PROJECT FINAL REPORT

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1. Final publishable summary report

1.1 Executive Summary

Climate change has long been known to affect the way humans use the land, for instance through affecting crop yields, the habitability of a region or hazards such as floods and storms. Likewise, land use is a strong global climate forcing agent. Land-based options to mitigate climate change are expected to deliver approximately a quarter of emissions reductions pledged by countries in their Nationally Determined Contributions (NDCs) under the Paris Climate Agreement, and are key to achieving a balance between anthropogenic emissions and removals in the second half of the 21st century. Land-based mitigation provides policy-makers with competing demands and trade-offs, but also possible co-benefits.

Land-based mitigation competes for land with food production, other ecosystem services & biodiversity. This competition can lead to increasing food prices as parts of existing agricultural land used to grow food is converted into bioenergy production. These price increase affect poor communities disproportionately. Land-based mitigation can also affect the ability of ecosystems to provide both the amount and the quality of ecosystem services, such as water provisioning, and can compete with the protection of biodiversity. It is, therefore, important to identify options that provide co-benefits, with possible measures including: Sustainable intensification through, for example, agroforestry and agropastoralism; Changing diets to reduce demand for land- and carbon-intensive products such as beef, through e.g. a tax or labelling; Restoring degraded forests to increase their carbon storage capacity and increase biodiversity; Using harvested wood products in buildings and other infrastructure to store carbon and reduce emissions from the production and transportation of cement.

In addition to greenhouse gas emissions and uptake, LULCC affects climate through biophysical effects such as the reflectance of sunlight from the Earth's surface, cooling from evapotranspiration and forests absorbing wind energy. The net effects of these processes play out differently in different parts of the world, and the magnitude is uncertain. It is, however, possible to evaluate regional and local impacts. Currently, land-based climate mitigation policy does not consider biophysical effects, but the following options are noted: Robust scientific results are needed before biophysical effects to be included in global policy frameworks; A method for the evaluation of the regional impacts of land cover transitions exists and can inform regional and national mitigation efforts; Biophysical effects are stronger and more certain at local scales and so have the potential to be considered in local land use planning policy; Due to the geographical variability in biophysical effects, the location of carbon offsetting schemes can determine much of their effectiveness.

Time lags and multiple goals strongly limit the effectiveness of land-based mitigation, but there is potential for improvement and co-benefits can be achieved. Time lags in policy implementation and uptake strongly influence the effectiveness of land-based mitigation policy, but uptake has been shown to be slow even in the presence of incentives, due to various social factors. Developing policies that systematically cut across policy sectors would achieve co-benefits for multiple policy goals, including the potential for achieving mitigation-adaptation synergies.

A key challenge for policymaking is considering the mechanisms for achieving land use visions that connect environmental research to issues of sustainable development, local communities, cultural heritage, and human health. Land-based mitigation is not a 'silver bullet' to avoid climate change, but alongside drastic reductions in fossil fuel emissions, it can contribute to delivering the 'balance of sources and sinks' envisioned in the Paris Agreement, if the policy options available to support this objective are implemented.

1.2 Project context and objectives

Context

Land-use and land-cover change is one of the key processes through which humans affect the functioning of the Earth system, contributing to both global environmental change and its impacts on human well-being. 40% of the land area is managed as croplands and pastures, and up to 80% of the land surface is impacted one way or the other by human activities.

Climate change has long been known to affect the way humans use the land, for instance through affecting crop yields, the habitability of a region or hazards such as floods and storms. Likewise, land use is a strong global climate forcing agent, through CO_2 release following deforestation, or emissions of greenhouse gases such as N_2O and CH_4 related to land management. At the beginning of LUC4C less well understood were the regional climate change implications through changes in biophysical exchange processes related to land-use related land-cover changes.

In the wake of the Paris COP21 agreement, issues of land use are becoming central for achieving a <2°C warming world. What is currently a source of greenhouse gases will need to be rapidly transformed into a sink, and maintained that way. Land-based options to mitigate climate change are expected to deliver approximately a quarter of emissions reductions pledged by countries in their Nationally Determined Contributions (NDCs) under the Paris Climate Agreement. Whether – and how – this can be achieved while enhancing yields, providing areas for conservation and biodiversity, and enhancing other ecosystem services is under debate.

Objectives

The overall objectives of *LUC4C* were to **advance our fundamental knowledge of the interactions between climate change and land-use change,** and in doing so **develop a framework for the synthesis of complex earth system science into guidelines that are of practical use for policy and societal stakeholders**.

The *LUC4C* project therefore sought to

1. discern the key elements of land use that have the largest effect on climate, including their dependencies across time and space;
2. develop innovative methods to better quantify the dynamic interactions between land use and the climate system at different time and space scales;
3. deliver a portfolio of synthesis products and best practice guidelines for the identification of benefits or adverse effects of land-based mitigation options across different scenarios and where conflicts occur, the need for trade-offs.

Over the course of the project duration, *LUC4C* examined the societal and environmental drivers of land-use and land-cover change (LULCC) relevant to climate change, and assessed regional and global effects of different land-based mitigation policies and adaptation measures. The representation of LULCC in land surface and climate models was improved especially with respect to quantifying the effects of global *vs*. regional, and biophysical *vs*. biogeochemical ecosystem-atmosphere exchange. The work in LUC4C also aimed to provide progress in process understanding that will lead to a better assessment of LULCC-climate effects on multiple ecosystem services and to analyse these in relation to other societal needs that provide either a synergy or trade-off to land-based climate mitigation and adaptation.

The following points emerged as highly relevant to be addressed and some of the key project deliverables provided evidence on these issues:

- Competition of land-based climate change mitigation for land with food production, other ecosystem services and biodiversity;
- Biophysical effects of land-use change can be significant for regional surface climate and need to be accounted for in climate change assessments;
- Policy decision making needs to factor in time-lags in order to assess effectiveness;
- The effort of land-based mitigation efforts need also be viewed in terms of risks, especially related to fire;
- Model experiments and mode-data comparisons have identified a number of large uncertainties in the land-use/climate change interplay which need to be acknowledged for policy decision making.

These objectives were investigated in the project with a range of observation as well as modelling techniques. These aimed at identifying uncertainties related to measurements, scenarios and modelling. At the same time, observations were also used to inform model-based assessments.

LUC4C also aimed to reach out to policy makers via various avenues, such as via the production of policy briefs, stakeholder events, panel discussions, sessions at COPs and contribution to climate and biodiversity policy assessments.

1.3 Main results

Today, nearly 80% of the land is impacted by human activities, approximately half of this area alone is used in form of cropland and pasture to provide food for the Earth's population. In addition, human societies demand fibre, firewood, building materials and space for settlements, recreation, spirituality and conservation. Given the large pool of carbon in global vegetation and soils, and the large exchange fluxes of greenhouse gases CO_2, N_2O and CH_4 between managed and natural ecosystems and the atmosphere, land use is also becoming increasingly central to fulfil yet another purpose: achieving a <2°C global warming in the wake of the Paris agreement. Land-based options to mitigate climate change are expected to deliver approximately a quarter of emissions reductions pledged by countries in their Nationally Determined Contributions (NDCs) under the Paris Climate Agreement, and are key to achieving the target of a balance between anthropogenic emissions and removals in the second half of the 21st century (Grassi *et al.*, 2017).

Managed lands which now are a source of greenhouse gases will rapidly need to be transformed into a sink, and maintained that way, while at the same time fulfilling demands by society for a broad range of ecosystem services beyond cli3mate regulation. Since the land area is limited in its extent and suitability, the direct and indirect implications of carbon dioxide removal options, and options for reducing GHG emissions on land must, therefore, be comprehensively addressed to understand their role in achieving a much broader range of environmentally important objectives in addition to helping deliver climate goals (such as SDGs or Aichi targets). Yet despite of being closely interconnected, land-use challenges such as food, fibre and energy supply, conservation and biodiversity, carbon sequestration and greenhouse gas emissions, water and air quality are still often studied (and managed) separately, which is inappropriate and high-risk considering that land-use decisions made today will have effects over decades.

Based on 40 months work in the LUC4C project, we highlight recent advances in our understanding of land-use change in the climate system, placed in context of the broader peer-reviewed literature, and identify emerging issues and challenges of land-use especially in view of supporting a <2ºC warming world.

1.3.1. Competition of land-based climate change mitigation for land with food production, other ecosystem services and biodiversity

The land area required to achieve emission reductions from land-based mitigation consistent with most 2°C scenarios is substantially higher than the land area currently identified as in marginal agricultural use or recently abandoned from agricultural use (Humpenoder *et al.*, 2014;Popp *et al.*, 2014;Engstrom *et al.*, 2016a). However, potential land allocation for climate change mitigation depends on other claims on the same lands, the degree of climate change, technological developments and dietary preferences (Humpenoder *et al.*, 2015;Alexander *et al.*, 2016a;Engstrom *et al.*, 2016a). There is evidence to suggest that land-based mitigation already has increased food prices, and models predict further increases, due to the competition for land and the direct use of food crops as a bioenergy feedstock (Kreidenweis *et al.*, 2016; see their Figure 2, next page). Land-based mitigation policies and strategies in one location affect land use elsewhere due to displacement; an example of indirect land-use change (iLUC)(Popp *et al.*, 2014) which can be a major source of GHG emissions that are not always reported, particularly when the displacement happens in countries with limited reporting of GHG fluxes.

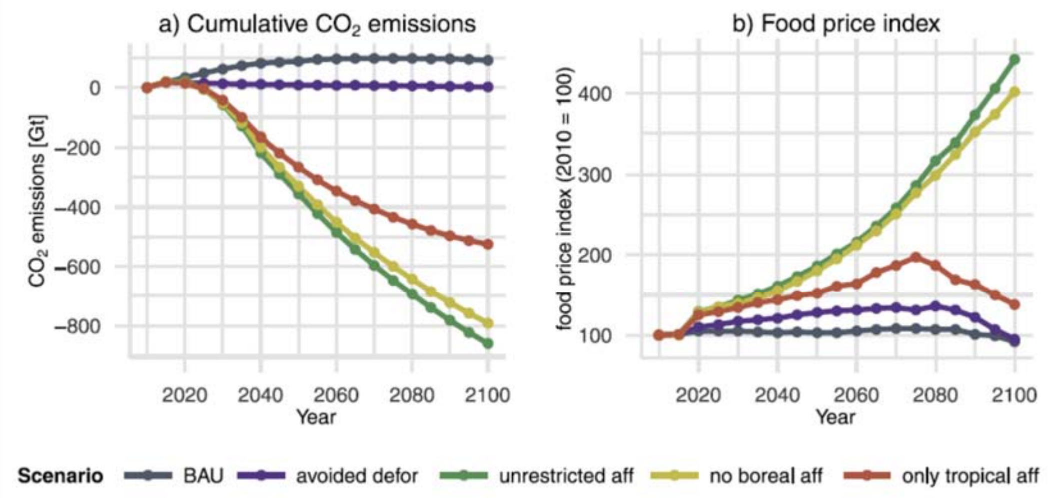

Figure 2. Cumulative emissions and food prices. (a) Cumulative CO_2 emissions from land-use change and afforestation from 2010 until 2100. (b) Laspeyres food price index for crop and livestock commodities (2010 = 100).

Terrestrial ecosystems provide a range of ecosystem services, but land-based mitigation may affect the ability of ecosystems to provide both the amount and the quality of some of these services. Intensification of agricultural land use could free up more land for climate mitigation, but will likely have adverse environmental impacts, such as the pollution of water resources by nitrogen detrimental, effects on air quality, or altered runoff and flood risks (Bonsch *et al.*, 2016; Krause *et al.*, 2017, see their Figures 2 and 4, next page). For instance, bioenergy production has a higher water demand than any other alternative energy source, and can compete with other water uses unless managed carefully (Bonsch *et al.*, 2016;Krause *et al.*, 2017).

Intensification of food production could lead to more land being available for other uses, but is associated with large nitrogen losses to the atmosphere and water pollution from fertilisers (Krause *et al.*, 2017). Provisioning services (such as food and biomass production) and regulating services (such as carbon sequestration or flood protection) are currently often not compatible, but they could be with more integrated approaches to land management. Provisioning services are often more tangible and easier to exchange in the market than regulating services (Bayer *et al.*, 2015), cultural services, or the protection of biodiversity (Eitelberg *et al.*, 2017).

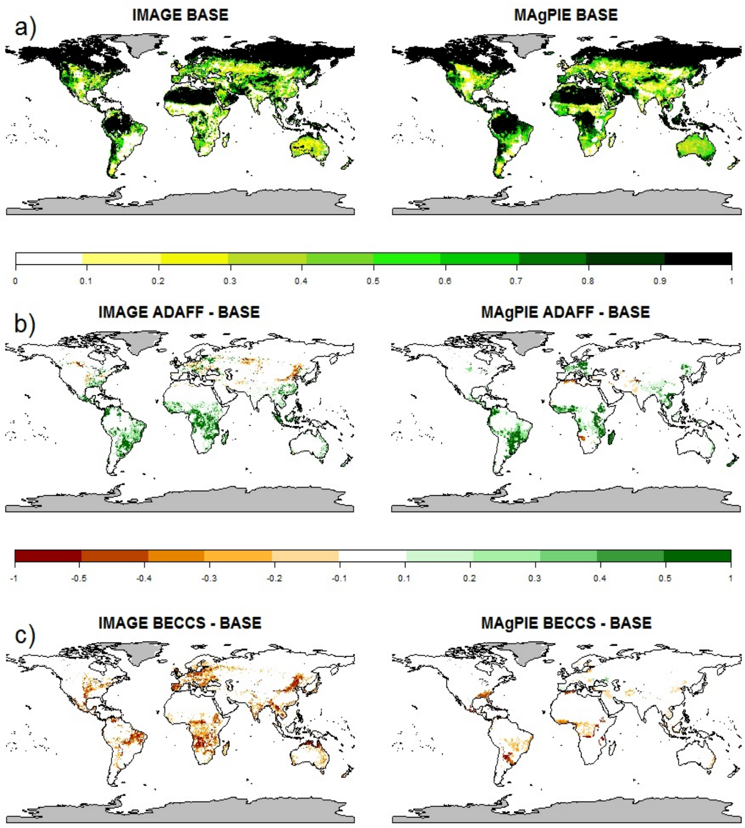

Figure 2 (from Krause et al.)

a) Fraction of grid-cell under natural vegetation (including area afforested, but not degraded forests) by the end of the century (2090-2099) in the BASE scenarios.

b) Difference in the natural vegetation fraction between the ADAFF and the BASE scenario (2090-2099).

c) Same as b) but between BECCS and BASE.

Land-based mitigation competes for land with biodiversity, but there is also potential for achieving co-benefits. Some land-based mitigation options are incompatible with biodiversity goals (Krause *et al.*, 2017). Afforestation using monoculture plantations reduces species richness when introduced into (semi-)natural grasslands (Popp *et al.*, 2014); a habitat that is prioritised for instance by EU policies on biodiversity.

Evidence suggests that when faced with conflicting mitigation and biodiversity goals, biodiversity is typically given a lower priority, especially if the mitigation option is considered risk-free and economically feasible (Humpenoder *et al.*, 2014;Alexander *et al.*, 2015;Humpenoder *et al.*, 2015;Eitelberg *et al.*, 2016). Approaches that promote synergies, such as avoided deforestation, land sparing and sustainable farming practices in bioenergy production, and longer rotation-times and mixed-species forests in afforestation-reforestation, can avoid the loss of biodiversity from land-based mitigation. Systematic land-use planning would help to achieve land-based mitigation options that also limit trade-offs with biodiversity.

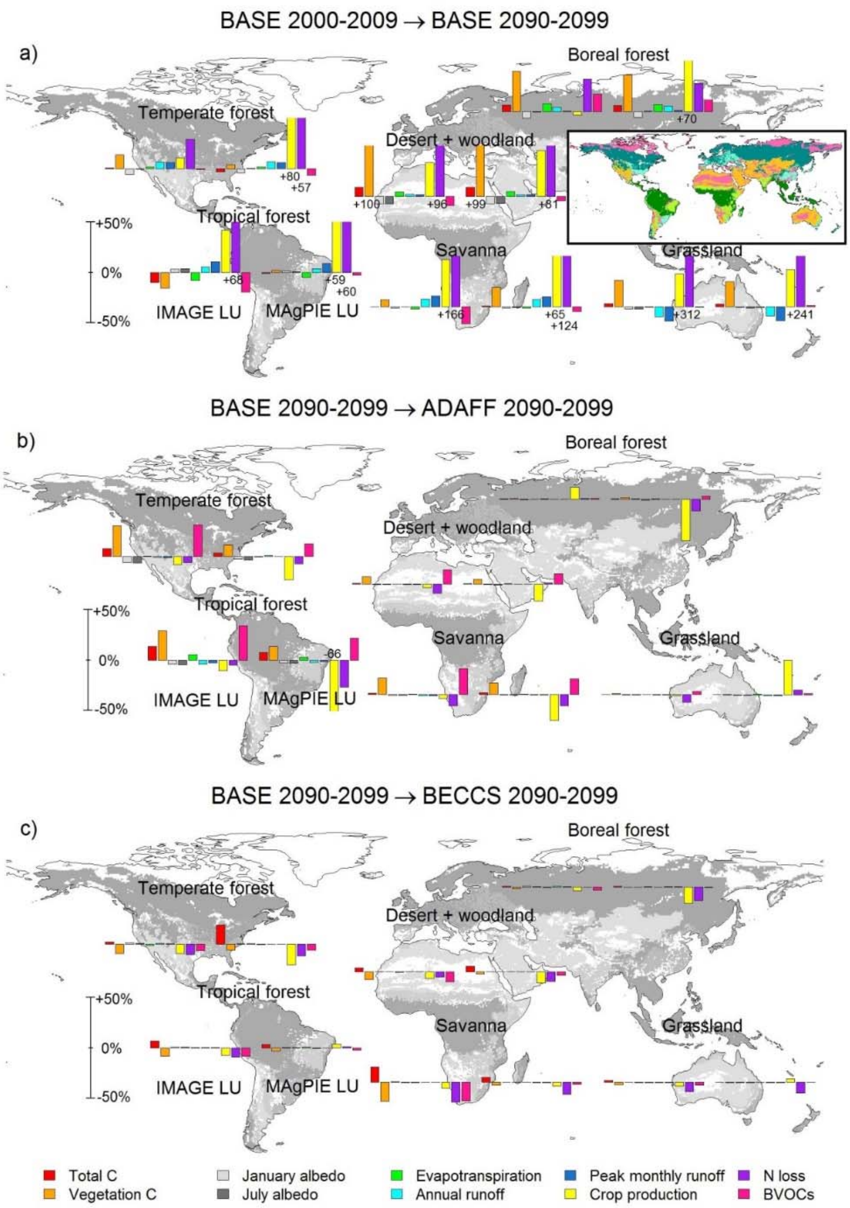

Figure 4 (from Krause et al.)

Global (per Biome) relative changes in analysed ecosystem properties and processes, simulated by LPJ-GUESS for different LUC scenarios from IMAGE and MAgPIE. Changes are capped at ±40% for clarity reasons, values exceeding 40% are written below the bar.

a) changes in the BASE simulation from 2000-2009 to 2090-2099.

b) changes from BASE to ADAFF by the 2090-2099 period.

c) same as b) but from BASE to BECCS

1.3.2 Biophysical effects of land-use change can be significant for regional surface climate and need to be accounted for in climate change assessments

Biophysical effects include the reflectance of sunlight from the Earth's surface (albedo), cooling from evapotranspiration, and the surface roughness that affect the wind speed. Changes in vegetation cover alter the reflection of sunlight; crops and pastures tend to be more reflective (higher albedo) than darker forests (lower albedo), and this has a cooling effect. However, forests have higher evapotranspiration rates than crops and pastures, which cools the land surface as well as recycling water to fall as rain. Also, forests absorbance of wind energy has implications for local surface temperatures. LULCC affects climate therefore not only through greenhouse gas emissions and uptake, but also through biophysical effects, especially at the regional scale (Perugini *et al.*, 2017; see their Figure 2, below; Quesada *et al.*, 2017a; Quesada *et al.*, 2017b). Larger scale LULCC can affect circulation patterns and have out of region impacts, however the scale at which this becomes important is uncertain (Quesada *et al.*, 2017b).

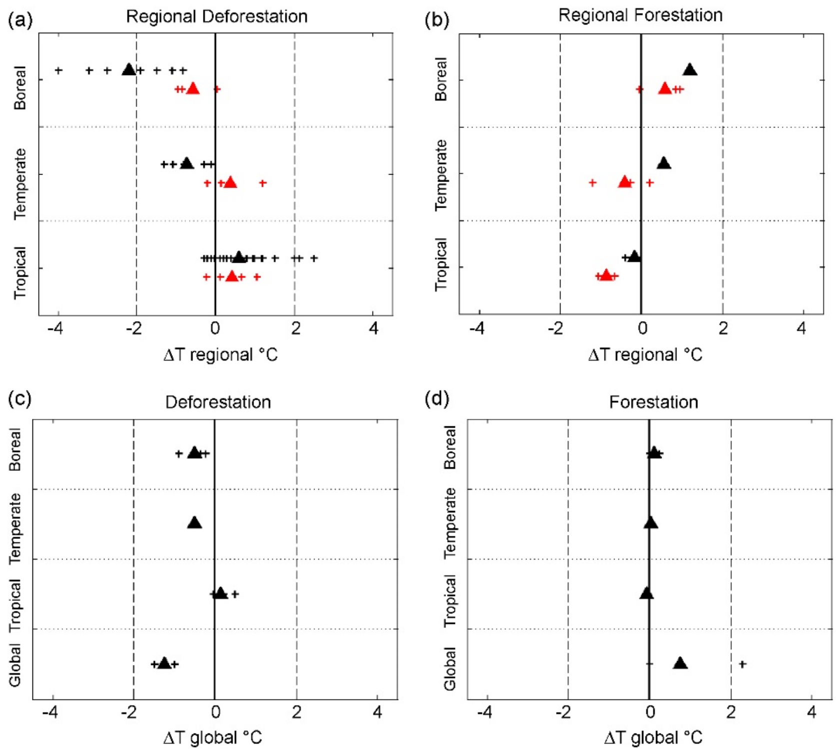

Figure 2 (from Peruginin et al.) Biophysical effects of complete regional LCC deforestation and forestation on regional and global average surface air temperatures (°C). Red crosses represent observational results, whereas black represent results from model simulations. The filled triangles are the mean of each cluster. Panels (a) and (b) show the regional ΔT associated with regional deforestation and forestation respectively, panels (c) and (d) show the global ΔT associated with regional and global deforestation and forestation.

The net effects of these processes play out differently in different parts of the world. Satellite observations show that large-scale regional deforestation has a predominantly warming effect in the tropics and parts of the temperate zone due to reduced evapotranspiration (Alkama and Cescatti, 2016). In the boreal zone, however, deforestation causes cooling due to increased reflection of sunlight linked with the effect of snow cover—although the agreement between measurements and models is less clear than in the tropics (Alkama and Cescatti, 2016; Perugini *et al.*, 2017). Uncertainties remain regarding the magnitude of the effect, especially for seasonal variables (e.g., maximum summer temperatures) and for the effects on precipitation, but it is now well established that the regional biophysical effects of land-cover change are substantial (Alkama and Cescatti, 2016; Duveiller *et al.*, 2016; Perugini *et al.*, 2017;Quesada *et al.*, 2017a; Quesada *et al.*, 2017b). Furthermore, biophysical effects on local temperature are more rapid than warming arising from global atmospheric CO_2 levels. Thus, mitigation actions taken at the regional level would benefit from considering the consequences of biophysical effects on local temperature as well as the impacts of GHG emissions. There are major benefits in doing so, especially in tropical regions, since accounting for the biophysical climate effects of LULCC can support both mitigation and adaptation objectives and thus make policy more effective. Future atmospheric CO_2 increases will increase vegetation growth through a ‘fertilisation’ effect, and this will further enhance the biophysical cooling effects of forests. Thus, avoided deforestation as a land-based mitigation option benefits from positive effects on both the regional and global climate systems (Pugh *et al.*, 2016b).

Current global policy frameworks do not consider biophysical effects, and hence opportunities exist for policy to realise co-benefits. Although local biophysical climate impacts from LULCC are large, they tend to be much smaller when aggregated globally; this has implications for global policy. The process of including land-based mitigation in the UNFCCC context has been a matter of long and complex negotiations. Hence, the relatively small and currently uncertain global biophysical effects make it difficult to justify efforts to include these effects in the complex negotiations of the UNFCCC process, at present. However, it is now possible to evaluate the regional biophysical impacts (changes in local temperature) of land cover transitions, following a tiered approach similar to that of the IPCC method to estimate the effects of GHG emissions. The method applies three levels of increasing complexity, from Tier 1 (i.e. default method and factors) to Tier 3 (i.e. country-specific methods and factors; see LUC4C deliverable report 7.2 and 7.4, and Figures from these deliverables, below and next page). The procedures proposed for each tier are transparent, taking into consideration the UNFCCC reporting principles and could inform mitigation efforts at regional or national scales to realise the co-benefits of accounting for biophysical effects.

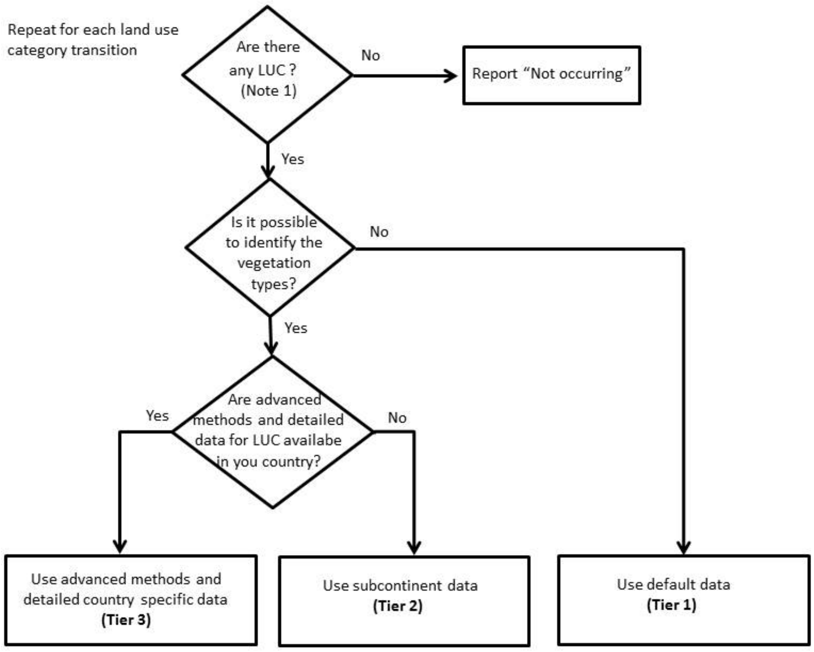

Figure 1 (from D7.2). Decision tree for identification of appropriate tier-level for land converted to another LU category.

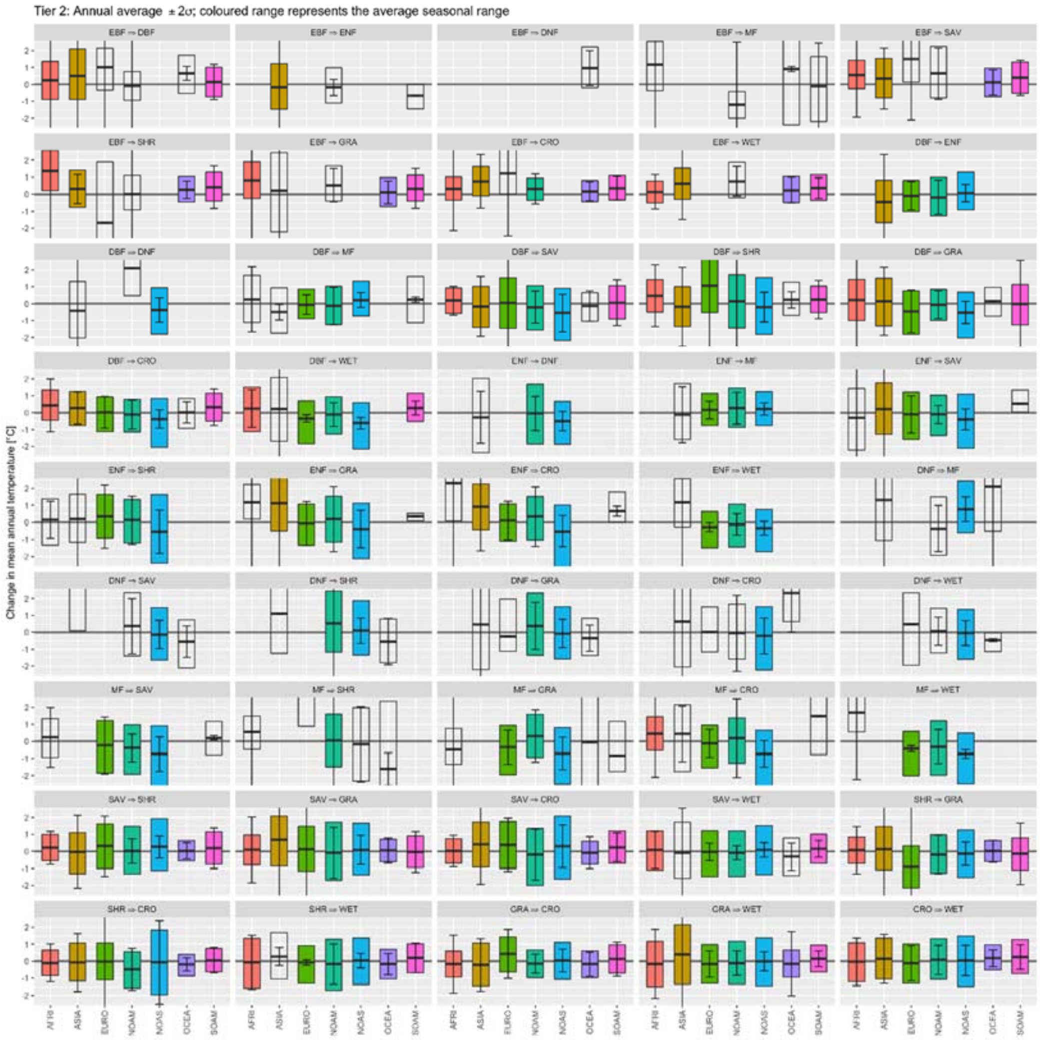

Figure 2 (D 7.2). Changes in temperature following different potential transitions and aggregated per climate zones at Tier 2 level. Each plot refers to a specific potential LC transition while the coloured bars refer to subcontinent classes. The thick black lines represent the mean annual values; the error bars show the spatial variability around these means and are represented by ±2 standard deviations; the bars dimension refers to the effect of seasonal variability. The colour of the bars serve to highlight which macro-region is shown, and when no colour is shown this indicates the sample number to derive that specific statistic was below 30 points.

1.3.3 Policy decision making needs to factor in time-lags in order to assess effectiveness

The relative contribution to climate mitigation of different land-based mitigation options changes through time (Pugh *et al.*, 2015;Krause *et al.*, 2016). Avoided deforestation provides immediate mitigation gains by reducing rapid carbon emissions that take place when forests are cut or burnt (as well as having co-benefits with multiple ecosystem services). Afforestation-reforestation can take up carbon immediately upon planting, but with varying, relatively small annual gains due to the slow rate of forest growth, and responding soil carbon pools, especially as forests approach maturity (Krause *et al.*, 2016). Harvesting and replanting, with carbon storage in harvested wood products or use as bioenergy, can enable the same land to continue to contribute to mitigation, but care has to be taken to sustainably manage repeated harvesting in order not to deplete soil carbon stocks which seems to have a larger contribution that often anticipated. Large uncertainties in historic land-cover and land-use estimates make recommendations challenging (Arneth *et al.*, 2017). Overall, bioenergy (especially lignocellulosic) is expected to contribute more to mitigation scenarios in the second half of the century, but this will depend on the availability of advanced negative emissions technologies (Popp *et al.*, 2016).

Time lags in policy implementation and uptake strongly influence the effectiveness of land-based mitigation policy (Rounsevell *et al.*, 2014; Alexander *et al.*, 2015; Brown *et al.*, 2015; Brown et al., submitted, see their Figure 1, below). There are large uncertainties associated with the development and implementation of BECCS and other land-based mitigation options. Barriers arising from the rate of technological development and the considerable need for financial investment mean that the large-scale implementation of BECCS is not likely until around the middle of the 21st century, at the very earliest (Popp *et al.*, 2016). Furthermore, farmers may be slow to begin growing bioenergy crops even with financial support. Such barriers could limit the success of bioenergy as a land-based mitigation option. This demonstrates the importance of immediate policy action and measures to support more rapid policy intervention and uptake.

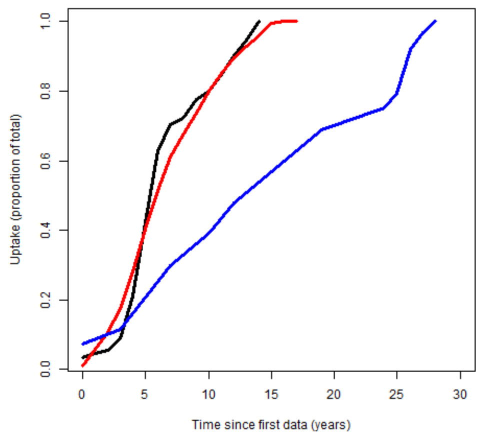

Figure 1 (from Brown et al., submitted): Cumulative uptake of Oil Seed Rape 1969-1997 (blue line), Scottish Woodland Grant Scheme, 1992-2004 (red line) and Energy Crops Scheme, 2002-2015 (black line).

Changing food consumption patterns (e.g. through low-meat diets, reducing over-eating and waste, and eating alternative protein sources) reduces the land area needed for food production providing opportunities for land-based mitigation (Alexander *et al.*, 2017a;Alexander *et al.*, 2017b). This also builds resilience to climate change, since the additional availability of land could offset the negative impact of climate change on crop yields and thus food production. These examples demonstrate potential opportunities, but there is little scientific evidence to support understanding of the full extent of mitigation-adaptation synergies (or trade-offs). Still, developing policies that systematically cut across policy sectors would achieve co-benefits for multiple policy goals. Co-benefits are not always realised, and a single sector focus can often cause unintended negative impacts on other sectors, e.g. by promoting land clearing for biofuels, which is associated with negative impacts on carbon stocks and flooding prevention. Well-grounded, land-based mitigation strategies can have positive social benefits, but conversely, land-based mitigation can have negative environmental and social impacts if poorly planned.

1.3.4 The effort of land-based mitigation efforts need also be viewed in terms of risks, especially related to fire

The success of afforestation-reforestation and avoided deforestation as mitigation options is subject to the changing risks from disturbances that affect forest permanence and depend on continued monitoring and management of forest stands over the long term. Temperature extremes and prolonged dry-spells increase fire risk, heat-waves and droughts will reduce the fitness of ecosystems, and a warmer climate could also lead to enhanced insect outbreaks. Such disturbances arising from climate extremes, wildfires, pests, and diseases affect afforestation-reforestation and avoided deforestation, but also yields of food and bioenergy crops (Bodin *et al.*, 2016; Pugh *et al.*, 2016a; Frieler *et al.*, 2017). There is as yet no agreement on the main processes underlying heat-effects on yields, but irrigation was found to dampen the negative effects of high temperatures considerably (Schauberger et al., 2017).

Fire is the sole episodic event that is included explicitly in current global scale ecosystem models (Hantson *et al.*, 2016;Rabin *et al.*, 2017), other causes of mortality are subsumed in a generic "background" disturbance. With warmer and drier temperatures fire risk is increasing but whether the enhanced fire risk also translates into larger burned area is debatable.. Studies showed that future burned area is reduced in (sub-)tropical semi-arid regions, where enhanced levels of CO_2 foster shrub encroachment into C4 grass-dominated systems, while increasing human population density prevents fire spread globally. Across a range of RCPs and SSPs, Knorr et al (Knorr *et al.*, 2016) demonstrated that uncertainties in future population growth combined with degree of urbanisation are of similar magnitude to uncertainties related to future climate change on burned area. Scenarios with moderate climate change combined with slow urbanisation at relatively large population growth resulted in a global decline of burned area – but not in an overall declining risk for humans *per se* since population increases in fire-prone regions (Knorr et al., 2016, see their Figure 3, below).

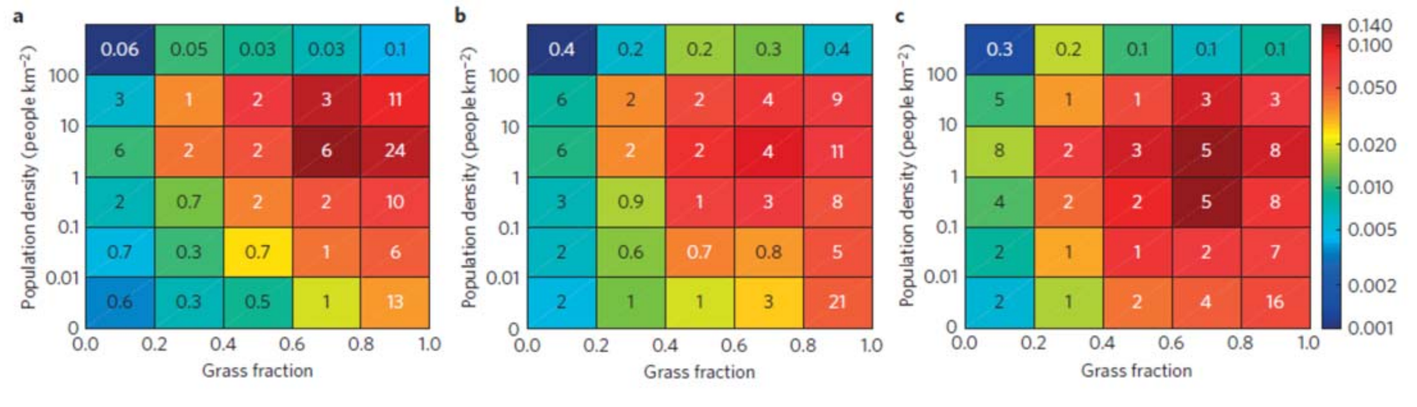

Figure 3 | Two-dimensional histogram plots showing mean fire frequency (fractional burned area, colour scale, in yr^{-1}) and fraction of global burned area (%) by ranges of grass fraction of total (grass and woody) vegetation and population density. a, Burned area, population and grass fraction for 1971–2000. **b**,**c**, Burned area, population and grass fraction for 2071–2100; RCP4.5 emissions with SSP3 demographics (**b**) and RC8.5 emissions with SSP5 demographics (**c**).

Better understanding disturbances and how to manage them in a changing climate would reduce uncertainty and therefore the risks associated with investment in mitigation options. Monitoring, Reporting, and Verification (MRV) of forest carbon and other land-based mitigation schemes need to be able to properly consider disturbances (and associated carbon losses) to provide confidence that land-based mitigation projects will meet their long-term objectives. This is, however, a sensitive issue within policy communities, since there is a common understanding that natural disturbances should not be accounted for by countries, since they are not anthropogenic. However, recent advances in satellites and modelling capabilities can support MRV, along with capacity-building in developing countries.

1.3.5 Model experiments and mode-data comparisons have identified a number of large uncertainties in the land-use/climate change interplay which need to be acknowledged for policy decision making

Quantitative assessment of model performance is crucial when using model output to support policy, and decision makers have accepted the inevitable uncertainty that comes with modelling environmental change. While progress has been made, systematic model evaluation that utilises all suitable streams of measurements or statistical information, and identification of uncertainties within and between models is still a critical challenge.

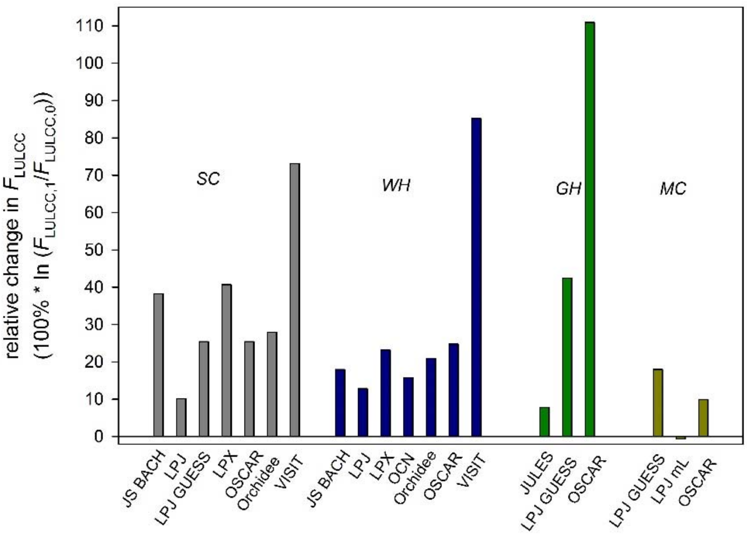

Figure (adopted from Arneth et al, their Figure 2): Response ratio of land-use change emission flux with (F_{LULCC}) and without ($F_{LULCC,0}$) a number of land management processes such as shifting cultivation (SC), wood harvest (WH) and various crop management options (GH, MC).

The individual modelling tools used for understanding and projecting the broad implications of land-based mitigation (e.g., land-use models, dynamic global vegetation models, climate models, biodiversity models) all suffer from incomplete process-representations or uncertain parameterisations. Model-intercomparisons (Schmitz *et al.*, 2014;Sitch *et al.*, 2015;Lawrence *et al.*, 2016) result in ensemble outputs that can help to assess how well models can reproduce historical variables and/or to derive a range of future changes. Whether or not agreement between models should be interpreted as a “robust” understanding of a system’s response is debatable and requires careful analysis and in-depth knowledge of the participating models, especially with respect to which processes are accounted for, and how these processes are included (Ahlstrom *et al.*, 2015; Arneth *et al.*, 2017, see their Figure 2, above).

In an analysis of future land-cover change, all kinds of existing future scenarios were compared (i.e. not specifying that the models should be run following a joint protocol) that were produced by a diverse set of global and European models (Alexander *et al.*, 2016b; Prestele *et al.*, 2016). Not surprisingly, large spread in future projections of main land-cover types were due to the different scenarios. However, the analysis identified also equally large uncertainty due to the modelling approach which highlight the needs to better understand the pros and cons of different land-use modelling paradigms and to ensure that models that seek to identify impacts incorporate a much broader range of future projections (and past hindcasts; (Bayer *et al.*, 2017)) than available so far.

Formalised parameter uncertainty analysis has not yet been applied in many land-use change models. Recently, a statistical analyses of input parameter variability identified which of these affected outputs most strongly (in that study: related to meat consumption or yield improvement rates; (Engstrom *et al.*, 2016b), and also investigated uncertainties in the parameters describing the scenario that was used to calculate land-use change (Engström et al., 2016). Using conditional probability ranges, broad overlap in the uncertainty distributions of future global total crop area was found for very different scenarios (SSP2,4,5), due to compensation effects that arose from changes in drivers. Future cropland area under SSP1 and 3 framework stood out (Engström et al., 2016) with assumptions (and uncertainties) in the SSP1 leading to notably declining crop area (associated with e.g., population decline and increasing yields; (Engström *et al.*, 2016).

In summary, land-based mitigation is not a 'silver bullet' to avoid climate change, but alongside drastic reductions in fossil fuel emissions, it can contribute to delivering the 'balance of sources and sinks' in the Paris Agreement. Land-based mitigation is currently the only way to remove CO_2 from the atmosphere at a scale that is potentially relevant to climate mitigation. The land sector will not be emissions-free, as emissions are necessarily associated with food production. Moreover, there is a real danger that land-based mitigation will compete with food production, the provision of other ecosystem services, and protection of biodiversity. Further analysis is required to understand fully the many trade-offs beyond climate mitigation that arise from land management and to identify policy options that support co-benefits. Land-based mitigation could potentially enable the land sector as a whole to approach a balance of sources and sinks, and, if barriers are overcome and sustainability ensured, it could further offset some of the more unavoidable emissions from fossil fuels.

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1.4 Project impact and dissemination (max 10 pages) (including the socio-economic impact and the wider societal implications of the project so far) and the main dissemination activities and exploitation of results

Four main activities were pursued in LUC4C to disseminate project outcomes and to ensure impact at various levels:

- Policy outreach events
- Contribution to international assessments
- Education
- Scientific meetings and conferences

1.4.1 Policy outreach

LUC4C (co)organised two side events at the UNFCCC COP21 in Paris, which included “Synergies and Trade-Offs in Land-Based Climate Mitigation and Biodiversity”, which took place at the Rio Pavillon, and presented an analysis of the latest science on land-use change climate impacts (including biophysical effects) and mitigation potential (including trade-offs and socio-economic context), and the extent to which the land sector (e.g. Reduced Emissions from Deforestation and Degradation, bioenergy, agricultural sector) is included in national and international policy, including Intended Nationally Determined Contributions (INDCs). The event discussed the several disconnects between the production of scientific knowledge and the knowledge needs and uptake seen in current land-climate policy-making. This event was quite timely with respect to development of policy, and development of new science evidence related to effects of land-based mitigation scenarios within the IPCC scenario framework.

L-R: **Alex Popp**, Potsdam Institute of Climate Impact Research; **Carlos Martin-Novella**, Deputy Secretary, IPCC; **David Cooper**, Deputy Executive Secretary, CBD Secretariat; **Hoesung Lee**, Chair, IPCC; **Mark Rounsevell**, University of Edinburgh; and, **Almut Arneth**, Karlsruhe Institute of Technology

At COP21 (Dec. 2015), LUC4C participated also in the organisation of the side-event on ”Mmulti-level climate governance: an integrated analysis of national, regional and local policies”. In that event, the project coordination (Prof. Arneth) presented LUC4C research entitled: Using the natural capital and ecosystem services concept to assess synergies and trade-offs in land-based mitigation.

Likewise at the COP 13 of the CBD in Cancun (Dec. 2016) on" Climate, biodiversity and sustainable development – benefits from a new global land management strategy". The primary goals of this science event were:

- to demonstrate current research progress in understanding the impact of the land system on both biodiversity and climate change, building on a broad range of innovative methods, using observations to enrich predictive modelling and scenarios,
- to gather the needs of policy makers and civil society in driving future research and assessment in this field.

Earlier, during the Brussels "Green Week" LUC4C participated in a Stand representing *"Nature-Based Solutions for Biodiversity & Climate Change"*, which highlighted the work of 4 European Commission funded research projects that used Nature-Based Solutions (NBS) to address biodiversity and climate change for the benefit of human wellbeing.

Also in Brussels, LUC4C led a lunch-time debate "*Land-based climate mitigation in a < 2 degree world: potentials and potential pit-falls".* The event was chaired by DG RTD and DG CLIMA and aimed to exchange knowledge on land-based climate change mitigation, supported by the latest EC-funded research, after the adoption of the Paris Agreement & in view of the IPCC report on limiting global warming to 1.5ºC.

In association with the final science workshop of LUC4C, a stakeholder workshop was organised in Brussels in Septembe 2017 which focused on "*The role of land use in achieving the <2oC Paris COP21 target: Key Messages on Policy Implications*", and was attended by a range of European policy stakeholders as well as a number of the scientists from the LUC4C project.

All of these siden-events and panel debates were well attended and the discussions fed back to the LUC4C work and its output materials (incl a nunber of policy briefs which can be downloaded from the project web-site, www.luc4c.eu). The final stakeholder day in particular was specifically designed such that the key outcomes of the processes to identify implications and options for policy (workshop and LUC4C expert judgement) were presented in the deliverable *Recommendations to support best practice for climate mitigation and adaptation policy* (D1.3). Key policy implications and options were identified as:

- Achieving sustainable intensification through, for example, agroforestry and agropastoralism;
- Changing diets to reduce demand for land- and carbon-intensive products such as beef, through e.g. a tax or labelling;
- Restoring degraded forests to increase their carbon storage capacity and increase biodiversity;
- Using harvested wood products in buildings and other infrastructure to store carbon and reduce emissions from the production and transportation of cement and iron;
- Robust scientific results are needed before biophysical effects are to be included in global policy frameworks;
- A method for the evaluation of the regional impacts of land cover transitions exists and can inform regional and national mitigation efforts;

- Biophysical effects are stronger and more certain at local scales and so, have the potential to be considered in local land use planning policy;
- Due to the geographical variability in biophysical effects, the location of carbon offsetting schemes can determine much of their effectiveness;
- Raising awareness in farmer communities, through measures such as knowledge hubs and advisory schemes, to enhance policy and technology uptake;
- Incentivizing adaptation measures in both the agricultural and forest sectors would build resilience to climate change and support land-based mitigation;
- Forward-looking policies to maintain carbon storage over longer time-frames, instead of short term carbon maximisation that negatively affects ecosystem functioning.

1.4.2. Contribution to assessments

Researchers in LUC4C have been involved in the IPCC assessments for many years. Importantly for the multi-disciplinary aspect of LUC4C results, scientist also became actively engaged in the ongoing assessments of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). Prof. Rounsevell (LUC4C WP 1 lead) acted as co-chair of the IPBES Regional Assessment for Europe, Russia and Central Asia, which will be defended in the IPBES plenary in spring 2018. Prof. Arneth (LUC4C coordinator) is Coordinating Lead Author in the ongoing IPBES Global Assessment in the chapter on Future Scenarios of Nature, Nature's Contribution to People and Good Quality of Life. She is also a CLA in the IPCC Special Report on Climate change and Land, which has just commenced.

Participation to these Assessments is important as ensures that results reported in the LUC4C published scientific literature contributes to inform the climate and environmental policy process. In that light, Prof. Arneth also participated a workshop ("Research on climate smart agriculture") organised in February 2015 by DG AGRI discussing the research needs towards the development of a Climate Change and Agriculture research agenda to guide further activities under Horizon2020 in particular with regard to Societal Challenge 2 (Food Security, Sustainable Agriculture and Forestry, Marine, Maritime and Inland Water Research and the Bio-economy).

1.4.3 Education

Education of the next generation of environmental scientists is an important component of dissemination and impact. All LUC4C senior scientists contribute to teaching and supervision of students and young investigators. Specifically for LUC4C, a one-week winter school was organised for 25 international doctoral and post-doctoral researchers on "People, climate and the terrestrial biosphere" which aimed through lectures and practical work to give a broad overview of the role of the terrestrial biosphere in the Earth system, with a strong focus on anthropogenic land-use change and management and their implications. Lectures given during the course were filmed and are available via KIT on iTUNES U.

LUC4Kit includes the creation, development and delivery of an innovative, easy-to-use, pedagogical, fast and useful emulator tool ("LUC4Kit explorer", available in 46.43.3.32/luc4c) to provide maps, time series, and custom global and regional averages of changes in carbon variables in response to pre-established and user's land cover changes (LCC) scenario. The data provided for visualization (see *Figure 1*) is based on three sets of simulations performed with the dynamic global vegetation model LPJ-GUESS Carbon-Nitrogen version. The tool aims primarily at university students. A full documentation for pedagogical and policy-maker purposes will also be made available online (currently under development), it has been tested in a first course with ~15 M.Sc students during a lecture course in Karlsruhe, when the project responsible scientists (Benjamin Quesada and Almut Arneth) gave a practical course on carbon cycle and land-use. With the tool, users can specify own experiments, select output variables and safe output data (for later post-processing by different types of software).

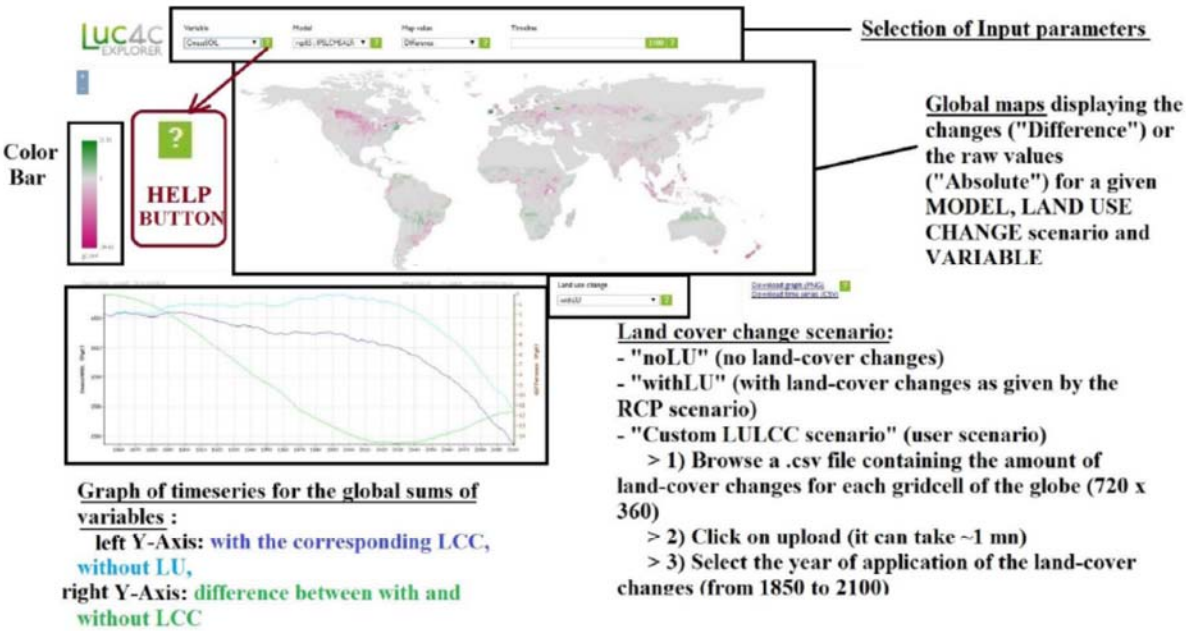

Figure 1: Snapshot of the current emulator tool including input parameters, tuneable color bar, visualization global map, timeseries, tuneable regional or global land-cover change scenario. Several options of downloading outputs are available (maps in .png or .pdf, timeseries in .xls, .xlsx and .csv formats).

*

1.4.4. Wider science dissemination

Scientist presented their work at numerous international conferences, both in form of oral presentations as well as posters. Conference sessions that were organised through LUC4C included, among others:

Global scenarios of land-use change and land-based mitigation, and their importance in the climate system at the Paris 2015 conference "Our common future under climate change" which was a large international meeting designed specifically to lead up to the COP 21 later that same year.

At the conference of the Future Earth Project iLEAPS, September 2017 in Oxford, LUC4C co-onvened the session "*Land-use change in a warming worl: Interactions between climate and socio-ecological systems, and implications for land-based climate change mitigation*".

At the annual autumn meeting of the American Geophysical union, in 2016 in San Francisco, LUC4C co-convened a session on "*Impacts of land use and land cover change in a changing climate, using modeling and measurements*".

2. Use and dissemination of foreground

As specified in the reporting guidelines, the following sections synthesis the project's dissemination measures (Section A). No Patents or other commercially relevant information (Section B) were produced.

Section A (public)

- A1: List of all scientific (peer reviewed) publications relating to the foreground of the project.
- A2: List of all dissemination activities (publications, conferences, workshops, web sites/applications, press releases, flyers, articles published in the popular press, videos, media briefings, presentations, exhibitions, thesis, interviews, films, TV clips, posters).

A1: LIST OF SCIENTIFIC (PEER REVIEWED) PUBLICATIONS, MOST IMPORTANT ONES ARE MARKED IN YELLOW										
No.	Title	Main author	Title of the periodical or the series	Number, date or frequency	Publisher	Place of publication	Date of publication	Relevant pages	Is open access(4) provided to this publication?	DOI
1	Towards decision-based global land use models for improved understanding of the Earth system	M. D. A. Rounsevell, et al.	Earth System Dynamics	Vol. 5/Issue 1	Copernicus Gesellschaft mbH	Germany	01/01/2014	117-137	Yes	10.5194/esd-5-117-2014
2	Global models of human decision-making for land-based mitigation and adaptation assessment	A. Arneth , et al.	Nature Climate Change	Vol. 4/Issue 7	American Heart Association		25/06/2014	550-557	Via LUC4C repository	10.1038/nclimate2250
3	Gross changes in reconstructions of historic land cover/use for Europe between 1900 and 2010	Richard Fuchs, et al.	Global Change Biology	Vol. 21/Issue 1	Blackwell Publishing	United Kingdom	01/01/2015	299-313	Yes	10.1111/gcb.12714
4	Effect of land-use change and management on biogenic volatile organic compound emissions - selecting climate-smart cultivars	Maaria Rosenkranz, et al.	Plant, Cell and Environment	Vol. 38/Issue 7	Blackwell Publishing	United Kingdom	01/12/2014	n/a-n/a	Via LUC4C repository	10.1111/pce.12453
5	Global carbon budget 2014	C. Le Quéré , et al.	Earth System Science Data	Vol. 7/Issue 1	Copernicus GmbH (Copernicus Publications)	Germany	01/01/2015	47-85	Yes	10.5194/essd-7-47-2015
6	Global carbon budget 2013	C. Le Quéré , et al.	Earth System Science Data	Vol. 6/Issue 1	Copernicus GmbH	Germany	01/01/2014	235-263	Yes	10.5194/essd-6-235-2014

					(Copernicus Publications)					
7	Land-use protection for climate change mitigation	Alexander Popp, et al.	Nature Climate Change	Vol. 4/Issue 12	Nature Publishing Group	United Kingdom	17/11/2014	1095-1098	Via LUC4C repository	10.1038/nclimate2444
8	Trade-offs between land and water requirements for large-scale bioenergy production	Markus Bonsch, et al.	Global Change Biology Bioenergy	Vol. 7/Issue 3	WILEY-BLACKWELL		01/11/2014	n/a-n/a	Via LUC4C repository	10.1111/gcbb.12226
9	Investigating afforestation and bioenergy CCS as climate change mitigation strategies	Florian Humpenöder, et al.	Environmental Research Letters	Vol. 9/Issue 6	Institute of Physics Publishing		01/05/2014	064029	Yes	10.1088/1748-9326/9/6/064029
10	Historical and future quantification of terrestrial carbon sequestration from a Greenhouse-Gas-Value perspective	Anita D. Bayer, et al.	Global Environmental Change	Vol. 32	Elsevier Limited	United Kingdom	01/05/2015	153-164	Via LUC4C repository	10.1016/j.gloenvcha.2015.03.004
11	Modelling the response of yields and tissue C : N to changes in atmospheric CO₂ and N management in the main wheat regions of western Europe	S. Olin, et al.	Biogeosciences	Vol. 12/Issue 8	European Geosciences Union	Germany	01/01/2015	2489-2515	Yes	10.5194/bg-12-2489-2015
12	Importance of vegetation dynamics for future terrestrial carbon cycling	Anders Ahlström , et al.	Environmental Research Letters	Vol. 10/Issue 5	Institute of Physics Publishing		01/05/2015	054019	Yes	doi:10.1088/1748-9326/10/5/054019
13	The dominant role of semi-arid ecosystems in the trend and variability of the land CO2 sink	A. Ahlstrom , et al.	Science	Vol. 348/Issue 6237	American Association for the Advancement of Science	United States	22/05/2015	895-899	Via LUC4C repository	10.1126/science.aaa1668
14	Recent trends and drivers of regional sources and sinks of carbon dioxide	S. Sitch , et al.	Biogeosciences	Vol. 12/Issue 3	European Geosciences Union	Germany	01/01/2015	653-679	Yes	10.5194/bg-12-653-2015
15	The potential of old maps and encyclopaedias for reconstructing historic	Richard Fuchs , et al.	Applied Geography	Vol. 59	Elsevier BV	Netherlands	01/05/2015	43-55	Yes	10.1016/j.apgeog.2015.02.013

	European land cover/use change									
16	Drivers for global agricultural land use change: The nexus of diet, population, yield and bioenergy	Peter Alexander , et al.	Global Environmental Change	Vol. 35	Elsevier Limited	United Kingdom	01/11/2015	138-147	Yes	10.1016/j.gloenvcha.2015.08.011
17	Soil carbon management in large-scale Earth system modelling: implications for crop yields and nitrogen leaching	S. Olin , et al.	Earth System Dynamics	Vol. 6/Issue 2	Copernicus Gesellschaft mbH	Germany	01/01/2015	745-768	Yes	10.5194/esd-6-745-2015
18	Sensitivity of burned area in Europe to climate change, atmospheric CO 2 levels and demography: A comparison of two fire-vegetation models	Minchao Wu , et al.	Journal of Geophysical Research - Biogeosciences	120	American Geophysical Union		01/01/2015	n/a-n/a	Yes	10.1002/2015JG003036
19	Implications of climate mitigation for future agricultural production	Christoph Müller , et al.	Environmental Research Letters	Vol. 10/Issue 12	Institute of Physics Publishing		01/12/2015	125004	Yes	10.1088/1748-9326/10/12/125004
20	Applying Occam's razor to global agricultural land use change	Kerstin Engström , et al.	Environmental Modelling and Software	Vol. 75	Elsevier BV	Netherlands	01/01/2016	212-229	Yes	10.1016/j.envsoft.2015.10.015
21	Global Carbon Budget 2015	C. Le Quéré , et al.	Earth System Science Data	Vol. 7/Issue 2	Copernicus GmbH (Copernicus Publications)	Germany	01/01/2015	349-396	Yes	10.5194/essd-7-349-2015
22	Simulated carbon emissions from land-use change are substantially enhanced by accounting for agricultural management	T A M Pugh , et al.	Environmental Research Letters	Vol. 10/Issue 12	Institute of Physics Publishing		01/12/2015	124008	Yes	10.1088/1748-9326/10/12/124008
23	Revisiting the concept of a symmetric index of agreement for continuous datasets	Gregory Duveiller , et al.	Scientific Reports	Vol. 6	Nature Publishing Group	United Kingdom	14/01/2016	19401	Yes	10.1038/srep19401
24	Biophysical climate impacts of recent changes in global forest cover	R. Alkama , et al.	Science	Vol. 351/Issue 6273	American Association for the Advancement of Science	United States	05/02/2016	600-604	No	10.1126/science.aac8083

25	Assessing the influence of historic net and gross land changes on the carbon fluxes of Europe	Richard Fuchs , et al.	Global Change Biology	2016	Blackwell Publishing	United Kingdom	01/12/2015	n/a-n/a	Yes	10.1111/gcb.13191
26	Major forest changes and land cover transitions based on plant functional types derived from the ESA CCI Land Cover product	Wei Li , et al.	International Journal of Applied Earth Observation and Geoinformation	Vol. 47	Elsevier		01/05/2016	30-39	No	10.1016/j.jag.2015.12.006
27	Greening of the Earth and its drivers	Zaichun Zhu , et al.	Nature Climate Change	advance online publication	Nature Publishing Group	United Kingdom	25/04/2016	advance online publication	No	10.1038/nclimate3004
28	Spatially downscaling sun-induced chlorophyll fluorescence leads to an improved temporal correlation with gross primary productivity	Gregory Duveiller , et al.	Remote Sensing of Environment	Vol. 182	Elsevier Inc.	United States	01/09/2016	72-89	Yes	10.1016/j.rse.2016.04.027
29	The status and challenge of global fire modelling	Stijn Hantson , et al.	Biogeosciences	Vol. 13/Issue 11	European Geosciences Union	Germany	01/01/2016	3359-3375	Yes	10.5194/bg-13-3359-2016
30	Hotspots of uncertainty in land use and land cover change projections: a global scale model comparison	Reinhard Prestele , et al.	Global Change Biology	n/a	Blackwell Publishing	United Kingdom	01/05/2016	n/a-n/a	Yes	10.1111/gcb.13337
31	Key knowledge and data gaps in modelling the influence of CO2 concentration on the terrestrial carbon sink	T.A.M. Pugh , et al.	Journal of Plant Physiology	n/a	Urban und Fischer Verlag GmbH und Co. KG	Germany	01/05/2016	n/a-n/a	Via LUC4C repository	http://dx.doi.org/10.1016/j.jplph.2016.05.001
32	Regional carbon fluxes from land use and land cover change in Asia, 1980–2009	Leonardo, Calle, et al.	Environmental Research Letters	11/7	Institute of Physics Publishing		08/07/2016	074011	Yes	
33	Global change pressures on soils from land use and management	Pete Smith , et al.	Global Change Biology	Vol. 22/Issue 3	Blackwell Publishing	United Kingdom	01/03/2016	1008-1028	No	10.1111/gcb.13068
34	Climate analogues suggest limited potential for intensification of production	T.A.M. Pugh , et al.	Nature Communications	Vol. 7	Nature Publishing Group	United Kingdom	20/09/2016	12608	Yes	10.1038/ncomms12608

	on current croplands under climate change									
35	The impact of high-end climate change on agricultural welfare	M. Stevanovic , et al.	Science Advances	Vol. 2/Issue 8	American Association for the Advancement of Science (AAAS)	United States	01/08/2016	e1501452 - e1501452	Yes	10.1126/sciadv.1501452
36	Land-Use and Carbon Cycle Responses to Moderate Climate Change: Implications for Land-Based Mitigation?	Florian Humpenöder , et al.	Environmental Science and Technology	Vol. 49/Issue 11	American Chemical Society	United States	02/06/2015	6731-6739	Via LUC4C repository	10.1021/es506201r
37	Assessing uncertainties in land cover projections	Peter Alexander , et al.	Global Change Biology	n/a	Blackwell Publishing	United Kingdom	01/08/2016	n/a	Via LUC4C repository	10.1111/gcb.13447
38	Demand for biodiversity protection and carbon storage as drivers of global land change scenarios	David A. Eitelberg , et al.	Global Environmental Change	Vol. 40	Elsevier Limited	United Kingdom	01/09/2016	101-111	Yes	http://dx.doi.org/10.1016/j.gloenvcha.2016.06.014
39	Land management: data availability and process understanding for global change studies	Karl-Heinz Erb , et al.	Global Change Biology	n/a	Blackwell Publishing	United Kingdom	01/09/2016	n/a	Via LUC4C repository	10.1111/gcb.13443
40	Accounting for interannual variability in agricultural intensification: The potential of crop selection in Sub-Saharan Africa	P. Bodin , et al.	Agricultural Systems	Vol. 148	Elsevier BV	Netherlands	01/10/2016	159-168	Via LUC4C repository	http://dx.doi.org/10.1016/j.agsy.2016.07.012
41	Global Carbon Budget 2016	Corinne Le Quéré , et al.	Earth System Science Data	Vol. 8/Issue 2	Copernicus GmbH (Copernicus Publications)	Germany	01/01/2016	605-649	Yes	10.5194/essd-8-605-2016
42	Reduction of monsoon rainfall in response to past and future land-use and land-cover changes	Benjamin Quesada , et al.	Geophysical Research Letters	n/a	American Geophysical Union	United States	01/01/2016	n/a	Via LUC4C repository	10.1002/2016GL070663
43	Assessing uncertainties in global cropland futures using a conditional probabilistic modelling framework	Kerstin Engström , et al.	Earth System Dynamics	Vol. 7/Issue 4	Copernicus Gesellschaft mbH	Germany	01/01/2016	893-915	Yes	10.5194/esd-7-893-2016

44	Livestock in a changing climate: production system transitions as an adaptation strategy for agriculture	Isabelle Weindl , et al.	Environmental Research Letters	Vol. 10/Issue 9	Institute of Physics Publishing		01/09/2015	094021	Yes	10.1088/1748-9326/10/9/094021
45	Afforestation to mitigate climate change: impacts on food prices under consideration of albedo effects	Ulrich Kreidenweis , et al.	Environmental Research Letters	Vol. 11/Issue 8	Institute of Physics Publishing		01/08/2016	085001	Yes	10.1088/1748-9326/11/8/085001
46	Uncertainties in the land use flux resulting from land use change reconstructions and gross land transitions	Anita D. Bayer , et al.	Earth System Dynamics	n/a	Copernicus Gesellschaft mbH		21/06/2016	1-24	Yes	10.5194/esd-2016-24
47	Reducing uncertainties in decadal variability of the global carbon budget with multiple datasets	Wei Li , et al.	Proceedings of the National Academy of Sciences of the United States	Vol. 113/Issue 46	National Academy of Sciences	United States	15/11/2016	13104-13108	Via LUC4C repository	10.1073/pnas.1603956113
48	Impact of LULCC on the emission of BVOCs during the 21st century	Sebastian Szogs, et al.	Atmospheric Environment	Vol. 165	Elsevier Limited	United Kingdom	01/09/2017	73-87	Yes	10.1016/j.atmosenv.2017.06.025
49	A human-driven decline in global burned area	N. Andela , et al.	Science	Vol. 356/Issue 6345	American Association for the Advancement of Science	United States	30/06/2017	1356-1362	No	10.1126/science.aal4108
50	Satellites reveal contrasting responses of regional climate to the widespread greening of Earth	Giovanni Forzieri , et al.	Science	Vol. 356/Issue 6343	American Association for the Advancement of Science	United States	16/06/2017	1180-1184	No	10.1126/science.aal1727
51	Natural Resource Grabbing: The Case of Tropical Forests and redd+	Annalisa Savaresi	Natural Resources Grabbing: An International Law Perspective		Brill		22/10/2015	159-180	No	10.1163/9789004305663_010
52	The Legal Status and Role of REDD+ Safeguards’	Annalisa Savaresi	Research Handbook on REDD+ and International Law	24	Edward Elgar	Cheltenham Glos, United Kingdom	31/07/2015	126-156	Yes	

53	Historical carbon dioxide emissions caused by land-use changes are possibly larger than assumed	A. Arneth , et al.	Nature Geoscience	Vol. 10/Issue 2	Nature Publishing Group	United Kingdom	30/01/2017	79-84	Via LUC4C repository	10.1038/ngeo2882
54	Consistent negative response of US crops to high temperatures in observations and crop models	Bernhard Schauberger , et al.	Nature Communications	Vol. 8	Nature Publishing Group	United Kingdom	19/01/2017	13931	Yes	10.1038/ncomms13931
55	Losses, inefficiencies and waste in the global food system	Peter Alexander , et al.	Agricultural Systems	Vol. 153	Elsevier BV	Netherlands	01/05/2017	190-200	Yes	10.1016/j.agsy.2017.01.014
56	Could consumption of insects, cultured meat or imitation meat reduce global agricultural land use?	Peter Alexander , et al.	Global Food Security Journal		Elsevier	Netherlands	01/04/2017		Via LUC4C repository	10.1016/J.GFS.2017.04.001
57	Biophysical effects on temperature and precipitation due to land cover change	Perugini et al.	Environmental Research Letters	12	IOP	UK	05/2017		Yes	10.1088/1748-9326/aa6b3f
58	Atmospheric, radiative, and hydrologic effects of future land use and land cover changes: A global and multimodel climate picture	Quesada et al.	Journal of Geophysical research	122	American Geophysical Union	USA	27/05/2017	5113-5131	Via LUC4C repository	10.1002/2016jd025448
59	The Fire Modeling Intercomparison Project (FireMIP), phase 1: Experimental and analytical protocols	Rabin et al.	Geoscientific Model Development	10	Copernicus	Germany	5/2017	1175-1197	Yes	10.5194/gmd-2016-237
60	Global consequences of afforestation and bioenergy cultivation on ecosystem service indicators	Krause et al.	Biogeosciences	14	Copernicus	Germany	03/11/2017	4829-4850	Yes	10.5194/bg-2017-160
61	Global gridded crop model evaluation	Müller et al	Geoscientific Model Developmnet	10	Copernicus	Germany	10/11/2017	1403-1422	Yes	10.5194/gmd-10-1403-2017
62	Modelling feedbacks between human and natural processes in the land system.	Robinson et al	Earth System Dynamics Discussion		Copernicus	Germany	11/2017		Yes	10.5194/esd-2017-68

A2: LIST OF DISSEMINATION ACTIVITIES								
No.	Type of activities	Main leader	Title	Date	Place	Type of audience	Size of audience	Countries addressed
1	Posters	Karlsruher Institut fuer Technologie	Agricultural processes substantially reduce projections of the terrestrial carbon sink	03/02/2014	International Conference GV2M Global Vegetation Monitoring and Modeling, Avignon, France	Scientific community (higher education, Research)	30	International
2	Posters	POTSDAM INSTITUT FUER KLIMAFOLGENFORSCHUNG	Representation of multiple cropping systems in land use data sets	03/02/2014	Avignon, France	Scientific community (higher education, Research)	50	International
3	Oral presentation to a scientific event	THE UNIVERSITY OF EXETER	Carbon Balance of the terrestrial biosphere in the 20th Century	05/02/2014	Global vegetation monitoring and modeling, Avignon, GV2M	Scientific community (higher education, Research)	150	International
4	Organisation of Workshops	Karlsruher Institut fuer Technologie	Putting people on the land. Winter School for PhD students and Postdocs	03/03/2015	Garmisch-Partenkirchen, Germany	Scientific community (higher education, Research)	30	International
5	Oral presentation to a scientific event	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	Modeling the functioning of Mediterranean agroecosystems to assess impacts of global change on ecosystem services. (implies model development needed for LUC4C)	19/03/2014	2nd Global Land Project Open Conference, Berlin, Germany.	Scientific community (higher education, Research)	50	International
6	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	"Managed land and the climate system: Is the representation in Earth-System Models sufficient?"	19/03/2014	2nd GLP Open Science Meeting, Berlin, Germany	Scientific community (higher education, Research)	20	International
7	Web sites/Applications	Karlsruher Institut fuer Technologie	LUC4C Website: luc4c.eu	31/03/2014	Garmisch-Partenkirchen, Germany	Scientific community (higher education, Research) - Civil		worldwide

						society - Policy makers - Medias		
8	Oral presentation to a scientific event	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	How much water do we need for irrigation under climate change in the Mediterranean? (implies model development needed for LUC4C)	28/04/2014	European Geosciences Union General Assembly, Vienna, Austria	Scientific community (higher education, Research)	50	International
9	Interviews	CENTRO EURO-MEDITERRANEO SUI CAMBIAMENTI CLIMATICI SCARL	LUC4C 1st Stakeholder Consultation at the Subsidiary Bodies of the UNFCCC 40th meeting.	04/06/2014	Bonn, Germany	Policy makers	36	EU member states (27), and other extra EU states
10	Oral presentation to a scientific event	CENTRO EURO-MEDITERRANEO SUI CAMBIAMENTI CLIMATICI SCARL	Presentation of activities of the CMCC Division "Impact on Agriculture, Forest and Natural Terestrial Ecosystems" to the CMCC Scientific Advisory Panel	12/06/2014	Ugento (Lecce, Italy)	Scientific community (higher education, Research)	20	International
11	Posters	THE UNIVERSITY OF EXETER	"Worldwide changes in plant Water Use Efficiency diagnosed from atmospheric observations"	01/07/2014	GEWEX conference, The Hague, the Netherlands	Scientific community (higher education, Research)	65	International
12	Organisation of Workshops	FEDERAL STATE EDUCATIONAL ESTABLISHMENT OF HIGHER PROFESSIONAL EDUCATION RUSSIAN STATE AGRARIAN UNIVERSITY-MOSCOW TIMIRYAZEV AGRICULTURAL ACADEMY	Moscow Environmental School MOSES-2014	01/07/2014	Moscow, RTSAU	Scientific community (higher education, Research)	70	International
13	Posters	Karlsruher Institut fuer Technologie	Plants in a box (not directly linked to LUC4C)	16/07/2014	Congress Center Garmisch-Partenkirchen, Germany	Scientific community (higher education, Research) - Civil society - Policy makers	60	International
14	Oral presentation to a scientific event	STICHTING VU-VUMC	Land Use Climate Interactions	01/09/2014	Grindelwald, Switzerland	Scientific community (higher education, Research)	50	International

15	Oral presentation to a scientific event	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	Scenarios for sustainable futures of Mediterranean agriculture based on ecosystem service supply (implies model development needed for LUC4C)	08/09/2014	7th Ecosystem Services Partnership conference on “local action for the common good”, San Jose, Costa	Scientific community (higher education, Research)	60	International
16	Oral presentation to a scientific event	STICHTING VU-VUMC	Land system science: from understanding to sustainability solutions	24/09/2014	Taipei, Taiwan	Scientific community (higher education, Research)	100	International
17	Oral presentation to a scientific event	THE UNIVERSITY OF EXETER	Trends in Global Plant Water Use Efficiency diagnosed from Fluxnet and Tree Ring observations	01/12/2014	AGU conference, San Francisco, US	Scientific community (higher education, Research)	300	International
18	Flyers	Karlsruher Institut fuer Technologie	Factsheet Climate Change	31/03/2014	Garmisch-Partenkirchen, Germany	Scientific community (higher education, Research) - Civil society - Policy makers		International
19	Posters	Karlsruher Institut fuer Technologie	LUC4C Poster	31/03/2014	Garmisch-Partenkirchen, Germany	Scientific community (higher education, Research)		International
20	Films	Karlsruher Institut fuer Technologie	Putting People on the Land. Introducing the interactions between terrestrial ecosystems, climate and society	03/03/2015	Garmisch-Partenkirchen, Germany	Scientific community (higher education, Research)		International
21	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	The sensitivity of terrestrial carbon stocks to forest disturbance regimes Dynamic global vegetation modelling: towards a third generation	12/05/2015	Landskrona, Sweden	Scientific community (higher education, Research)	16	international
22	Organisation of Workshops	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	GCP land use and C workshop	26/05/2015	Paris, France	Scientific community (higher education, Research)	50	US, UK, Germany, UN, France, China, Australia

23	Flyers	Karlsruher Institut fuer Technologie	Booklet: How agriculture and forestry change climate, and how we deal with it (English version)	30/05/2015	Garmisch-Partenkirchen, Germany	Scientific community (higher education, Research) - Civil society - Policy makers - Medias		International
24	Organisation of Workshops	FEDERAL STATE EDUCATIONAL ESTABLISHMENT OF HIGHER PROFESSIONAL EDUCATION RUSSIAN STATE AGRARIAN UNIVERSITY-MOSCOW TIMIRYAZEV AGRICULTURAL ACADEMY	Moscow Environmental School MOSES-2015	01/07/2015	Moscow, RTSAU	Scientific community (higher education, Research)	51	International
25	Oral presentation to a scientific event	THE UNIVERSITY OF EXETER	Global Land Programme Open Science Meeting	07/07/2015	Paris, France	Scientific community (higher education, Research)		global
26	Posters	CENTRO EURO-MEDITERRANEO SUI CAMBIAMENTI CLIMATICI SCARL	"Metrics for the net climate effect of land use change in support of land based mitigation and adaptation policies"	07/07/2015	Paris, France	Scientific community (higher education, Research)	70	International
27	Oral presentation to a scientific event	THE UNIVERSITY OF EXETER	Quantifying the impact of LULCC on biogeochemical cycles into the future under alternative mitigation and policy scenarios. What are the carbon costs of different mitigation options?	07/07/2015	Paris, France	Scientific community (higher education, Research)	70	global
28	Organisation of Workshops	Karlsruher Institut fuer Technologie	Our common future under Climate Change: Land-use and climate change	07/07/2015	Paris, France	Scientific community (higher education, Research)	35	international
29	Posters	Karlsruher Institut fuer Technologie	Widespread vulnerability of current crop production to climate change demonstrated using a data-driven approach	07/07/2015	Paris, France	Scientific community (higher education, Research)	2200	international
30	Posters	Karlsruher Institut fuer Technologie	Carbon emission from land-use change is substantially enhanced by agricultural management	07/07/2015	Paris, France	Scientific community	2200	international

						(higher education, Research)		
31	Posters	CENTRO EURO-MEDITERRANEO SUI CAMBIAMENTI CLIMATICI SCARL	Metrics for the net climate effect of land use change in support of land based mitigation and adaptation policies	08/07/2015	Paris, France	Scientific community (higher education, Research)	2200	global
32	Posters	Karlsruher Institut fuer Technologie	Legacy effects of repeated land-use changes	09/07/2015	Paris, France	Scientific community (higher education, Research)	2200	international
33	Organisation of Workshops	Karlsruher Institut fuer Technologie	FireMIP	28/09/2015	Garmisch-Partenkirchen, Germany	Scientific community (higher education, Research)	17	international
34	Organisation of Workshops	Karlsruher Institut fuer Technologie	Land-based mitigation and the implications for biodiversity	01/12/2015	Paris, France	Civil society	25	global
35	Organisation of Workshops	Karlsruher Institut fuer Technologie	CBD/COP13: Land-based mitigation and the implications for biodiversity	01/12/2015	Cancun, Mexico	Scientific community (higher education, Research)	35	international
36	Oral presentation to a wider public	Karlsruher Institut fuer Technologie	Using the ecosystem services and natural capital concept to assess synergies and trade-offs in land-based mitigation	09/12/2015	COP21, Paris, France	Scientific community (higher education, Research) - Industry - Civil society - Policy makers - Medias	34	international
37	Oral presentation to a wider public	Karlsruher Institut fuer Technologie	Using Ecosystem Modelling to Support Assessment of Changes in Ecosystem Services and Natural Capital Due to Land-Based Mitigation	10/12/2015	COP21, Paris, France	Scientific community (higher education, Research) - Industry - Civil society - Policy makers - Medias	55	international

38	Oral presentation to a scientific event	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	AGU 2015 conference	10/12/2015	San Francisco, USA	Scientific community (higher education, Research)	100	global
39	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	“Detecting people”	16/12/2015	AGU, San Francisco, USA	Scientific community (higher education, Research)	80	international
40	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	Future land-use change emissions: CO_2, BVOC and wildfire	17/12/2015	AGU, San Francisco, USA	Scientific community (higher education, Research)	80	international
41	Oral presentation to a scientific event	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	Modelling land use change processes in ORCHIDEE	08/02/2016	Paris, France	Scientific community (higher education, Research)	50	US, UK, Germany, UN, France, China, Australia
42	Organisation of Workshops	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	GCP-LUC4C Workshop	08/02/2016	Paris, France	Scientific community (higher education, Research)	40	international
43	Organisation of Workshops	THE UNIVERSITY OF EXETER	WP3 meeting, planning final set of policy simulations	10/02/2016	Paris, France	Scientific community (higher education, Research)	20	global
44	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	Widespread vulnerability of current crop production to climate change: A data-driven approach	15/03/2016	Berlin, Germany	Scientific community (higher education, Research)	55	international
45	Posters	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	Quantifying the response of climate to changes in land cover : can we separate direct effects from feedbacks in earth system models’ outputs?	17/04/2016	Vienna, Austria	Scientific community (higher education, Research)	150	global

46	Oral presentation to a scientific event	JRC -JOINT RESEARCH CENTRE-EUROPEAN COMMISSION	Save the forests to mitigate climate, twice	18/04/2016	Vienna, Austria	Scientific community (higher education, Research)	200	global
47	Posters	JRC -JOINT RESEARCH CENTRE-EUROPEAN COMMISSION	Vegetation controls on the biophysical surface properties at global scale	21/04/2016	Vienna, Austria	Scientific community (higher education, Research)	200	global
48	Oral presentation to a scientific event	JRC -JOINT RESEARCH CENTRE-EUROPEAN COMMISSION	Trading space for time: a methodology to quantify the biophysical and biogeochemical effects of land use change in absence of change	11/05/2016	Prague, Tzech Republic	Scientific community (higher education, Research)	180	global
49	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	Recent developments in Digital Global Vegetation Models (DGVMs): C/N dynamics and crops yields	23/05/2016	Boulder, Colorado, USA	Scientific community (higher education, Research)	45	international
50	Oral presentation to a scientific event	THE UNIVERSITY OF EDINBURGH	Global scale agricultural systems: the role of diet, trade and food waste	23/05/2016	Boulder, Colorado, USA	Scientific community (higher education, Research)	45	international
51	Oral presentation to a scientific event	UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH NONPROFIT CORPORATION	An overview of current global human dimension methods: integrated assessment models	23/05/2016	Boulder, Colorado, USA	Scientific community (higher education, Research)	45	international
52	Oral presentation to a scientific event	THE UNIVERSITY OF EDINBURGH	Extending ABM approaches to national and continental scales	23/05/2016	Boulder, Colorado, USA	Scientific community (higher education, Research)	45	international
53	Oral presentation to a scientific event	STICHTING VU-VUMC	An overview of current global human dimension methods: Land use and land cover change models	23/05/2016	Boulder, Colorado, USA	Scientific community (higher education, Research)	45	international
54	Oral presentation to a scientific event	CENTRO EURO-MEDITERRANEO SUI CAMBIAMENTI CLIMATICI SCARL	Dynamical Vegetation Model 30'	24/05/2016	Trieste, Italy	Scientific community	117	40 countries

						(higher education, Research)		
55	Organisation of Workshops	THE UNIVERSITY OF EXETER	WP3 global runs scoping workshop	26/05/2016	Amsterdam, Netherlands	Scientific community (higher education, Research)	20	global
56	Oral presentation to a scientific event	STICHTING VU-VUMC	Improving the representation of the diversity and intensity of complex Mediterranean land systems	27/05/2016	Marseille, France	Scientific community (higher education, Research)		global
57	Oral presentation to a scientific event	CENTRO EURO-MEDITERRANEO SUI CAMBIAMENTI CLIMATICI SCARL	Uncertainty of land use – land cover change projections on climate	30/05/2016	Ugento, Italy	Scientific community (higher education, Research)	80	Italy
58	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	Disturbance, mortality and turnover in global vegetation modelling	28/06/2016	Lancaster, UK	Scientific community (higher education, Research)	40	international
59	Organisation of Workshops	FEDERAL STATE EDUCATIONAL ESTABLISHMENT OF HIGHER PROFESSIONAL EDUCATION RUSSIAN STATE AGRARIAN UNIVERSITY-MOSCOW TIMIRYAZEV AGRICULTURAL ACADEMY	Moscow Environmental School MOSES-2016	01/07/2016	Moscow, RTSAU	Scientific community (higher education, Research)	53	International
60	Organisation of Workshops	THE UNIVERSITY OF EXETER	WP3 analysis workshop	13/07/2016	Exeter, UK	Scientific community (higher education, Research)	20	global
61	Organisation of Workshops	Karlsruher Institut fuer Technologie	FireMIP	21/10/2016	Hamburg, Germany	Scientific community (higher education, Research)	22	international
62	Oral presentation to a scientific event	STICHTING VU-VUMC	Mediterranean Land systems: future changes to diversity, multifunctionality and intensity in a dynamic region	25/10/2016	Beijing, China	Scientific community (higher education, Research)	100	global

63	Oral presentation to a scientific event	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	Impact of ratios of gross forest loss to gain on land use change carbon flux	25/10/2016	Beijing, China	Scientific community (higher education, Research)	50	global
64	Oral presentation to a scientific event	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	Carbon emissions from historical land use change associated with forest age dynamics simulated by ORCHIDEE model	25/10/2016	Beijing, China	Scientific community (higher education, Research)	50	global
65	Oral presentation to a scientific event	STICHTING VU-VUMC	Tradeoffs and synergies in land use targets for climate mitigation and biodiversity conservation	26/10/2016	Beijing, China	Scientific community (higher education, Research)	100	global
66	Oral presentation to a scientific event	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE	What are the carbon and water costs of different land-based climate mitigation options?	27/10/2016	Beijing, China	Scientific community (higher education, Research)	100	global
67	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	Synergies and trade-offs between ecosystem service indicators in different land-based mitigation options	27/10/2016	Jülich, Germany	Scientific community (higher education, Research)	23	international
68	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	Widespread vulnerability of current crop production to climate change: A data-driven approach	28/10/2016	Birmingham, UK	Scientific community (higher education, Research)	50	UK
69	Organisation of Workshops	FONDAZIONE CENTRO EURO-MEDITERRANEO SUI CAMBIAMENTI CLIMATICI	Presentation of the Results of Meta analysis of biophysical effects of land use change to the European Issue group on AFOLU issues at the UNFCCC negotiation	05/11/2016	COP 22, Marrakesh, Marocco	Scientific community (higher education, Research)	60	International
70	Organisation of Workshops	denkstatt Bulgaria OOD	Life-cycle assessment of the albedo effect of LULCC	21/11/2016	Sofia, Bulgaria	Scientific community (higher education, Research)	25	Bulgaria
71	Organisation of Workshops	Karlsruher Institut fuer Technologie	LUC4C side-event	05/12/2016	COP 13,Cancun, Mexico	Scientific community (higher education,	50	International

						Research) - Policy makers		
72	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	Land-based climate change mitigation and impacts on ecosystem state and functioning (Arneth et al.)	05/12/2016	COP 13, Cancun, Mexico	Scientific community (higher education, Research) - Civil society - Policy makers - Medias	50	International
73	Oral presentation to a scientific event	STICHTING VU	Land use modelling, biodiversity and climate change scenarios, Predicting biodiversity change and impacts on ecosystem function symposium	04/04/2017	London, UK	Scientific community (higher education, Research)	60	International
74	Oral presentation to a scientific event	STICHTING VU	Multi-agent models of climate change and adaptation	19/04/2017	Complexities 2017 symposium, San Diego, USA	Scientific community (higher education, Research)	100	International
75	Oral presentation to a scientific event	FONDAZIONE CENTRO EURO-MEDITERRANEO SUI CAMBIAMENTI CLIMATICI	European Geosciences Union General Assembly 2017: A tool to evaluate local biophysical effects on temperature due to land cover change transitions	23/04/2017	Vienna, Austria	Scientific community (higher education, Research)	150	International
76	Organisation of Workshops	FONDAZIONE CENTRO EURO-MEDITERRANEO SUI CAMBIAMENTI CLIMATICI	A tool to evaluate local biophysical effects on temperature due to land cover change transitions	05/06/2017	CMCC Annual Meeting, Lecce, Italy	Scientific community (higher education, Research)	100	Italy
77	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	The impact of LUC on BVOC emissions (Arneth et al.)	11/09/2017	iLEAPS Conference,Oxford, UK	Scientific community (higher education, Research)	120	International
78	Oral presentation to a scientific event	STICHTING VU	Conservation Agriculture – Global spatial distribution and implications for land-based climate change mitigation and adaptation	11/09/2017	iLEAPS, Oxford, UK	Scientific community (higher education, Research)	120	International
79	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	Synergies and trade off between ecosystem service indicators in	11/09/2017	iLEAPS Conference, Oxford, UK	Scientific community	120	International

			afforestation and bioenergy land-use scenarios (Arneth et al.)			(higher education, Research)		
80	Oral presentation to a scientific event	STICHTING VU	The future of Europe's landscapes	12/09/2017	IALE EUROPE conference, Ghent, Belgium	Scientific community (higher education, Research) - Policy makers	120	International
81	Oral presentation to a scientific event	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	Biophysical and bio-geochemical effects of large-scale land cover changes	25/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International
82	Oral presentation to a scientific event	FONDAZIONE CENTRO EURO-MEDITERRANEO SUI CAMBIAMENTI CLIMATICI	A tool to evaluate local biophysical effects on temperature due to land cover change transitions	25/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International
83	Oral presentation to a scientific event	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	Bioenergy crops modelling in ORCHIDEE	25/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International
84	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	Quantifying the global carbon sink in secondary forest	25/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International
85	Oral presentation to a scientific event	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	Land use change and net carbon sink	25/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International
86	Oral presentation to a scientific event	UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH NONPROFIT CORPORATION	Investigating the biogeochemical effects of land management in the Community Earth System Model	25/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International
87	Oral presentation to a scientific event	THE UNIVERSITY OF EDINBURGH	Losses and inefficiencies in the global food system	25/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International

88	Oral presentation to a scientific event	STICHTING VU	Land-based mitigation options beyond afforestation and bioenergy: the case of conservation agriculture	25/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International
89	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	Future land-use and -management projections under population growth and climate change using a coupled ecosystem & land use model framework	25/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International
90	Oral presentation to a scientific event	MINISTERIE VAN INFRASTRUCTUUR EN MILIEU	Modelling forest plantations for carbon uptake with the IMAGE-LPJmL integrated assessment model	25/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International
91	Oral presentation to a scientific event	MINISTERIE VAN INFRASTRUCTUUR EN MILIEU	Afforestation for climate change mitigation ? exploring potentials and trade-offs in deep mitigation scenarios	25/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International
92	Oral presentation to a scientific event	JRC -JOINT RESEARCH CENTRE- EUROPEAN COMMISSION	The effects of land use change on the local surface energy balance: a global assessment from remote sensing, uncoupled and coupled climate models	25/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International
93	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	Synergies and trade-offs between ecosystem service indicators in afforestation and bioenergy land-use scenarios	27/09/2017	LUC4C International Science Symposium , Brussels, Belgium	Scientific community (higher education, Research)	55	International
94	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	Agent-based modelling of obstacles and consequences for land-based mitigation	27/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International
95	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	CROPLAND CHRONICLES: global patterns, causes and environmental consequences of cropland ; management intensity	27/09/2017	LUC4C International Science Symposium , Brussels, Belgium	Scientific community (higher education, Research)	55	International

96	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	Evaluation of global fire models within the Fire Model Intercomparison Project (FireMIP)	27/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International
97	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	Carbon removal from land-based mitigation is highly uncertain	27/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International
98	Oral presentation to a scientific event	Karlsruher Institut fuer Technologie	An online tool to estimate climate and carbon cycle changes in response to land-cover changes scenario based on LPJ-GUESS simulations	27/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International
99	Oral presentation to a scientific event	STICHTING VU	Improving the representation of responses to climate change in land-use change modelling	27/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International
100	Oral presentation to a scientific event	MINISTERIE VAN INFRASTRUCTUUR EN MILIEU	Making the 2 / 1.5 degree climate targets consistent with Food Security objectives	27/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International
101	Oral presentation to a scientific event	FEDERAL STATE EDUCATIONAL ESTABLISHMENT OF HIGHER PROFESSIONAL EDUCATION RUSSIAN STATE AGRARIAN UNIVERSITY-MOSCOW TIMIRYAZEV AGRICULTURAL ACADEMY	Land-use changes potential for reducing CO_2 emissions in the RF conditions	27/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International
102	Oral presentation to a scientific event	CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	Smaller carbon emissions from gross land use change by including secondary land cohorts in a global dynamic vegetation model	27/09/2017	LUC4C International Science Symposium, Brussels, Belgium	Scientific community (higher education, Research)	55	International
103	Organisation of Workshops	denkstatt Bulgaria OOD	Regional characterisation factors for the albedo effect of LULCC in LCA	23/10/2017	Sofia, Bulgaria	Scientific community (higher education, Research)	45	Bulgaria

104	Organisation of Workshops	FONDAZIONE CENTRO EURO-MEDITERRANEO SUI CAMBIAMENTI CLIMATICI	Improving knowledge of land cover change impacts on climate: role of biophysical effects beyond carbon	26/10/2017	SISC Conference, Bologna, Italy	Scientific community (higher education, Research) - Civil society - Policy makers	50	International
105	Organisation of Workshops	THE UNIVERSITY OF EDINBURGH	The role of land use in achieving the <2oC Paris COP21 target: Key Messages on Policy Implications	27/10/2017	Brussels, Belgium	Scientific community (higher education, Research) - Policy makers	30	International

Section B (Confidential or public: confidential information to be marked clearly)

No applications for patents, trademarks, registered designs, etc. were made in LUC4C.

No exploitable foreground was created.

3. Report on societal implications

Replies to the following questions will assist the Commission to obtain statistics and indicators on societal and socio-economic issues addressed by projects. The questions are arranged in a number of key themes. As well as producing certain statistics, the replies will also help identify those projects that have shown a real engagement with wider societal issues, and thereby identify interesting approaches to these issues and best practices. The replies for individual projects will not be made public.

A General Information *(completed automatically when **Grant Agreement number** is entered.*	
Grant Agreement Number:	603542
Title of Project:	Land use change: assessing the net climate forcing, and options for climate change mitigation dand
Name and Title of Coordinator:	Prof. Dr. Almut Arneth

B Ethics	
1. Did your project undergo an Ethics Review (and/or Screening)? • If Yes: have you described the progress of compliance with the relevant Ethics Review/Screening Requirements in the frame of the periodic/final project reports? Special Reminder: the progress of compliance with the Ethics Review/Screening Requirements should be described in the Period/Final Project Reports under the Section 3.2.2 *'Work Progress and Achievements'*	***No***
2. Please indicate whether your project involved any of the following issues (tick box)	***No***
RESEARCH ON HUMANS: No	
• Did the project involve children?	
• Did the project involve patients?	
• Did the project involve persons not able to give consent?	
• Did the project involve adult healthy volunteers?	
• Did the project involve Human genetic material?	
• Did the project involve Human biological samples?	
• Did the project involve Human data collection?	
RESEARCH ON HUMAN EMBRYO/FOETUS: No	
• Did the project involve Human Embryos?	
• Did the project involve Human Foetal Tissue / Cells?	
• Did the project involve Human Embryonic Stem Cells (hESCs)?	
• Did the project on human Embryonic Stem Cells involve cells in culture?	
• Did the project on human Embryonic Stem Cells involve the derivation of cells from Embryos?	
PRIVACY: No	
• Did the project involve processing of genetic information or personal data (eg. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)?	
• Did the project involve tracking the location or observation of people?	
RESEARCH ON ANIMALS: No	

• Did the project involve research on animals?	
• Were those animals transgenic small laboratory animals?	
• Were those animals transgenic farm animals?	
• Were those animals cloned farm animals?	
• Were those animals non-human primates?	
RESEARCH INVOLVING DEVELOPING COUNTRIES No	
• Did the project involve the use of local resources (genetic, animal, plant etc)?	
• Was the project of benefit to local community (capacity building, access to healthcare, education etc)?	
DUAL USE: No	No
• Research having direct military use	
• Research having the potential for terrorist abuse	

C Workforce Statistics

3. Workforce statistics for the project: Please indicate in the table below the number of people who worked on the project (on a headcount basis).

Type of Position	Number of Women	Number of Men
Scientific Coordinator	1	
Work package leaders	3	5
Experienced researchers (i.e. PhD holders)	6	25
PhD Students	1	6
Other	1	

4. How many additional researchers (in companies and universities) were recruited specifically for this project?	**21**
Of which, indicate the number of men:	17

D Gender Aspects

5. Did you carry out specific Gender Equality Actions under the project?
- ○ Yes
- X No

6. Which of the following actions did you carry out and how effective were they?

		Not at all effective				Very effective
❑	Design and implement an equal opportunity policy	○	○	○	○	○
❑	Set targets to achieve a gender balance in the workforce	○	○	○	○	○
❑	Organise conferences and workshops on gender	○	○	○	○	○
❑	Actions to improve work-life balance	○	○	○	○	○
○	Other:					

7. Was there a gender dimension associated with the research content – i.e. wherever people were the focus of the research as, for example, consumers, users, patients or in trials, was the issue of gender considered and addressed?
- ○ Yes- please specify
- X No

E Synergies with Science Education

8. Did your project involve working with students and/or school pupils (e.g. open days, participation in science festivals and events, prizes/competitions or joint projects)?
- X Yes- please specify: winter school for doctoral students
- ○ No

9. Did the project generate any science education material (e.g. kits, websites, explanatory booklets, DVDs)?
- X Yes- please specify: website (luc4c.eu), emulator tool (46.43.3.32/luc4c), information booklet, factsheets and policy briefs (downloadable at project website)
- ○ No

F Interdisciplinarity

10. Which disciplines (see list below) are involved in your project?
- ○ Main discipline[1]: 1.4
- ○ Associated discipline[1]: 1.5
- ○ Associated discipline[1]: 4.1

G Engaging with Civil society and policy makers

11a Did your project engage with societal actors beyond the research community? *(if 'No', go to Question 14)*
- X Yes
- ○ No

11b If yes, did you engage with citizens (citizens' panels / juries) or organised civil society (NGOs, patients' groups etc.)?
- ○ No
- ○ Yes- in determining what research should be performed

○ Yes - in implementing the research
X Yes, in communicating /disseminating / using the results of the project

11c In doing so, did your project involve actors whose role is mainly to organise the dialogue with citizens and organised civil society (e.g. professional mediator; communication company, science museums)?	○ X	Yes No

12. Did you engage with government / public bodies or policy makers (including international organisations)

○ No
○ Yes- in framing the research agenda
○ Yes - in implementing the research agenda
X Yes, in communicating /disseminating / using the results of the project

13a Will the project generate outputs (expertise or scientific advice) which could be used by policy makers?

○ Yes – as a **primary** objective (please indicate areas below- multiple answers possible)
X Yes – as a **secondary** objective (please indicate areas below - multiple answer possible)
○ No

13b If Yes, in which fields?

Agriculture Audiovisual and Media Budget Competition Consumers Culture Customs Development Economic and Monetary Affairs Education, Training, Youth Employment and Social Affairs		Energy Enlargement Enterprise Environment External Relations External Trade Fisheries and Maritime Affairs Food Safety Foreign and Security Policy Fraud Humanitarian aid		Human rights Information Society Institutional affairs Internal Market Justice, freedom and security Public Health Regional Policy Research and Innovation Space Taxation Transport	

[1] Insert number from list below (Frascati Manual).

13c If Yes, at which level?

- ○ Local / regional levels
- ○ National level
- X European level
- X International level

H Use and dissemination

14. How many Articles were published/accepted for publication in peer-reviewed journals?	**56**
To how many of these is open access[2] provided?	**50**
How many of these are published in open access journals?	**29**
How many of these are published in open repositories?	**21**
To how many of these is open access not provided?	**6**
Please check all applicable reasons for not providing open access:	
X publisher's licensing agreement would not permit publishing in a repository ❑ no suitable repository available X no suitable open access journal available ❑ no funds available to publish in an open access journal X lack of time and resources ❑ lack of information on open access ❑ other[3]: ……………	

15. How many new patent applications ('priority filings') have been made? *("Technologically unique": multiple applications for the same invention in different jurisdictions should be counted as just one application of grant).*	**0**

16. Indicate how many of the following Intellectual Property Rights were applied for (give number in each box).	Trademark	**0**
	Registered design	**0**
	Other	**0**

17. How many spin-off companies were created / are planned as a direct result of the project?	**0**
Indicate the approximate number of additional jobs in these companies:	

18. Please indicate whether your project has a potential impact on employment, in comparison with the situation before your project:

❑	Increase in employment, or	❑	In small & medium-sized enterprises
❑	Safeguard employment, or	❑	In large companies
❑	Decrease in employment,	X	None of the above / not relevant to the project
X	Difficult to estimate / not possible to quantify		

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[2] Open Access is defined as free of charge access for anyone via Internet.

[3] For instance: classification for security project.

19. For your project partnership please estimate the employment effect resulting directly from your participation in Full Time Equivalent (*FTE = one person working fulltime for a year*) jobs:	*Indicate figure:* **55**
Difficult to estimate / not possible to quantify	❑

I Media and Communication to the general public

20. As part of the project, were any of the beneficiaries professionals in communication or media relations?

O Yes X No

21. As part of the project, have any beneficiaries received professional media / communication training / advice to improve communication with the general public?

O Yes X No

22 Which of the following have been used to communicate information about your project to the general public, or have resulted from your project?

X	Press Release	❑	Coverage in specialist press
❑	Media briefing	❑	Coverage in general (non-specialist) press
❑	TV coverage / report	X	Coverage in national press
❑	Radio coverage / report	❑	Coverage in international press
X	Brochures /posters / flyers	X	Website for the general public / internet
X	DVD /Film /Multimedia	X	Event targeting general public (festival, conference, exhibition, science café)

23 In which languages are the information products for the general public produced?

X	Language of the coordinator	X	English
X	Other language(s)		

Question F-10: Classification of Scientific Disciplines according to the Frascati Manual 2002 (Proposed Standard Practice for Surveys on Research and Experimental Development, OECD 2002):

FIELDS OF SCIENCE AND TECHNOLOGY

1. NATURAL SCIENCES

1.1 Mathematics and computer sciences [mathematics and other allied fields: computer sciences and other allied subjects (software development only; hardware development should be classified in the engineering fields)]

1.2 Physical sciences (astronomy and space sciences, physics and other allied subjects)

1.3 Chemical sciences (chemistry, other allied subjects)

1.4 Earth and related environmental sciences (geology, geophysics, mineralogy, physical geography and other geosciences, meteorology and other atmospheric sciences including climatic research, oceanography, vulcanology, palaeoecology, other allied sciences)

1.5 Biological sciences (biology, botany, bacteriology, microbiology, zoology, entomology, genetics, biochemistry, biophysics, other allied sciences, excluding clinical and veterinary sciences)

2 ENGINEERING AND TECHNOLOGY

2.1 Civil engineering (architecture engineering, building science and engineering, construction engineering, municipal and structural engineering and other allied subjects)

2.2 Electrical engineering, electronics [electrical engineering, electronics, communication engineering and systems, computer engineering (hardware only) and other allied subjects]

2.3. Other engineering sciences (such as chemical, aeronautical and space, mechanical, metallurgical and materials engineering, and their specialised subdivisions; forest products; applied sciences such as geodesy, industrial chemistry, etc.; the science and technology of food production; specialised

technologies of interdisciplinary fields, e.g. systems analysis, metallurgy, mining, textile technology and other applied subjects)

3. MEDICAL SCIENCES

3.1 Basic medicine (anatomy, cytology, physiology, genetics, pharmacy, pharmacology, toxicology, immunology and immunohaematology, clinical chemistry, clinical microbiology, pathology)

3.2 Clinical medicine (anaesthesiology, paediatrics, obstetrics and gynaecology, internal medicine, surgery, dentistry, neurology, psychiatry, radiology, therapeutics, otorhinolaryngology, ophthalmology)

3.3 Health sciences (public health services, social medicine, hygiene, nursing, epidemiology)

4. AGRICULTURAL SCIENCES

4.1 Agriculture, forestry, fisheries and allied sciences (agronomy, animal husbandry, fisheries, forestry, horticulture, other allied subjects)

4.2 Veterinary medicine

5. SOCIAL SCIENCES

5.1 Psychology

5.2 Economics

5.3 Educational sciences (education and training and other allied subjects)

5.4 Other social sciences [anthropology (social and cultural) and ethnology, demography, geography (human, economic and social), town and country planning, management, law, linguistics, political sciences, sociology, organisation and methods, miscellaneous social sciences and interdisciplinary , methodological and historical S1T activities relating to subjects in this group. Physical anthropology, physical geography and psychophysiology should normally be classified with the natural sciences].

6. HUMANITIES

6.1 History (history, prehistory and history, together with auxiliary historical disciplines such as archaeology, numismatics, palaeography, genealogy, etc.)

6.2 Languages and literature (ancient and modern)

6.3 Other humanities [philosophy (including the history of science and technology) arts, history of art, art criticism, painting, sculpture, musicology, dramatic art excluding artistic "research" of any kind, religion, theology, other fields and subjects pertaining to the humanities, methodological, historical and other S1T activities relating to the subjects in this group]