Using scenarios and mapping to support sustainable agricultural policy development
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Purpose of this guidance

This document aims to offer guidance on how scenarios describing different plausible future contexts can be used to map potential changes in land-use, biodiversity and ecosystem services and support sustainable agricultural policy development. Future land-use, as well as the highly uncertain future context within which land-use-related policy operates, has major impacts on biodiversity and ecosystems and the goods and services they provide to people. The guidance provides a step-by-step process on how to combine the use of scenarios and spatial mapping during policy review to strengthen policies in the face of future uncertainly. Further information on the use of scenarios with spatial mapping and other background material is included to help better understand the methods, and enable users to adapt the approach to different purposes.

The approach taken in this document has been applied to policy development and revision in three national contexts in Africa and regional contexts in Latin America and East Asia.

A workflow for the approach is outlined in the sections below, and the steps can be adapted to different policy contexts and spatial scales. The approach comprises four stages:

Stage 1. Define the objective of the policy review exercise that will benefit from the use of future scenarios and the spatial mapping of potential impacts on biodiversity and ecosystem services
Stage 2. Develop relevant scenarios and quantify the drivers of land-use change under each
Stage 3. Map land-use change and its impacts on biodiversity and ecosystem services under each scenario
Stage 4. Revise policy using a scenario-guided approach integrating the impacts of land-use change on biodiversity and ecosystem services, and considering the drivers that underlie likely future pressures and (spatial) trade-offs as well as plausible future contexts for decision-making
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Introduction

Over the coming decades, society will have to balance competing needs for land to feed the growing human population, to provide resources and energy to satisfy the ever-accelerating human consumption of natural resources, to slow global warming and to reduce the rate of loss of biodiversity and ecosystem services. Land-use and land-management decisions have major impacts on biodiversity and ecosystems, and the goods and services they provide to people. Decision makers need to balance competing demands whilst also accounting for potential changes in these demands in the future, for example due to population growth, urbanisation and climate change. In addition, many uncertain factors, such as globalisation, commodity markets, and governance regimes may also influence the future and affect policy outcomes.

It is impossible to predict economic, political and social conditions in the medium to long-term future. Many of the drivers of change that determine these conditions are beyond the control of decision makers. Scenarios are increasingly used by scientists and decision makers to better understand and plan for this uncertainty1. They represent different plausible futures, each with unique challenges and opportunities, and help decision makers explore the implications of drivers outside the sphere of their influence. Scenario development itself is also a tool to bring together stakeholders with different objectives around common plausible futures and generate shared action.

Scenarios can help to consider what future land-use may look like and the future contexts within which policy targeting land-use may have to operate. Quantifying and mapping the impacts of potential future land-use change on biodiversity and ecosystem services helps to visualise potential future pressures and spatial trade-offs. Understanding the drivers that underlie these impacts can inform action to address them, and help develop policies that are more robust and more likely to achieve their intended outcomes – even under unpredictable future conditions.

This document offers guidance on how scenarios describing different plausible future contexts can be used to map potential changes in land-use, biodiversity and ecosystem services within a process to develop or review sustainable agricultural policy. It is aimed at national and regional decision makers, including governments, landscape management authorities and regional organisations.

This guidance is an output of UNEP-WCMC’s project on Engaging stakeholders in using scenarios of land-use change due to agricultural commodity development in the Lake Victoria Basin funded by the John D. and Catherine T. MacArthur Foundation. This project assessed potential threats to biodiversity and ecosystem services from agricultural development in the Lake Victoria Basin (van Soesbergen et al., 2018). The results can be used to support future policy development and review activities in the region (https://wcmc.io/commodities). The information in this guidance is based on the experience and lessons learnt from this work and related work by UNEP-WCMC and project partners (e.g. Ash et al., 2010; Vervoort et al., 2013; Sassen, 2015).

The guidance provides an overview of steps, as well as references to background material, to help better understand the methods and to adapt the approach to specific purposes. It focusses on applying modelled and mapped scenario outcomes to support review and development of sustainable national or regional level policy. The document assumes basic understanding of scenarios, modelling, mapping and policy development. For more detail on definitions and technical methods underlying the different elements, the reader is referred to additional information and learning resources in the Appendix.

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1 Also for policy prioritisation, to frame research questions and guide agenda setting
Overview of the scenario-guided policy review approach

Figure 1 shows a visual overview of the approach taken to review, or contribute to the development of policies through the lens of scenarios and spatial mapping. The main steps are summarised below and in the following sections of this guidance document.

**Stage 1:** The process starts by identifying the objective(s) of the policy review or development exercise that will benefit from the use of future scenarios and the mapping of potential impacts. This includes identifying all relevant policies, plans or other decision-making mechanisms, which could be targeted in order to achieve the objective.

**Stage 2:** Once a policy or plan has been selected, scenarios that describe plausible development trajectories and future socio-economic contexts in which the policy will operate are developed in a participatory setting. These scenarios are a set of qualitative storylines describing plausible future contexts, and quantified using appropriate modelling tools. The agreed set of scenarios then provide the context for, and help determine, the driving factors of future land-use which is mapped during Stage 3. The focus policy or plan will be explored in the context of these scenarios, rather than forming part of the scenario assumptions.

**Stage 3:** Maps of future land-use under each scenario are developed based on a set of assumptions relating to the driving factors defined by the chosen scenarios. Land-use/cover maps form the basis of habitat (for species) maps and maps of ecosystem functions (as an indicator of ecosystem services provision). Projected changes in land cover under the different scenarios can then be assessed for their potential impacts on biodiversity and ecosystem functions.

**Stage 4:** In the final ‘policy review’ stage, steps are outlined to review the selected policy or plan in a multi-stakeholder workshop setting, to identify and prioritise measures to improve the policy or plan in relation to the objective identified in Stage 1.
A step-by-step guide covering each of the four stages is outlined below. The steps can be adapted as needed to different policy review contexts.

| Stage 1                                                                 | 1. Identify the objective(s) of the policy review  
| 2. Select a land-use related policy or plan to focus on and identify other relevant policies, plans or decision-making mechanisms |
| The above steps should ideally take place during a multi-stakeholder workshop |
| Stage 2                                                                 | 3. Develop future scenarios that describe plausible development trajectories and future contexts for decision making  
| 4. Determine and quantify the drivers that influence land-use change under the different scenarios |
| Stage 3                                                                 | 5. Map current land-use and future land-use changes under each chosen scenario  
| 6. Map current biodiversity and ecosystem services  
| 7. Map impacts of land-use change on future biodiversity and ecosystem services |
| Stage 4                                                                 | Organise a multi-stakeholder review workshop and:  
| 8. Conduct a high-level review of the selected policy  
| 9. Interpret scenarios for key elements of interest and consider spatial impacts  
| 10. Review the policy against each scenario and the spatial impacts of land-use change on biodiversity and ecosystem services and formulate recommendations for policy improvement  
| 11. Translate scenario-derived recommendations into suggested additions or changes to the policy document  
| 12. Work with stakeholders to devise next steps for update of policy recommendations |
Stage 1: Define policy review objectives

Reviewing a policy document\(^2\) through the lens of different future scenarios can be a useful approach to test the feasibility and impacts of policy options under different future contexts. This can help to identify possible elements or actions that can mitigate or enhance particular outcomes under different futures. This guidance focuses on supporting the review of land-use related policy in light of potential implications for biodiversity and ecosystem services.

This first stage identifies the objectives of the scenario-guided policy review and is best undertaken in a small project team. This team should include an initial set of stakeholders with a good understanding of the national and regional policy landscape, and technical experts in scenario development. The team's goal is to identify objectives, relevant policy processes, and timelines and a wider network of stakeholders to engage in the process.

**Step 1. Identify the objective of the policy review**

Before starting the scenario-guided review process, an objective needs to be identified. Below are different options that can form the basis of an objective.

**a. Identify and address potential future pressures**
- Consider outcomes under different future scenarios and identify spatial areas where pressure is likely to be high under certain or all scenarios.
- Consider how policy can address some of the highest pressures or balance trade-offs where impacts are inevitable, e.g. through cross-sectoral policy coordination.
- Identify areas that require further action at the local level. For example, planning implementation of the policy at local administration level may need to be informed by the contexts provided by national-level scenario outcomes.

**b. Test strategies or specific policy options under different future scenarios**
- Test the outcomes of different policy options for biodiversity and ecosystem services, such as rules to curb deforestation (e.g. Forest Code in Brazil), or promote restoration (e.g. REDD+ in various countries), or decisions to expand protected areas and whether for example these lead to spatial shifts or changes in the intensity of pressures.
- Consider the feasibility of different policy options under different future scenarios (i.e. barriers to and opportunities for implementation), and prioritise those which are most viable, and have the best potential outcomes under the greatest number of future scenarios.

**c. Improve policy robustness to future uncertainty**
- Consider the likelihood of policy objectives being met under different future contexts and make the policy more robust to this future uncertainty, whilst also addressing potential pressures on biodiversity and ecosystem services. This can also lead to the development, testing and prioritisation of different policy options as in b. above.

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\(^{2}\) The "policy" or "policy document" referred to throughout this document equally could be a plan or a strategy, or any other document that aims to guide decisions and actions toward a desired outcome.
Step 2. Select a policy or planning process to focus on

In some cases, the policy to be reviewed will have been identified as part of setting the objective (Step 1). In other cases, the policy landscape needs to be reviewed in order to identify the relevant policies for the scenario-guided review, using (but not limited to) the following guiding questions:

a. Is there a link with the objective of the review (e.g. in this document we have focused on policies relevant to agriculture, biodiversity and ecosystem services)?

b. Is the policy due to be renewed or revised within the time-frame of the project?

c. Is a revision to the policy likely to be effective? (in terms of its implementation and results)

d. Is there adequate budget to implement the policy?

Select the policy to be reviewed, but keep a list of all relevant policies, plans or other decision-making mechanisms, particularly those which may have trade-offs or synergies with the focus policy during implementation. During this process it is useful to also identify relevant regional policies.
Stage 2: Develop scenarios and quantify drivers of land-use change

Scenarios offer a way to address uncertainty about the future by creating "coherent, internally consistent storylines that explore plausible future states of the world or alternate states of a system" (adapted from IPCC, 2013). Even though any single scenario could be extremely unlikely to happen, a set of different scenarios can help explore possible futures – rather than trying to predict one (van Notten et al., 2003).

Scenarios, as used in this policy review process, describe plausible development trajectories and future states for a country or region. They describe different contexts for decision making that are shaped by socioeconomic, political, institutional and biophysical factors that are mostly beyond the control of individual decision-makers, such as population growth, technological developments, governance regimes, environmental policies or climate change. Yet these factors may influence whether and where new pressures might arise that need a future policy response, and whether an existing policy will be able to meet its objectives under these future conditions.

The policy review process described in this guidance, considers both the future land-use outcomes of such scenarios as well as the contexts they provide for future land-use related decision-making.

Step 3. Define future scenarios describing plausible development trajectories and future contexts for decision making

There are many different approaches to developing scenarios and the choice of methods depends on the specific objective. Describing the process of scenario development is beyond the scope of this guidance, though a review of approaches can be found in the ‘Methods Resources’ section. Below is a short description of considerations when using scenarios in policy review.

Scenarios are not meant to be predictions of the future but rather a diverse set of extreme but possible future trajectories which define the scope of plausibility (Figure 2). It is therefore preferable to develop an even number of scenarios, to avoid a tendency amongst users to assume that the middle-numbered scenario in an odd-numbered set is the most plausible or desirable. A set of four scenarios is often developed. Similarly, though a so-called business-as-usual scenario\(^3\) can be part of such a set, it is better avoided as users may assume this is the most plausible one.

Scenarios are often developed first as qualitative storylines (e.g. Box 1), which are then (partly) quantified using mathematical modelling (e.g. Boxes 2 - 4). This approach is also used in this guidance (Step 4). In addition, the land-use implications of the scenarios are made spatially explicit (Step 5).

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\(^3\) A business-as-usual scenario simply refers to the expected continuation of current trends (e.g. population growth continues at the same rate, driving conversion of natural habitat to agricultural land to meet increasing demand for food).
Scenarios can refer to a few interacting factors only (e.g. x% future increased demand for and production of meat, leads to x% more greenhouse gas emissions in the livestock sector), or be more complex, and consist of a multitude of interrelated and interacting factors that vary with time and in space. Such scenarios can be derived from models built upon a set of assumptions (e.g. about the drivers of change and their interaction) which may be changed to explore different plausible futures (e.g. in Box 4).

A scenario-based review process can use and adapt existing scenarios or develop new ones. Relevant future scenarios may have been defined through separate processes (e.g. the Shared Socioeconomic Pathways (SSPs, O’Neill et al., 2014) and related Integrated Assessment scenarios or see example in Box 1). Yet, while global scenarios are extremely useful for global and larger scale land-use modelling studies, they are not always the best option to explore alternative futures at regional or local scales and to address regionally specific issues. Various organisations and countries have also developed their own scenarios for specific purposes. Moreover, existing scenarios can be reinterpreted for specific places or to address specific questions, for example for individual countries (if they were regional scenarios), specific stakeholder groups, or for the specific concerns of the policy under review (see Step 9). Alternatively, new scenarios can be developed as part of the policy review process. In this case, a longer period of stakeholder engagement will be needed. For an example of the development and adaptation of scenarios for a policy review process in East Africa, see Vervoort et al. (2013).

Box 1: CCAFS East Africa scenarios
The East Africa scenarios were developed by regional stakeholders and experts (from different sectors) in a process facilitated by the CGIAR program on Climate Change, Agriculture and Food Security (CCAFS) (Vervoort et al., 2013). The scenarios focus on socioeconomic change and regional adaptive capacity. They are framed by a set of drivers considered highly important yet highly uncertain for the future of food security, the environment and livelihoods in East Africa. In this case, two axes of uncertainty were used: mode of governance and extent of regional integration. For each, two opposing states in the future were defined and combined into a 2x2 matrix which created four combinations, each containing a plausible future end state for the region in 2030. Each scenario was elaborated into a storyline, describing trends and events from 2010 to 2030, and incorporating other relevant drivers identified during the scenario development process. This “axes method” is a common method for scenario development, used in most global scenario studies such as the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES), Millennium Ecosystem Assessment, Global Environment Outlook and others.

Step 4. Determine and quantify the drivers that influence land-use change
Quantification of scenarios using appropriate modelling tools allows further examination of possible future interactions between many different drivers, and allows for more in-depth comparisons between conditions, under different future scenarios. Quantification generates data that can be visualised as maps, graphs, or descriptive statistics, which in turn can be used to test and revise underlying model assumptions. It also helps us to understand whether the qualitative scenarios are internally coherent and plausible.

For the purpose of the scenario-guided review process described in this guidance, we are interested in quantifying those factors that most directly influence land-use change such as for example changes in demand, agricultural production and yields (see example in Box 2). In addition to quantified information on these direct factors, the scenarios also provide the broader contexts for these changes, such as population growth, technological developments, governance regimes, environmental policies, global geopolitics or climate change.
Qualitative scenarios are generally first translated into (semi-)quantitative assessments of a range of drivers and their indicators, by giving relative ratings to the importance and direction of change for indicators over time (for example for expected change in crop yields). Ideally this takes place with input from the stakeholders involved in developing the scenarios (see Vervoort et al., 2013).

A simple approach is to quantify land-use change under each scenario through stakeholder defined rules. These rules can then drive a GIS model to map future land-use (Step 5, see Box 3). However, more complex modelling approaches can also be used. For example, an economic model can be used to produce outputs on future demand, and thus required supply of food under different scenarios. These outputs can then be used to drive a land-use change model which allocates agricultural production spatially, based on various suitability criteria (Step 5, Box 4). Integrated assessment models exist that combine these steps (for example IMAGE – Integrated Model to Assess the Global Environment, Stehfest et al., 2014).

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**Box 2: Example of modelled change in production for coffee and maize in Tanzania under different scenarios**

The figures show the outputs of a model that projected the expected changes in crop production under different future socio-economic scenarios for East Africa (see also van Soesbergen et al., 2018). Expected increases in crop production, as shown in these graphs, can be due to increases in yield and/or expansion of production area. Depending on the balance between the two, the potential consequences for biodiversity and ecosystem services will be different. Whether increase in yield or increase in area prevails is influenced by biophysical potential, but also by broader factors determined by the different scenarios, such as the likelihood of investments into agricultural intensification and biodiversity conservation.
Box 3: Quantifying and mapping scenarios to inform agriculture decision-making in the Eastern Arc Mountains, Tanzania

The ‘Valuing the Arc’ (VTA) project in Tanzania developed two scenarios of plausible futures and policy contexts for the Eastern Arc Mountains in Tanzania, using a collaborative multi-stakeholder process. The scenarios were developed for the year 2025. The scenario-building process included descriptions of how the scenarios’ storylines impacted on different sectors (agriculture, water supply, tourism, forestry, and population). These impacts were quantified through a set of stakeholder-defined spatially explicit rules: stakeholders determined, ranked and weighed the impacts of different sets of drivers on major land cover classes, and the location of these impacts. These rules were subsequently used to create future land cover maps in a GIS model. Within the VTA project, these maps formed the basis for assessments and modelling of the production and flow of ecosystem services, their beneficiaries and values (Fisher et al. and Swetnam et al., 2011).

Box 4: Quantifying scenarios to map future land-use change

The four CCAFS regional scenarios for East Africa (see Box 1) were translated into semi-quantitative assessments of a range of drivers and indicators by regional stakeholders and quantified using two agricultural economic models: International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) (Robinson et al., 2015), developed by the International Food Policy Research Institute (IFPRI) and the Global Biosphere Management Model (GLOBIOM) (Havlik et al., 2011), developed by the International Institute for Applied Systems Analysis (IIASA). The models helped examine alternative futures for food supply, demand, trade, prices and food security and, subsequently, their effects on land-use. The GLOBIOM model results also include a spatial allocation of land-use changes, whereas the IMPACT results were used to drive a separate land-use model developed by the Center for Environmental Systems Research at Kassel University (LandShift) (Schaldach et al., 2011). The latter has been done for regions in East Africa, South East Asia and Latin America as part of UNEP-WCMC’s wider work on commodities and biodiversity in collaboration with CCAFS (van Soesbergen & Arnell, 2015; van Soesbergen et al., 2018). For example, the figure below shows maps of modelled baseline (2005) and potential future (2050) land use in Lake Victoria Basin under the four CCAFS scenarios.
Stage 3: Map spatially explicit scenario implications

Land-use is the most important direct factor affecting biodiversity and the ability of ecosystems to provide ecosystem services. Combining spatially explicit information on potential future agricultural development, and on biodiversity and ecosystem services provision, can help decision makers to identify potential impacts of land-use change. It also helps to identify possible spatial trade-offs, and prioritise areas for further investigation or action. For guidance on incorporating spatial data and mapping into national biodiversity policies/strategies, see Bowles-Newark et al. (2014).

Land-use change is the result of a combination of socioeconomic and biophysical variables or driving factors. Maps of future land-use are developed based on a set of assumptions relating to the driving forces defined by the chosen scenarios (Steps 3 and 4). The modelling and mapping itself is generally done by GIS specialists (Steps 5-7), based on the scenario inputs, and results are reviewed by stakeholders during subsequent steps in Stage 4.

Whether using complex or simpler modelling approaches to quantify scenarios in terms of land-use change, the main steps for mapping scenario-driven changes in land-use, biodiversity and ecosystem services are described in Steps 5-7.

Step 5. Map current land-use and future land-use change

Land cover refers to the physical surface characteristics of land (for example, vegetation or built structures) whereas land-use describes the economic and social functions of land, i.e. how land cover is used by people (FAO & UNEP, 1999). Land cover should therefore be considered separately from land-use, but in practice they are often combined. The area of interest can be a region, country or other area where there is a need to inform agriculture-related policy and land-use planning.

Land cover maps form the basis of habitat maps (for species) and maps of ecosystem functions. To link land-use model outputs to biodiversity and the provision of ecosystem services, the outputs from land-use change modelling need to include land-use/land-cover classes that represent or can be linked to different habitats and ecosystem functions.

Global maps of land cover or land-use can be used, or more specific or accurate data at the national or regional level where available. Table 1 in Appendix 1 contains examples of global level sources of data on land cover and agricultural land-use.

Potential future land-use change under different scenarios can be mapped using modelling approaches that allocate land-use based on a complex and dynamic set of interacting factors determined by the

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4 A driving force affecting land-use leads to either a change in the total area under a specific land-use type, or a change in the spatial distribution of land-use types within a larger area.
scenarios, or more simply through stakeholder defined rules, which can for example drive a GIS model to map future land-use (see also Step 4).

Land-use models are important tools. They allow the consideration of complex interactions and feedback of driving factors, and can be used relatively easily to explore the impacts of different policy options (e.g. implementation of policies to curb deforestation or promote restoration, trade policies). Land-use change modelling can be carried out at different spatial scales, and different levels of complexity. For more information on different types of land-use models and on drivers (types of drivers, causes, factors, feedbacks and interactions) see van Soesbergen et al. (2016) and Box 5.

**Box 5: Four types of land-use change models:**
- **Geographic models** allocate area or commodity demand on suitable* locations with suitability based on local characteristics.
- **Economic models** use supply and demand of land intensive commodities as a base for allocation of land (albeit at large geographical scales).
- **Integrated models** combine geographic and economic approaches, using an economic analysis of world markets and policies to quantify demand and supply and allocation of land-use based on geographic analysis.
- **Agent-based models** consist of a number of different ‘agents’ such as households that interact with each other and their environment, and make decisions and change their actions based on these interactions.

Many land-use models are developed for specific geographical regions or case studies, and may not be transferable to other contexts.

*For more detail on approaches to mapping agricultural suitability see Farrow et al. (2016)

**Step 6. Map biodiversity and ecosystem services**

**Biodiversity**

Biodiversity is complex and difficult to measure and map. Many approaches have been devised to measure and map biodiversity at the ecosystem, community, species and genetic levels, but consistent data at very fine resolution over larger scales is difficult to obtain (Hill et al., 2016).

The most commonly used measures of biodiversity are the number of species present (species richness) and the number of individuals present (abundance). Other measures, such as species endemism, rarity or threat, are particularly relevant for investigations that support conservation prioritisation.

There are large gaps in spatial data on species distributions. Biodiversity is therefore generally mapped using surrogate measures, partial measures or indices, including composite indices. A surrogate may be based on species or groups of species, or on environmental indicators, whose spatial distribution is known and quantified, and can be used to represent general patterns of biodiversity. Key Biodiversity Areas (IUCN, 2016) for example are determined using a combination of criteria relating to species, ecosystems and threat. Examples of environmental surrogates are biomes, ecosystems or habitat types (e.g. forests, wetlands), or even climatic variables that indicate suitability for particular species. Table 2 in Appendix 1 contains example sources of global (surrogate) data on the spatial distribution of biodiversity.

For more detail on measures of biodiversity, please refer to the methods / resources section of this guidance and the associated E-learning course.
Box 6: Mapping biodiversity and ecosystem functions (change) in the Lake Victoria Basin

For the Lake Victoria Basin, biodiversity was assessed using an index of biodiversity importance based on the relative distribution of suitable habitat for each assessed species, for each watershed within a region (van Soesbergen et al., 2018). The metric combined known species distribution data for birds, mammals and amphibians from the International Union for Conservation of Nature (IUCN) Red List and an established method of linking species’ habitat preferences to land-use/cover types (Buchanan et al., 2011). Ecosystem function was assessed by linking land-use categories to potential ecosystem function. Binary links were established that expressed whether particular land-cover types, land-uses or other ecological properties support specific ecosystem functions, based on information from literature or on expert knowledge (as described in Kienast et al., 2009). Impacts of land-use change on biodiversity and ecosystem functions were subsequently inferred by linking land-use change to changes in land-cover (see Step 7).

For example, the figure below shows maps of potential future (2050) ecosystem function impacts of changing land use in Lake Victoria Basin under one of the four CCAFS scenarios, split among three groups of ecosystem functions, showing potential trade-offs.

Commodity provision change

Regulating provision change

Wild provision change
Ecosystem services

Different aspects of ecosystem services can be mapped such as supply, flow, beneficiaries, demand or values. Indicators and proxies derived using data on land cover or land use are the most commonly used method for mapping ecosystem services. They aim to map the potential for an ecosystem to supply ecosystem services and they are derived from empirical data (indicators) or modelled estimates. For example, carbon storage service can be estimated and mapped using calculated relationships between land cover classes, biomass and carbon.

Other approaches include the use of process-based models or participatory mapping. Process-based models can be used to calculate ecosystem service values and flow given other input variables (including land use) and to model potential future change. Participatory mapping can help to identify locations of supply, delivery and valuation. Priority areas that are particularly important or sensitive to pressures, can also be identified through the use of expert judgement. For further information on methods and tools for assessing and mapping ecosystem services, please see van Soesbergen et al. (2018) and the methods resources section of this guidance.

Step 7. Map the impacts of land use change on biodiversity and ecosystem services

Changes in land use or land management can cause changes in species composition and abundance and affect the provision and value of ecosystem services, often increasing some services while decreasing others.

Impacts of land-use change on biodiversity are most often inferred by linking land-use change to changes in habitat types such as: forest cover, wetlands and grasslands, changes in habitat quality and landscape connectivity, or to changes in areas of known high species richness and rarity, or changes in extent of suitable habitat for (groups of) species (e.g. Box 6). Similarly, impacts of land-use change on ecosystem services in landscapes, are most often inferred by linking changes in land-cover to potential ecosystem functions (e.g. Box 6).

Mapping potential impacts of land-use change on biodiversity and ecosystem services can be done using different approaches, for example:

- Land-use change modelling combined with biodiversity and ecosystem function assessments, either integrated into a land-use change model, or by comparing biodiversity and ecosystem function values for current and potential future land-use in a separate analytical step.
- Simple data overlays of future land-use maps (outputs from land-use change model or other rule-based mapping process) with maps of current biodiversity and ecosystem functions to identify areas of likely future conversion and infer potential pressure on biodiversity and ecosystem services.

It is also possible to compare the potential future impacts of land-use change on biodiversity and ecosystem services to identify potential trade-offs and synergies among them. It is worth keeping in mind that relationships between land-use and biodiversity are complex and often bi-directional. Land-use and land-management practices can play an important role in sustaining biodiversity, but biodiversity resources can also determine land-use in some places.

Maps of the potential impacts of future land-use change on biodiversity and ecosystem services, can be used to inform (agricultural) policy development and review. They allow the visualisation of potential future pressures, help identify drivers, test policy options and strengthen agricultural policy in light of future uncertainty.

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5 In this context reference is also often made to ecosystem assets, stock or natural capital.
Stage 4: Scenario-guided policy review

This section outlines some key elements and steps to a successful scenario-guided policy review. The policy review itself is suited to a workshop setting involving a large, diverse group of regional and national stakeholders, including representatives from the ministry or institution responsible for the revision and implementation of the chosen policy.

The policy under review is first assessed at a high level, to familiarise people with its contents, and for an initial identification of issues to be addressed on the basis of the review objective. The policy is then evaluated against the scenarios, both in terms of its feasibility under these different futures, and how it can address some of the future pressures identified through the mapping steps. In light of the findings, recommendations to improve the policy are formulated and the policy text is reviewed. Involvement of and dissemination to key policy makers is essential to ensure uptake of the recommendations.

During this stage, stakeholders are brought together in a workshop setting to carry out the review (steps 8-11). The steps outlined below are recommendations which can be adjusted to individual countries and policy contexts.

**Step 8. Conduct a high-level review of the selected policy**

A high-level review helps to familiarise people with the policy document and to identify elements to focus on during more in-depth group discussions. The stakeholders for the review process should include people responsible for developing the policy, knowledge providers (e.g. university researchers), representatives of different groups (e.g. civil society, county governments, NGOs), relevant regional institutions and the core project team who were responsible for setting the objectives for the policy review.

The materials used in this step and prepared in advance of the workshop include:

- the full policy documents of the chosen policy,
- a high-level summary of the policy,
- preferably a list of indicators that can be used to monitor implementation of the policy and its impact in relation to the objective of the review.

**Phase 1:** Participants start by reviewing the overarching goals of the full policy, keeping in mind the specific objective of the review process (defined in Step 1). They identify any elements that are missing from the scope of the policy or that may need to be addressed in more detail. The review can be guided using the following questions:

a. What are the likely benefits or risks of the policy in relation to the review objective, and are these addressed in the policy? Which elements are missing? E.g. social safeguards in REDD+ policy, or potential environmental and social impacts in an agricultural investment policy.

b. How can these benefits, risks or any other missing elements be translated into (additional) goals in the chosen policy?

c. Which goals for the chosen policy should be prioritised in relation to the specific objective of the process?

**Phase 2:** After reviewing the overarching goals of the policy, participants then review and add to the existing list of indicators for monitoring the policy implementation and impact (if available). They then
use this updated list to review the policy summary, adding or proposing changes to its various elements.

Other considerations: In addition to reviewing the target policy as a whole, its thematic area, e.g. agriculture, can also be reviewed against other policy themes to assess how different policies and their implementation potentially relate to each other. For example: How do water issues relate to agriculture? How does agriculture relate to food and nutrition security? Here, the impacts of agriculture on the environment and the relationships between different themes can be made more explicit using a conceptual map. A national policy can also be compared to equivalent policies within a region, to support regional coordination (e.g. Box 7).

Box 7: Example: policy review to support regional harmonisation

Biodiversity and ecosystem services occur across borders, as do impacts of human activity on them. This means that it is often necessary to coordinate with neighbouring countries when implementing activities that may influence, for example, the migration of species or the provision of certain ecosystem services such as (e.g. water) supply. At the policy level too, regional harmonisation can avoid unintended consequences and conflicts. For a regional policy review, the group reviews the target national policy through a regional lens. This includes reviewing high-level summaries of the equivalent policies for other countries in the region, and also against region-wide policies. The review can be guided using the following questions:

a. Which relevant elements from the other countries’ policies/plans are missing from the target policy/plan and could improve the plan, and vice versa?
b. How can these elements be translated into objectives in the target policy/plan?
c. Which objectives for the target policy can be formulated to improve regional collaboration, and vice versa?

This information can be further used within the next steps elaborated in this guidance.

Step 9. Interpret scenarios for key elements of interest and consider spatial implications

In many cases the land-use, biodiversity and ecosystem services maps will have been developed independently of the policy review process (see Stage 3), using modelling tools and sometimes global data. This means that results cannot always (accurately) represent local variation. The exercises in this step help to specify the results of the modelling and mapping, and to think through the implications of the scenarios for land use, biodiversity and ecosystem services, as well as the underlying drivers that may lead to these impacts.

The materials used in this scenario adaptation step include:

- the reviewed and edited high-level policy summary,
- the consolidated list of indicators,
- the maps of modelled land-use change and change in biodiversity and ecosystem services under each scenario from Step 7,
- base maps including administrative boundaries and topographic features.

Phase 1: In groups, workshop participants review each scenario narrative and corresponding maps, in order to:

a. identify pressures and potential spatial trade-offs on the maps,
b. discuss how they (may) relate to the contexts created by the scenario, to specific drivers (e.g. access to markets, mechanisation, governance etc.) or other factors including those that are independent of the scenario narratives (for example, biophysical factors affecting suitability for agriculture in certain areas).
This exercise also allows an evaluation of the modelling and mapping results, based on regional and local expertise.

Phase 2: the participants re-interpret and specify the maps for the purpose of the exercise, linking to the policy under review. For this, the indicators from Step 8 are used in a participatory mapping setting to develop the scenarios spatially. Each scenario group indicates on their base map:

a. where main developments/changes in the key indicators are likely to happen under each scenario,
b. any potential impacts on biodiversity/ecosystem services,
c. any other impacts (some may be key indicators already).

The new maps are presented to all participants and remain visible to be considered in the next steps.

Phase 3: Based on the maps, the participants again discuss any areas that stand out, or particular pressures that have impacts on many aspects of biodiversity and ecosystem functions, e.g. those that affect the basis of food production, the integrity of protected areas, or the ability to mitigate climate change.

In particular, they should discuss how these impacts (may) relate to the contexts created by the scenario, to specific drivers or other factors. This will help to identify institutions, processes and people that can help achieve intended outcomes (Step 10).

Step 10. Review the policy against each scenario and the spatial impacts of land-use change on biodiversity and ecosystem services and formulate recommendations for improvement

The different scenarios represent different plausible futures, which offer different enabling or limiting environments for a policy as a whole, or for individual policy elements or objectives, as well as for the decision makers implementing the policy. In this step the policy is tested against all the scenarios, and recommendations are formulated to strengthen it. During this step it is important to keep in mind the original aim of the review (for example, to address potential future pressures, test policy options, or make a policy more robust to future uncertainty).

After reviewing the overarching goals and objectives of the policy in relation to the objective of the review (Step 8), the scenarios, their spatially explicit implications and underlying drivers (Step 9), the stakeholders now review the policy against each scenario.

Phase 1: based on the results of Step 9, participants work through, review and further prioritise the most relevant policy elements and any associated policy implementation activities identified in Step 8 (phase 1) in the context of each scenario.

Phase 2: reflecting on the maps, and for each given prioritised element or strategic issue within the policy, the group can ask questions such as:

a. Are there geographic areas that need particular attention, e.g. where are there are clear trade-offs?
b. Will the policy objectives and associated implementation activities help address some of these pressures and trade-offs within the context of each scenario? If not, why not?
c. How will the implementation activities under the selected policy objective work within the context of each scenario and are they realistic or feasible to achieve within the context of the scenario? If not, why not?

These discussions form the basis for recommendations to strengthen the policy under each scenario. They can be recommendations for existing policy elements to be amended, or new elements to be added to the policy, which would, for example, allow addressing some of the pressures and trade-offs identified through the maps or make the policy more robust under a particular scenario. Some recommendations may also prioritise the policy implementation activities in certain areas, to minimise trade-offs, or maximise synergies under all scenarios.

**Phase 3:** the recommendations for policy improvements under each scenario need to be considered in light of the other scenarios and their potential implications for biodiversity and ecosystem services, alongside any additional spatial information gathered from participants. Recommendations on the feasibility and/or implications across all scenarios are consolidated and used to identify where the policy’s strengths and weaknesses lie. Guiding questions can be:

a. What is the most likely “no-regret” policy option under all scenarios?
b. What enabling factors, i.e. institutions, processes and people, could help achieve intended policy outcomes under most future circumstances?
c. What needs to be added/changed to the policy to meet the review objective?

**Step 11. Translate scenario-derived recommendations into suggested additions or changes to the policy document**

Any proposed additions, changes or general considerations will form a set of recommendations which can be prioritised using the following guiding notes:

a. Compare the changes that were recommended for each scenario, and evaluate their relative strengths and weaknesses in terms of potential uptake.
b. Compare which recommended changes would improve the feasibility of the desired policy outcomes across a range of futures.
c. Assess whether changes or any other elements of the discussion can be incorporated into the overarching vision, mission, objectives and outcomes of the policy.
Alongside electronic changes to a working policy document, this discussion should lead to a prioritised set of recommendations for consideration by decision makers which capture the key elements of the scenario-guided review.

**Step 12. Work with stakeholders to devise next steps for uptake of policy recommendations**

Effective and regular communication with and between stakeholders driving the policy review process is key to ensure uptake and impact of the scenario-guided recommendations. These stakeholders can also advise on the best way to communicate the recommendations to the right people. For example, the recommendations may form the basis of a policy briefing document or policy memo, to present to senior members of the ministry responsible for the policy. Communicating the results of the review in an accessible form can be an effective tool to ensure dissemination to key decision makers.

Finally, the scenario-based review process should have a clear understanding of timelines and any other relevant policy documents that need to be considered. The process should also make sure that the recommendations align with the targeted policy/decision-making process, to ensure they are taken up and considered during the finalisation of the policy.
Conclusions

The approach described in this guidance integrates three important tools when it comes to planning for future sustainability in agricultural development: multistakeholder participation, scenarios and mapping.

Multi-stakeholder participation, including people from different sectors of government and society, helps ensure that as many visions and interests as possible are taken into account into future development planning. Scenarios, developed in multi-stakeholder settings, help people discuss and consider plausible futures that will affect them all, generate shared action and take into account future uncertainty.

Many socioeconomic, political, institutional and biophysical factors that shape future contexts are beyond the control of individual decision makers. Scenario-based policy review can help to identify institutions, processes and people that can help achieve intended policy outcomes. Mapping scenario outcomes gives geographic meaning to future scenarios, helping to communicate messages about pressures on the natural environment in a way that is understandable for a wide range of stakeholders. Maps also help people to relate to each other and provide a concrete basis for discussion about different interests and objectives.

Scenarios not only provide plausible future contexts for decision-making but also help to understand the drivers that underlie likely future pressures and (spatial) trade-offs. They can inform action to address the drivers and help develop policies that are more robust and much more likely to achieve their intended outcomes under unpredictable future conditions.
Technical guidance documents

The four stages of identifying an objective, developing scenarios, spatial analysis of biodiversity and ecosystem services, and policy review form key elements in supporting decision-making around sustainable agricultural development. The documents, e-learning modules and webinars below complement the three phases of this work, and provide more in-depth detail on the methods used and a wider overview of methodological approaches in the area of sustainable agricultural development.

Technical method reviews

A series of technical reviews produced by UNEP-WCMC outline existing approaches to mapping biodiversity, ecosystem services and agricultural suitability, as well as using land-use change models and developing future scenarios. Together, these reviews can support decision makers at national and sub-national levels to adopt an ecosystem-based approach to agricultural development policy and land-use planning. A summary of each review is provided below.

Available at: https://wcmc.io/technicalreviews

**Mapping Agricultural Suitability.** This report provides an overview of existing approaches to mapping agricultural suitability, including review of the underlying data, at different scales. The review seeks to better understand the spatial scales and timescales considered by existing approaches to map agricultural suitability and the criteria and methods used to assess land suitability for different crops or land-use types (Farrow et al., 2016).

**Mapping biodiversity over large spatial scales: a review into current approaches for species level analysis.** This review assesses various approaches to measuring biodiversity at the species level, and models that can be used to assess the present patterns, and project these into the future against possible scenarios. The main categories of approaches are: biodiversity measures, biodiversity models, surrogates of biodiversity (Hill et al., 2016).

**Approaches to mapping ecosystem services.** This report provides an overview of the state-of-the art in mapping ecosystem services, with the intention of building the understanding and capacity of decision makers to make informed decisions around the use of ecosystem services maps and models. The report provides a broad overview of the various conceptual models and frameworks for mapping ecosystem services, and reviews ecosystem services mapping approaches, showing that there are many different approaches and a number of things that need to be considered when ecosystem services mapping is undertaken (Burgess et al., 2016).
A review of land-use change models. This document provides an overview of the current state of land-use modelling as well as the usability, applicability and availability of modelling tools, particularly in relation to land-use change as a driver of change in biodiversity and ecosystem services. A general overview of existing models is presented along with their data requirements and different scenarios that can be used to drive these models. This document can serve as a reference for organisations to make informed choices on the capacity needs, and options for the use of land-use models in assessments of land-use change, and resulting impacts on biodiversity and ecosystem services (van Soesbergen et al., 2016).

Scenario development: a review of approaches. This report reviews approaches to scenario development in support of policy development and decision-making. It is based on the consideration of synergies and trade-offs between agricultural or other natural resource-based development, and maintaining biodiversity and ecosystem service values (Fancourt et al., 2016).

E-Learning course and webinars

Based on the technical method reviews above, the e-learning course on Managing Productive Landscapes provides some of the key knowledge, tools and methods that can support a more integrated approach in planning for sustainable agricultural development. This can be applied at both national and sub-national levels, to help develop more robust policies and plans in the face of future uncertainty. It will enhance understanding of the trade-offs and synergies between agricultural production and ecosystem management, through the application of tools and methods to assess these. The course is composed of two main learning modules, with five lessons and a short informative PowerPoint presentation. Module 1 focusses on 'Approaches for assessment and analysis', including on existing approaches, tools and data to map biodiversity and ecosystem services and agricultural suitability at the landscape scale. Module 2 provides guidance on how to use the methods and data from module 1, to assess trade-offs and synergies to support policy and decision-making, through the use of land-use change models and supported by scenario development and analysis.

Available at: https://www.conservationtraining.org/course/view.php?id=264 Two free webinars complement the above e-learning course. The aim of these webinars is to support the application of a landscapes approach to decision-making and development planning. The presenters provide in-depth insight and practical experience on two key topics:

- Landscape planning in theory and practice http://wcmc.io/landscapeplanning and
- Scenario Planning in theory and practice http://wcmc.io/scenariowebinar
Additional tools

The **Capacity Development Assessment Tool (CDAT)** establishes a common and systematic approach to assessing the capacity development needs of partners and/or evaluating impact, in terms of strengthening capacity. The tool is designed to be comprehensive, yet flexible enough to be tailored to a range of capacity development scenarios. This includes working to develop the capacity of individuals, organisations and national or multi-national networks and collaborations. The CDAT is composed of a suite of Excel worksheets at different scales, which allow the user/s to better understand and prioritise capacity development needs in relation to performing a task, achieving an objective, or implementing a project or programme. Each element of capacity is assessed and scored for its current level of capacity and the feasibility to achieve the desired capacity.

Available at: [https://wcmc.io/CDAT](https://wcmc.io/CDAT)

**Mapping Biodiversity Priorities** sets out a practical, science-based approach to spatial biodiversity assessment and prioritisation, and is intended to be applied at the national level in any country. It shows how it is possible to use available spatial data to conduct a useful national assessment of biodiversity in a short space of time, and with minimal resources. It is aimed at a wide audience and in particular those involved in revising or implementing National Biodiversity Strategies and Action Plans (NBSAPs).

Available at: [http://wcmc.io/_mapping_biodiversity_priorities](http://wcmc.io/_mapping_biodiversity_priorities)

The **IPBES methodological assessment report on scenarios and models of biodiversity and ecosystem services.** The methodological assessment of scenarios and models of biodiversity and ecosystem services, was carried out under the auspices of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). IPBES provides guidance for the use of scenarios and models for experts performing assessments within IPBES, as well as to scientists and other stakeholders and decision makers. The assessment focuses on a critical analyses of the state-of-the-art, and best practices for using scenarios and models in assessments and policy design, and implementation relevant to biodiversity and ecosystem services. It proposes means for addressing gaps in data, knowledge, methods and tools relating to scenarios and models. It, finally, makes a series of recommendations for action by IPBES member States, stakeholders and the scientific community to implement and encourage those best practices in regard to the use of scenarios and models, engage in capacity-building and mobilise indigenous and local knowledge.


The **Participatory Scenario Development tool** used for climate change adaptation (UNDP, UN Environment and World Resources Institute) provides step-by-step guidance on how to use the tool.

Available at: [http://www.gcfreadinessprogramme.org/sites/default/files/Participatory%20Scenario%20Development%20Tool%20and%20Guidance.pdf](http://www.gcfreadinessprogramme.org/sites/default/files/Participatory%20Scenario%20Development%20Tool%20and%20Guidance.pdf)
Related project resources

**UNEP-WCMC Commodities and Biodiversity: a project summary.** This report summarises the results of the Commodities and Biodiversity project, funded by the John D. and Catherine T. MacArthur Foundation. The project aimed to develop knowledge and tools for decision makers to balance different demands on land, plan appropriate actions and respond to future pressures on ecosystems in the three focal regions of the Foundation: the Great Lakes of East Central Africa, the Greater Mekong and its Headwaters, and the Watersheds of the Andes.

Available at: [http://wcmc.io/9183](http://wcmc.io/9183)

**Commodities and Biodiversity: Spatial analysis of potential future threats to biodiversity and ecosystem services.** This report presents the analytical framework developed to assess biodiversity and ecosystem services under different scenarios. This framework can be implemented at multiple geographic scales to evaluate priorities for conservation or other action. It considers spatially explicit drivers of land-use change, including changes in human population, commodity markets and agricultural production and has been applied using both global scenarios and regionally-developed scenarios at a higher resolution.


**The distribution of threats from future agricultural development to biodiversity and ecosystem services in the Lake Victoria Basin: Implications for policy.** This report can be used in conjunction with this guidance document. It presents and applies an analytical framework to assess and visualise likely future impacts on biodiversity and ecosystem functions, under different socioeconomic futures, for East Africa and discusses implications for policy.

Available at: [http://wcmc.io/commodities](http://wcmc.io/commodities)

**Workshop reports** for all regional and national workshops in the Lake Victoria Basin, where the approach presented in this guidance document have been tried and tested. These include regional inception and capacity-building workshop and national policy review workshops.

Available at: [http://wcmc.io/commodities](http://wcmc.io/commodities)
References


IPCC (2013) *Definition of terms used within the DDC pages*. Available at: http://www.ipcc-data.org/guidelines/pages/definitions.html


## Appendix 1

### Table 1: Example sources of global data on land cover and land-use

<table>
<thead>
<tr>
<th>Theme</th>
<th>Coverage</th>
<th>Data</th>
<th>Source</th>
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</table>

### Table 2: Examples of sources of globally curated biodiversity data

<table>
<thead>
<tr>
<th>Theme</th>
<th>Coverage</th>
<th>Data</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biodiversity</td>
<td>Global</td>
<td>Distribution Maps of The IUCN Red List of Threatened Species</td>
<td>IUCN. Available at: <a href="http://www.iucnredlist.org/technical-documents/red-list-training/iucnspatialresources">http://www.iucnredlist.org/technical-documents/red-list-training/iucnspatialresources</a></td>
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