those entering farming (agricultural colleges etc.).

Risk management tools (1 producer organisation) should be mandatory for all MSs to offer

Redefine the definition of permanent grassland in the EU. Currently permanent grassland is defined as a grassland that is 5 years old or moved. However, this encourages farmers to plough up fields before their pasture reaches 5 years (as they are then obliged to maintain it as grassland). The definition should extend to 10 or even 20 years' and include variable grassland.

Remove coupled support for farming such as suckling cows. There is no legitimacy to these subsidies. Instead give them the money to support pasture.

Long term – a new CAP?

Whilst all interviews believed that there was still a great deal of room for improvement in the current policy framework , 9 of the interviewees considered that the current CAP architecture would be too limiting in the drive to transition the European agriculture to a more sustainable model. Suggestions for an overhaul of the current CAP focused primarily on a shift away from direct payments and focus on income support to a policy that looked at the food system as a whole and/or compensated only public goods. A summary of additional suggestions included:

· That the CAP should be used almost entirely for paying for public goods (all respondents)

· A land use policy. When we consider that one farmer maybe managing several elements that are needed to meet certain climate/environmental objectives but deal with different policies (renewable energy, forestry) it makes sense for the whole farm should be considered as one unit.

· A Food-land-environmental policy. The current 'farm' policy does not consider consumption and food waste – both key drivers of what and how we produce.

· Eligibility for such a policy should not be based on if you have land but rather on if you produce public goods and could widen the recipient definition to include, for example, municipalities, distributors etc.

· Part of the policy should be devoted to a transition fund (subsidised credits and grants to support changing farming types, speeding up a move to agroecological practises etc.).

· Food pricing. Food prices need to reflect the real cost of production but recognising that food price rises are regressive effort should be made to simultaneously identify smarter schemes to support those that will struggle with food price rises.

- **Question 5: Do you think the methodology for impact assessment of future CAP reforms (or other land-based policy such as LULUCF regulation or the Renewable Energy Directive) needs to be improved, and if so, why and how?**

- **Lack of interaction between new indicators in the CAP**. There is a need for a holistic view of the agricultural challenges, including the economic, social and environmental and impacts of decisions.
- **Cumulative impacts of EU policies** with respect to coherence and the cumulative impact on resources
    - Impact assessments assume a **certain degree of implementation**, whereas much of the CAP is voluntary thus giving an inaccurate representation of the reality.
    - **Modelling trade-offs**. The need to model the trade-offs (incentives and disincentives and the range of juxtaposed issues).
    - MAC curves and other tools used to assess policy options are heavily tied to the economic cost of implementation. For example, some measures within the ECAMPA studies were dismissed, as although effective for climate, they were considered as being too costly when compared to other actions. However, the '**true' costs** should take into account the cost of inaction i.e. the cost of environmental externalities, the cost of inaction on climate.
    - **Data quality**. Impact assessments are often based on poor environmental data. For example, in the current impact assessment of the CAP modellers could not differentiate between organic and conventional agriculture as data for organic agriculture was lacking. One environmental interviewee mentioned that in a recent

study they found the environmental evidence behind the policy decisions in the CAP to be often baseless and another interviewee argued that unless we can measure impacts, such as soil carbon, how can farmers be compensated. If a farmer already has good soil carbon, does he/she not get compensated. Should they destroy the benefits to regain access to the incentives?

- **Human behaviour.** Farmers don't take pure economical decisions but rather decisions are also driven by timing/ income and cash flow availability/ culture etc. (the fact that farming has been a loss making industry for so long, and yet farmers continue to farm shows that there is more to it than economic impetus).
- **Farmers will rarely use the 'optimal' amount of pesticide or fertiliser** but will often over apply for the 'safety net'. This is not considered in impact assessments.
- **There is too much use of average figures by DG AGRI**. When DG AGRI uses average figures, it creates an inaccurate picture of the situation as the situation is far more complex at a local level (extensification and intensification can be in the same farm, region etc.).
- **Review the way farmer incomes are calculated**. Currently the calculation does not consider off farm income which brings in the calculation of farmer incomes far lower than reality, which is used as a justification for income support in the CAP
- **Illegality**. A great deal exists in the agricultural sector but is not picked up by statistics (overuse of water/ illegal workers/ land conversion not reported). This issue has been recognised in the fishery sector statistics but is yet to happen in agriculture.
- **Short term v long term**. Need to include the long-term impact on EU farmers whose income is still low compared to many trading blocs.
- **Wellbeing of farmers**. The overall wellbeing of farmers should be included as an indicator
- **Improve methods of LCAs that feed into models**. LCAs are very time specific i.e. they show a situation at a point in time, but do not take into consideration the long term impact of a system of production and therefore LCAs almost always favour intensive livestock systems as they are shown to produce more output per unit of input. Consider organic farming which has a greater focus on soil health. In the short-term organic comes out worse than conventional farming in terms of productivity and energy use etc. But in the long-term organic farming will have better soil health, less erosion, more carbon storage etc. Therefore, more work needs to go into adapting LCAs to measure agro-ecological systems.

3. Need analysis for expert practitioners

The workshop entitled "Improving environmental and social capacity of EC impact assessment tools" was held online on the 14th and 15th of July 2020. There were 37 attendees from different institutions, mainly from DG AGRI and JRC.

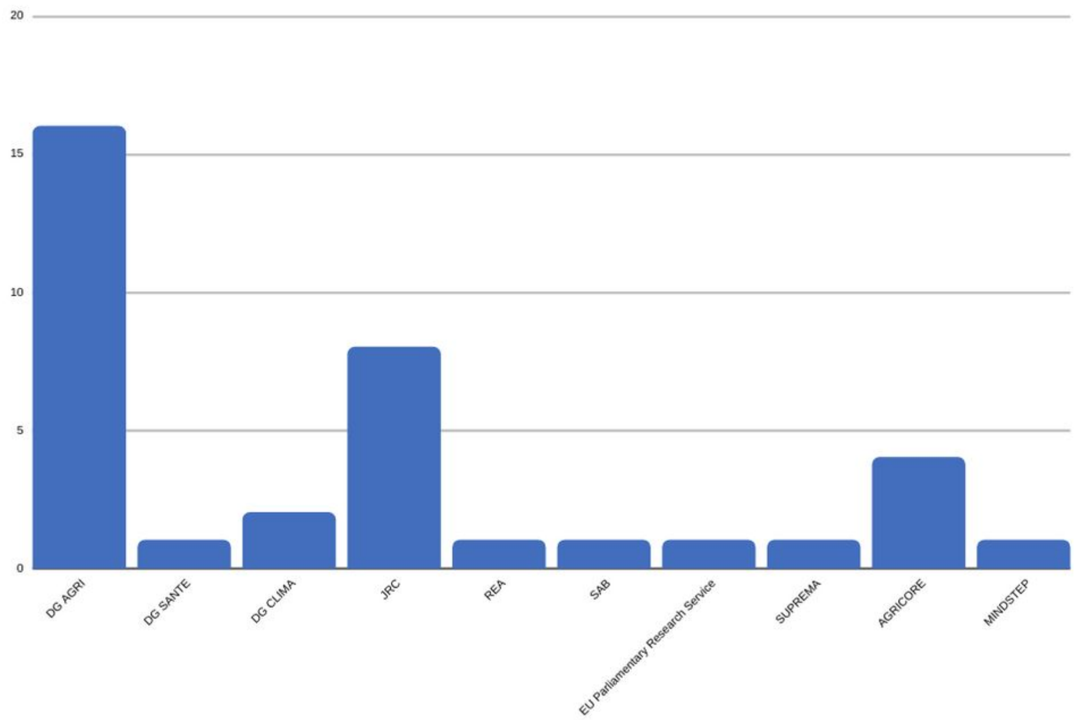

Figure 6: Number of workshop participants per organisation

The workshop was conducted of plenary sessions and three thematic breakout discussion groups which are briefly described in the following:

3.1. Agricultural impact modelling in the EC and Member States

In this session it was discussed who in the commission uses tools such as models and where there is a need for models in the policy cycle, regulation, inter-institutional agreements. Additionally, the need for IA on amendments to proposed policies during the co-decision process with the Council and the European Parliament was discussed. It was mentioned that it may be the exception to the rule for member states to **use models to make strategic plans**. In the long term, there may be a modelling need in the creation for future rounds of strategic plans. Changes on how IA is conducted in the modelling were also debated. Specifically a demand for adding **territorial aspects into future IA was mentioned**, more maps and perhaps more approaches to go below the NUTS3 level to use spatially explicit models may be required. Furthermore, **Foresight** has been mentioned as an increasingly important tool for making decisions regarding all stages of policy development.

3.2. Post-2020 CAP and SDGs indicators

In this session it was discussed which social or environmental indicators are currently missing and which are more important for modelling tools already in use. Some conclusions indicate that specifically, **landscape elements need to be included in models** as well as indicators to **evaluate ecosystem services. In particular, systematic evaluation of** peatlands in Europe was identified to be missing. Resilience of farming systems and how to evaluate this given that resilience must be modelled in a variety of ways was also a topic of concern among attendees. Farming systems present a lot of elements and components and only a multi-criteria assessment can integrate them in several models. Output indicators have been well considered but impact indicators are seen as more useful. However, resilience modelling requires a combination of indicators which is not currently clear in Post-2020 CAP documentation.

BESTMAP could explore how indicators can be combined to envisage the direction where the resilience of the system is going (improving or not). Finally, the role of models for transferring information from results indicators to impact indicators was discussed and identified also as a potential area to be explored in the project. The fact that not many SDGs indicators and CAP post 2020 indicators are in common was not seen as a problem because SDGs are more global and go further beyond agricultural aims. DG AGRI advised on proposals to have one composite indicator on improving farm resilience.

3.3. Macroeconomic and ecosystem services model linkages

The third session focused on the following questions “What land use/land cover/forestry changes and/or agri-environmental schemes adoption do the existing tools struggle with?” and “What evidence is there for non economic rationalization and farmers’ heterogeneous response to incentives, and how do existing models used by DGs/JRC (e.g. GLOBIOM) capture those?“. It was discussed that the importance of farmer decision making may have a large influence and that this is captured poorly by current tools, especially with regard to more complex behaviour. Most current models are based on economic decisions alone. The group shared a strong feeling that this needs to be captured due to its expected impacts on policy analysis. The group discussed how to look at the intricacies of complex behaviour without being overwhelmed by data and agreed there is a need to utilise existing datasets to use as predictors. In addition, limitations in using past data to predict the future during periods of change, as describing behaviour and decision making becomes more complex were discussed.

4. Needs analysis for biophysical modelling community

To reflect on a range of current issues arising from the biophysical modelling community, talks from the Isaac Newton Institute for Mathematical Sciences (INI), Cambridge, were used as a basis to collate and consider topics that need further research. INI ran two workshops in 2019; (1) Current status and key questions in Landscape Decision making (Isaac Newton Institute for Mathematical Sciences, 2019a) and Progress on novel mathematics and statistics for Landscape Decisions, including priorities for further research (Isaac Newton Institute for Mathematical Sciences, 2019b). Despite a myriad of information requirements surfacing from the biophysical community, several common themes arise; these can be grouped under; (1) uncertainty, (2) scale issues, (3) coupling of models across scales, and (4) issues around data resolution.

4.1. Uncertainty

Hydrological cycle diagrams can be misrepresented and simple and not reflective of uncertainty (Sheffield, 2019). Uncertainty is important to identify, and indeed has been investigated by data providers such as the British Geological Survey (BGS), though it can be difficult to add uncertainty to products (Marchant, 2019). Standard errors in products can be provided, but its usefulness is debatable, as will modellers use it in their models, as the errors may be treated as independent of each other, though may in fact be spatially correlated (Marchant, 2019). Uncertainty corresponds to one scale, but users of the data may change the scale (Marchant, 2019). There are uncertainties in the influence of different institutions/policies in the real world and in the 'model world' this can translate as to the need to consider different agents that act at different scales, and the interaction amongst them (Ziv, 2019). There are various challenges in decision making in the face of uncertainty, as Ziv (2019) identifies:

- Improving uncertainty quantification for Agent Based Modellers, including the ability to choose the appropriate level of model complexity. This requires data to help mitigate non-rationality of people.
- The statistical methods behind defining 'enumeration' units should be considered in line with the scaling behaviour of ecosystem services and ecosystems provisioning areas. But what scale should this be measured at?
- Interaction between modellers can be encouraged through a 'virtual lab' environment with collections of input or forcing parameterisations. This would allow different integrated models against commons standards.
- There is a long standing issue of valuing biodiversity and approaches of sing risk or vulnerability could be used to incorporate it into natural capital accounting.
- There is a need to develop a mathematical understanding of the validity of 'strategic' models compared to 'tactical' models. There is a need for a 'decision' tree for best practice for communicating and quantifying models for use with policy makers.

4.1.1. Propagation of uncertainty *(the effect of a variables uncertainties on uncertainty of a function based on them)*

The importance of the propagation of uncertainty is likely to be important depending on the product, i.e. for Home Buyers reports, with data provided by the BGS, if the boundary of a feature begin wrong by even only 50 meters can mean the difference of that feature being included in the buyers land, or not (Marchant, 2019). In terms of 3D geological modelling, the complexities of the different elements can mean that a lot of interpretation (which will vary even between experts) rather statistical or process based modelling, hence a challenge is how to quantify that type of uncertainty (Marchant, 2019).

4.2. Scales

Spatial scales can be looked at in two ways; the measure scale (including spatial extent and spatial resolution) and the phenomenological scale (Graham, 2019). Spatial structure can be 'lost' as the resolution is increased (Graham, 2019). Hence a balance in needs vs. resolution needs to be considered. An approach to help has included moving window approaches, multiscale geographically weighted regression and Bayesian melding (Graham, 2019).

There can be huge uncertainties as processes are upscaled. For example, with evapotranspiration, the range of processes can be at the plant, stand, catchment scale, though there are uncertainties regarding magnitude and variability across scales (Sheffield, 2019). Process interactions can occur both at and across multiple scales (i.e. surface water – groundwater interactions) (Sheffield, 2019). Hydrological processes operate and intersect at a range of characteristic time-space scales (Sheffield, 2019). Prediction can rely on the time scale, i.e. hourly runoff compared to daily runoff can result in extremes being lost in the data through aggregation, it will depend on the type of data that is available (Sheffield, 2019). Water and food security, especially has a problem of spatial scale. Varying scale of computation with model experiments can change the results dramatically (Sheffield, 2019).

There is a need to focus and think more about scaling in hydrology, it would help with understanding fundamental behaviour, identifying key processes and interactions, improve parametrisation of models through understanding scaling behaviour and decision making (Sheffield, 2019). As part of this there is a problem of how interactions with multiple processes across scales affect behaviour at other scales and the transference of information from the 'observable scale' to the 'decision scale' (Sheffield, 2019). There is a lack of data to characterize the processes and improve the models (Sheffield, 2019). There are lots of issues with how human interactions are characterised across the scales (Sheffield, 2019). There are scale implications for decision making (Sheffield, 2019).

4.3. Coupling models (across scales)

Model coupling is a difficult but important problem that needs addressing (Blair, 2019). There is both increased completely in distributed systems (i.e. internet of things, sensors, cloud computing, etc) and environmental sciences (Blair, 2019). Coupling of multiple models has several issues around interoperability and 'middleware'; semantics (data dictionaries and ontologies), transfer functions, scaling (scale matching), uncertainty and Quality of Service (management of the network and distributive system) (Blair, 2019). There are three elements as part of the solution; (1) coupling as a first class entity (allowing coupling to have a very complex architecture), (2) coupling framework, and (3) a virtual lab (Blair, 2019). There is a debate in the community of whether and/or where coupled modelled should be used (Harper, 2019). Model coupling has several communication challenges, including between disciplines and between models (scale mismatch, output/input mismatch), and the intensity of the process should not be underestimated (Harper, 2019). Structural uncertainty can also be an issue, where uncertainty comes from the actual model equations, and whether the right equations are being used, which can be addressed by comparing different models (Harper, 2019). Error propagating and uncertainty are also an issue for model coupling. This can be as amplification of errors and biases as a result of coupling, the difficulties in reducing bias, as a modelled system will behave differently from an uncoupled system, and cascading uncertainty (Harper, 2019). There is always a concern for uncertainty propagation, magnifying through models in integrated/coupled models, with more complex methods looking at uncertainty from the scenarios (Holman, 2019). Qualitative (variable-to-variable) uncertainty analysis can also be undertaken by capturing the views of the models, on their own models, which can be important (Holman, 2019). As a community we are not very good as sampling a range of models and the model structures within the range of models that are selected which are a result of modellers choices (Holman, 2019).

Rounsevell (2019) suggests that new coupled land system models have a need to:

- Account for human behaviour and decision processes.
- Have the ability to deal with international trade in land commodities.
- Process based representation of ecosystems.
- Linkages to ecosystem state.
- Linkages to impacts on biodiversity.
- Accommodate feedbacks between biophysical and human systems.
- Impacts on land system change.
- Cover multiple scales, from local to global.

4.4. Issues of data resolution

Currently, water use models, the skill level of the community can be seen to cover a spatial scale of basin to continent level, and temporally from monthly to centennial scale; the desired skill is from the field and weekly level upward) (Sheffield, 2019). Currently the resolution leads to low relevance for water-energy-food decision making (Sheffield, 2019). The resolution of data is also related to the geographer's 'modifiable unit area' problem, where the results can change of the unit area studied (Ziv, 2019).

5. Needs analysis for ABM modelling community

This section compiles the needs of the (land use ABM) modelling community important for improving agricultural models in the European context. The requirements as well as possible ways forward were raised during the discussions in a set of international workshops / conferences in the last years and can be classified in four domains: (5.1) the adequate incorporation of psychological and social factors in models of farmers decision making, (5.2) the need to develop suitable approaches to upscaling and bridging scales in social-ecological models and on generalising results from specific case studies, (5.3) the needs related to good modelling practise and transparency including validation and (5.4) the appropriate design of models to enhance policy support.

5.1. Psychological and social factors in models of farmers decision making

During a workshop on representation of EU farmers' decision making in agricultural agent-based models which took place in Zurich 2017, the organisers invited the developers of the most prominent agricultural agent-based models and further experts on incorporation of human decisions in agent-based modelling. With the help of participatory methods, challenges and prospects of agricultural ABMs were crystallized: Above all, there is a need to represent farmer behavior in models in a more realistic manner. In current models mostly only economic influence factors are considered (Groeneveld et al. 2017). In addition, the necessity to include cognitive individual processes, personal characteristic, learning and social interactions was expressed (cf. Huber et al. 2018). Furthermore, it was argued that the coexistence of agricultural and non-agricultural activities, the heterogeneity of household and family characteristics and the concurrence of short and long-term decisions are important properties of farmers' decision making (p. 156). However this claim is made for farmer decision making in general and not specific for adoption of agro-environmental schemes.

With respect to AES adoption it was stated that “Complex representations of decision-making with respect to cognitive or social aspects are currently not, or only partly, implemented in explanatory models with full empirical parameterization.”

However, it was pointed out that a more detailed representation of the decision-making processes may “intensify” “challenges of calibrating, validating and communicating agricultural ABM” in particular if they are used for policy support. The danger of creating “integronsters” (O’Sullivan 2016) has to be kept in mind and appropriately dealt with. To tackle these challenges careful software engineering techniques, sophisticated sensitivity and uncertainty analyses techniques are proposed. As a critical challenge, data availability in particular with respect to interaction among farmers was pointed out.

5.2. Upscaling and bridging scales in social-ecological models and generalising results from specific case studies

Key challenges and promising ways forward related to scaling were discussed in March 2018 when the UFZ hosted the international workshop on “Modelling approaches to enhance food security: Synergies from bridging the gap between the micro and the macro scale”. Land use modellers working at micro scale and those at macro scale carved out six conceptual and methodological challenges: (1) Interdisciplinary thematic scope; (2) Representation of agency by exploring the roles of new agent types in food systems; (3) Appropriate techniques for representing relationships and feedbacks across scales and organizational levels; (4) Integration of different modelling approaches; (5) Empirical foundation, data availability and model parameterization and (6) modelling transitions (including unexpected change) (cf. Müller et al. 2020). With respect to suitable approaches to upscaling and bridging scales, ways forward discussed with respect to (3) and (4) are of importance to mention here: Ad (3): As promising strategies for upscaling information from the micro to the macro level, firstly, statistical/ meta-modelling (e.g., summary functions and machine learning) and secondly the classification of land use(r) types using local scale (gridded) data for the identification of land systems (so called archetypes, cf. Václavík et al., 2013; Malek and Verburg, 2017) that capture essential features of the underlying system were referred to. In particular the second approach is adopted within the concept of farm system archetypes and will be of central importance in BESTMAP (cf. Ziv. et al. 2020). With respect to (4), the integration of modelling approaches in particular by the coupling of computational general equilibrium models (CGE) and ABMs is pointed out (Niamir & Filatova 2015 as one of the rare existing examples). Thereby the CGE is used to represent the whole economy, and an ABM to represent a sector in more detail including greater spatial detail and agent heterogeneity (Rounsevell et al. 2014).

Two specific workshops have been carried out at Helmholtz Centre Karlsruhe Institute of Technology KIT Garmisch-Partenkirchen, Germany (January 2018) and virtually in May 2020 on “Large-scale behavioural models” in organisation of Mark Rounsevell and Calum Brown. The aim of these workshops was to think forward on developing an alternative to current top-down macro-economic models by next generation models which include agency and behavioral processes in a more realistic way (cf. website of the respective Global Land Program Working Group) This involves also new representations of institutional processes and their relationships with land users. Furthermore, ways forward on coupling these large scale land use models with other large scale models, such as global vegetation models or climate emulators have been discussed.

In the centre of the International Symposium “From cases to general principles - theory development through agent-based modeling” in Hannover, Germany funded by Volkswagen Foundation 2018 was a critical reflection of best practices on use ABM for an improved understanding and management of complex social-ecological systems (Lorscheid et al. 2019). A focus was set on the need to identify general principles or to develop a general theory by using ABM. In order to fulfill these requirements, a cross-disciplinary discussion, goal-oriented synthesis and further development of modelling standards have been pointed out as ways forward.

5.3. Good modelling practise, transparency

With respect to the last point mentioned, modelling standards, the discussions during the international workshop “The Open Modeling Foundation Initiative: a Scientific Community for Common Standards and Best Practices for Integrative Modeling of the Earth System“ at the Institute for Advanced Sustainability Studies, Potsdam, Germany in May 2019 have been of importance. This initiative aims to “coordinate the development or adoption of pan-community standards that accelerate knowledge scaffolding among modeling scientists, and promote the creation and use of more reusable, replicable, interoperable, and reliable models.” (see also https://openmodelingfoundation.org/). The modellers in Bestmap have signed the open letter and are following the proposed guidelines (such as using open-access model repositories) and are contributing to advance them (e.g. ODD and ODD+D - a standard for ABM description, Grimm et al. 2006, Müller et al. 2013).

5.4. Use of models for policy support

Modelling is often proposed as a powerful tool to support policy making. In November 2019, the Competence Centre on Modelling of the Joint Research Centre of the European Commission organized a conference on modelling for policy support in Brussels to bring together researchers and policy makers involved in model development and use for policy support. Participants discussed challenges and best practices to improve the uptake and efficiency of models for policy making. Model transparency and quality was identified to be one of the key factors to make models accessible to policy makers who are not necessarily familiar with modelling. Furthermore, it was discussed how engaging stakeholders and policy makers already in the process of model design and development could be achieved. This could help to identify scenarios and data that are crucial for specific decisions in the model and thereby make models more helpful for decision making.

Although modelling for decision support is already a common practice in disciplines such as transportation planning, epidemiology, or pesticide risk assessment, the impact of socio-environmental modelling for policy making has been limited so far. By interviewing modelers from a diverse range of disciplines including socio-environmental modeling but also purely ecological modeling, Will et al. identified four key factors for successful modeling for policy and management support in socio-environmental systems: (1) modelling the human dimension has specific requirements that need to be taken into account, (2) harmonized data collection to ensure data availability and accessibility not only for environmental but also for socio-economic data is crucial for successful models, (3) the partnership between modelers and practitioners is an essential elements of the modelling process, and (4) as the consequences of decisions may reach well beyond the original scope of a single research questions, the interplay between modelers and practitioners is even more important. This includes that modelers are obliged to apply good modelling practices to ensure that practitioners can understand the model profoundly. Furthermore, a “policy champion” or “knowledge broker” as interface person between modelers and practitioners could support the collaboration of both parties.

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