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USE OF BIODIVERSITY SCENARIOS AT LOCAL, NATIONAL AND REGIONAL SCALES

Note by the Executive Secretary

1. The Executive Secretary is circulating herewith, for the information of participants in the twenty-first meeting of the Subsidiary Body on Scientific, Technical and Technological Advice, a note on the use of biodiversity scenarios at local, national and regional scales. The note has been prepare by the United Nations Environment Programme's World Conservation Monitoring Centre with inputs from the Secretariat of the Convention on Biological Diversity, Marta Coll (Institute of Marine Science, Barcelona), Rob Dunford (University of Oxford), Kasper Kok (Wageningen University), Olivier Maury (Institute of Research and Development, Marseille), Myron Peck (University of Hamburg) and Laura Pereira (Stellenbosch University).

2. This note provides additional information relevant to section III of document CBD/SBSTTA/21/2 in which scenarios and their role in informing decision making on biodiversity are reviewed. In response to recommendation XXI/1 it has been revised following a peer review process as well as to reflect addition work on this issue.

3. The report is presented in the form and language in which it was received by the Secretariat.

* CBD/SBSTTA/21/1.

I. INTRODUCTION AND SCOPE

1. The fifteenth meeting of the Conference of the Parties (COP) to the Convention on Biological Diversity (CBD) in 2020 is expected to adopt a post 2020 global biodiversity framework. This will take into account the 2050 Vision of the current Strategic Plan for Biodiversity 2011-2020, "Living in harmony with nature", where "by 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people". It will also take into account the 2030 Agenda for Sustainable Development as well as other relevant international processes including the Intergovernmental Platform for Biodiversity and Ecosystem Services, the Global Biodiversity Outlooks and UN Environment's Global Environmental Outlooks. Against this background, the aim of this document is to review how future scenarios of biodiversity and ecosystem services at local, national and regional scales, can help to inform the implementation of the Convention and its post 2020 global biodiversity framework.

2. Scenario analysis has emerged as a methodology for analysing uncertain, future pathways for complex social-ecological systems to support strategic decision making that anticipates opportunities, seeks to adapt to changes and to avoid disasters. As defined by the IPBES Methodological Assessment on Scenarios and Models of Biodiversity and Ecosystem Services "scenarios are representations of possible futures for one or more components of a system, particularly, in this assessment, drivers of change in nature and nature's benefits, including alternative policy or management options" (IPBES, 2016). The drivers of change can be indirect such as population, market forces, technology, societal preferences and policy decisions, or can be direct such as habitat change, climate change, the unsustainable use of biological resources, pollution and the introduction of invasive species. These drivers of change in nature and nature's benefits arise from complex, coupled social and ecological systems. As a result they exhibit thresholds and non-linear feedbacks, making predictions about the trajectories of change for nature challenging.

3. Scenario analysis provides a framework in which to explore, characterise and organise uncertainties across systems and scales. There are several ways in which scenario analysis can be used. The IPBES methodological assessment described four different types of scenarios: (a) "exploratory scenarios" that can support agenda setting, (b) "target-seeking scenarios" that can support policy design, (c) "policy-screening scenarios" to support implementation, and (d) scenarios for "retrospective policy evaluation" (also known as "ex post evaluation") that can support policy review (IPBES, 2016).

4. In addition to their use for informing decision making, scenarios have the potential to be powerful for raising awareness of an issue and engendering behavioural change, especially when they are participatory. Scenarios can illustrate the implications of certain actions on nature futures by identifying the negative consequences of some futures and by demonstrating that desirable alternative futures are attainable and what the pathways might be to achieving them. They can thus be a tool to empower action across different levels of society.

5. Two important sets of global scenarios that are commonly downscaled to provide sub-global scenarios arise from the Intergovernmental Panel on Climate Change (IPCC). The first is the Representative Concentration Pathways (RCPs), which provide scenarios for particular atmospheric greenhouse gas (GHG) concentrations, and thus can be used to derive likely changes in variables such as global air temperature or land use patterns (van Vuuren et al., 2011). The second set of scenarios is the shared socioeconomic pathways (SSPs) that describe particular combinations of socio-economic developments, population growth, and governance, which then affect trajectories of global change into the future (O'Neill et al., 2013). See CBD/SBSTTA/21/INF/2 for more detailed description of the RCPs and CBD/SBSTTA/21/INF/4 for further details on the SSPs.

6. There are many approaches to developing sub-global scenarios, for example they can be generated from the bottom up, built around the specific circumstances of the problem to be addressed. Or they can be built from the top down by describing how global-scale scenarios need to be adapted to fit the sub-global circumstances. Exploratory archetypes can be employed at the relevant scale to distinguish different storylines developed using participatory (such as WWF and AfDB, 2015) or expert (Millenium Ecosystem Assessment, 2005) approaches. Alternatively target-seeking scenarios can be used, focussing on specific goals, such as the Sustainable Development Goals, or those emerging from participatory processes (Bennet et al., 2016; Rosa et al., 2017).

Why focus on sub-global?

7. Implementation of the Convention's strategic plan relies on decisions taken at local, national and regional scale by a wide variety of stakeholders. Scenario analyses focussing at these spatial scales aim to inform strategic decision making for these stakeholders.

8. In both the terrestrial and marine realms, management and conservation of biodiversity can be informed by sub-global modelling and scenarios for three reasons:

    8.1. First, global scale integrated models are often too coarse to resolve features at a fine enough resolution for many issues related to practical, management decision making. For example, most integrated assessment models—which are typically employed for global scenario analyses to quantify key environmental and economic parameters, such as greenhouse gas emissions or land use configurations—work at temporal and spatial resolutions that are too coarse to address more than broad questions about biodiversity, soils or water resources (Kok et al., 2016).

    8.2. Second, when developed at the scale of the decision making problem (e.g. local, national or regional), scenarios can more directly take into account the specific circumstances of the problem, which might include particular combinations of drivers of change or policy questions. They can incorporate more relevant data to build scenarios and test them, including biological and ecological data but also socio-economic data, and therefore increase the realism of the scenarios. The additional realism of sub-global scenarios can help stakeholders to grasp trade-offs and understand potential costs and benefits.

    8.3. Third, sub-global scenario analyses can be used to assess the trade-offs or effectiveness of policy options at a scale in-line with that at which policy decisions are typically made. In general, except for bilateral or multi-lateral agreements such as the Straddling Fish Stocks Agreement or trans-boundary parks, biodiversity management occurs at the national (i.e. EEZ in marine environments) or finer scales. Therefore sub-global scenario analyses can investigate the impact of manageable drivers while accounting for global drivers that cannot be managed by local, national or regional decision-makers.

II. SUB-GLOBAL SCENARIOS AND THEIR ROLE IN IMPLEMENTATING THE CONVENTION ON BIOLOGICAL DIVERSITY

9. We reviewed how local, national and regional scenario analyses can contribute to the implementation of the Convention and the Strategic Plan for Biodiversity 2011-2020. This review is not systematic nor intended to comprehensively cover all sub-global scenario studies and we recognise for example that there are focussed landscape and seascape scale scenarios. Instead it summarises a set of illustrative example scenario analyses at each spatial scale (local, national and regional). In particular, we focussed on how such sub-global scenarios could help to inform sub-global decision making and policy processes, including the implementation of National Biodiversity Strategy and Action Plans. National Biodiversity Strategy and Action Plans are the principal instruments for implementing the

Convention at a national level. Article 6 of the Convention obliges Parties to develop national plans for the conservation and sustainable use of biological diversity and to integrate conservation and sustainable use of biological diversity into relevant sectoral and cross-sectoral plans and policies.

10. The Strategic Plan for biodiversity 2011-2020 is underpinned by five strategic goals. A. Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society. B. Reduce the direct pressures on biodiversity and promote sustainable use. C. To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity. D. Enhance the benefits to all from biodiversity and ecosystem services. E. Enhance implementation through participatory planning, knowledge management and capacity building. Scenarios can help to provide information on these goals in several ways. They can explore the interactions between biodiversity, conservation and other economic sectors and can help biodiversity become integrated into growth and development processes. As such scenarios are particularly useful for dealing with issues under Strategic Goals A, B and C.

Regional-scale scenarios

11. Regional-scale scenarios are those that consider how biodiversity might respond to drivers that occur across national boundaries. Scenarios at this scale can be valuable because drivers are often trans-boundary and because biodiversity does not typically correspond to national boundaries. Further pressures on biodiversity can also result from multiple sources, some of which may lie outside national borders. This is particularly true for the marine environment.

12. Marine systems face multiple pressures originating from various terrestrial and marine sources, often located in several countries. In these types of situations scenarios can be particularly helpful in exploring different policy approaches. For example in the Baltic Sea, which has nine countries along its coasts and a further four countries that lie within its catchment area, regional scenario analysis has permitted the exploration of the relationship between nutrient and fisheries management and the effects of climate change.

13. In a scenario exercise for the Baltic Sea Meier et al. (2014) found that nutrient loading and capture fisheries might affect these ecosystems considerably under climate change. Areas of the Sea with low or no dissolved oxygen are considered likely to increase under a range of business-as-usual nutrient load and climate scenarios. Similarly phytoplankton biomass is projected to approximately double by the end of 2100, whilst, stocks of commercially important cod and herring are projected to decline by over 50% in some scenarios with sprat emerging as dominant fish. However scenarios also indicate that such deleterious effects can be prevented if different management regimes are implemented for the Baltic Sea basin, but a trade-off exists between cod and herring stocks. For example if total nutrient run-off into the Baltic Sea is reduced (nitrogen by 135,000 tons per year and phosphorus by 15,250 tons per year) compared to a 1997-2003 reference period, and cod fishing was reduced such that the fisheries mortality rate does not exceed 30% of the estimated biomass of the cod fish stock (Niiranen et al., 2013), the stocks of cod in the Baltic Sea would increase but herring stocks would decline relative to the present. However, if nutrient run-off is allowed to continue under a business-as-usual scenario and fisheries pressure on cod remains high, herring stocks would increase in the far future (2070-2098), however, cod stocks will decline.

14. European fisheries are another example of a system requiring regional scale analysis. The Climate Change and European Aquatic Resources (CERES) suite of exploratory socio-political scenarios for European marine environments was created by downscaling the global Shared Socio-economic Pathways (SSPs) (CERES 2016). These scenarios explored the implications of various socio-economic and political conditions for fisheries and aquaculture. One of these scenarios is a “global

markets world", under which the European population grows to 750 million by 2050 and 846 million by 2100, GDP per capita increases by factors of 2 and 6 over the same time periods, people aspire to personal independence, taxes and regulation are reduced, consumerism is widespread, there is high fossil-fuel dependency and both infrastructure and ecosystems are highly engineered. Projections under this scenario suggest that demand for fish and shellfish in Europe might double by 2050 against current levels of European production and triple by 2100 with fish being obtained from the cheapest sources with few legal or technical restrictions by few high-tech boats that compete for global resources. As fish stocks are sequentially depleted there is a huge expansion of offshore fish farming relying on extensive cheap immigrant labour, global trade, technology developments and low energy prices. In contrast, under a sustainability focussed world in which population stabilises at 679 million by 2050 and then declines to 600 million by 2100 whilst GDP per capita increases by factors of 2 and 4 over the same time periods, people aspire to higher levels of welfare and a healthy environment, there is a strong cooperative society with declining income inequality, low resource intensity and low fossil fuel dependency. The outlook for marine ecosystems is brighter in this scenario. The demand for fish and shellfish is projected to flatten by 2050 and then declines, which combined with sustainable fishing methods could lead to sustainable fish supply. Aquaculture is projected to play a role in fish supply but is tightly regulated with high traceability and quality standards.

15. The two cases described above illustrate that some options have more desirable biodiversity outcomes, for example, reducing nutrient pollution and regulating fisheries to prevent the spread of anoxia in the Baltic Sea and to reconstruct ecosystems with an abundance of top predators. But there are trade-offs, for example a sustainable Baltic cod fishery is likely to come at the expense of the herring fishery. They also imply that integrated policy responses are required. For example, a strong regulatory regime in Europe and internationally will be required to achieve sustainable European fisheries and should implement certification, impact assessments for new fisheries and low impact fishing gears.

16. Regional scenarios are also useful in exploring dynamics in terrestrial environments. For example sub-Saharan Africa has two major biomes: tree-dominated forests and grass-dominated savannas. The distribution and structure of these two biomes has resulted from the interaction between climate, soils and disturbance regimes, especially fire and herbivory. In the future the effects of climate change and land-use change will likely play a greater role in determining the distribution and structure of these two biomes. It is therefore important to assess policy decisions that might change the land use patterns in the context of climate change.

17. To explore this Aleman et al. (2016) used the four RCP scenarios of climate change and consistent land use change patterns to explore the effects of these two drivers on the future distributions of forests and savannas in sub-Saharan Africa. African forests are likely to experience tree cover loss under all scenarios, mostly as a result of pasture and cropland area expansion. Under the scenario in which the strongest climate mitigation efforts are implemented, the Congo forest contracts and is fragmented, and 77% of the Guinean forest block and 97% of dry forests throughout Africa is lost. Tree cover is also projected to be lost from savannah systems, particularly in savanna areas bordering forests (Aleman et al., 2016). Part of the reason for these declines is that the strong climate mitigation efforts in the scenario rely on widespread bioenergy plantations. Therefore, in order to meet food demands in a world where, globally, land is being taken out of agricultural production to grow bioenergy crops, agricultural land in Africa is projected to expand. Understanding these trade-offs is valuable and suggests that widespread bioenergy use will likely cause negative biodiversity outcomes. To mitigate against forest habitat losses, the authors suggest more effective management of existing protected areas. Enforcement should be improved, especially in the forested protected areas of West and Central Africa, so that agricultural expansion is less likely at the edge of protected areas. In

savannas where there is relatively less protection, an increase in parks utilising traditional land management practices could be valuable in addition to re-evaluating systematic land use change planning for climate mitigation scenarios taking the conservation value of savanna ecosystems into account in addition to their agricultural value.

18. The biome changes described for Africa above demonstrate that climate change, and our responses to mitigate it, has the potential to substantially change the provision of ecosystem services at a regional scale. Changes in ecosystem services have been projected for Europe under climate change. However an important uncertainty is how societies will adapt to the changes in ecosystem services brought about by climate change.

19. In this context, Dunford et al. (2015) explored the implications of 8 different strategies for how Europe might adapt to potential climate impacts on ecosystem services in the 2050s under an extreme and a moderate climate scenario and either a utopian or dystopian socio-economic storyline. The utopian storyline assumed effective government, reduced inequality, higher well-being, global cooperation and moderate population growth. The dystopian world assumed rapid population growth in a world of increased inequality, unsuccessful innovation, political instability and insecurity. Under both extreme and moderate climate change, the technologically driven agricultural productivity improvements realised in the utopian socio-economic scenario caused agricultural land area to shrink and several ecosystem services (food, water and timber provision, atmospheric regulation) to be enhanced. In contrast, for a dystopian future, in which productivity gains were not available and thus agricultural land expansion is required to feed the growing population, most ecosystem services declined. Forest and farmland biodiversity was projected to decline under climate change in both socio-economic storylines, although declines were less severe with moderate climate and in a utopian society. Critically for policy makers, the strategies employed in response to such potential changes altered the ecosystem service outcomes considerably. For example, compared to the scenarios with no adaptation strategy, policies to reduce food imports by 19% and increase self-sufficiency resulted in increases in food provision, decreases in water and timber provision and atmospheric regulation, and negligible impact on forest or farmland biodiversity. The most extreme nature focussed strategy, in which protected area coverage doubles (targeting increasing connectivity between protected areas), tree species best matched to future climate conditions are planted and dietary shifts to minimise agricultural pressures occur, could increase timber provision, atmospheric regulation and forest biodiversity. However, food and water provision and farmland biodiversity might decline. The analysis demonstrates that future climate, food demand, innovations in agricultural productivity and adaptation strategies interact to drive land use changes and resultant ecosystem service changes. Also, critically, large scale land use change focussing on reversing declines in nature appears feasible even under extreme climate change and dystopian socio-economic conditions.

National-scale scenarios

20. National scale scenarios analyses are pertinent as this is the scale at which government decisions are typically made. National scale scenarios can provide useful information to the design and implementation of National Biodiversity Strategy and Action Plans as well as help to mainstream biodiversity into other economic sectors such as fisheries, agriculture and forestry.

21. The fisheries sector is crucial to the economy and well-being of many coastal nations. In Bangladesh, for example, fisheries accounts for 4.4% of the national GDP and provides around 60% of the national animal protein intake. For the 16 million people living near the coast, fish resources are vital. However there is growing evidence that climate change might reduce the productivity of fisheries in South and Southeast Asia. In the case of Bangladesh it is crucial to understand how this potential impact might affect the provision of fish products and in particular to explore how fisheries

management can mitigate against future climate impacts. Under business-as-usual climate change, total fisheries productivity in Bangladesh is projected to decline by up to 8.3% by 2100. However, impacts for two of the most important marine-captured fish impacts are projected to be more pronounced. Under business-as-usual climate change and fisheries management, by the 2050s decadal mean catch potential might fall by 42% for Hilsa shad and by 30% for Bombay duck compared to the 2000s. If management permits overfishing to take place then population collapse could occur and the catch potential of Hilsa shad might decline by as much as 87% by 2050. For Bombay duck the story is less severe but catch potentials might decline by 37% by 2050. In order to stabilise catches, fisheries will need to be better managed to avoid overfishing (Fernandes et al., 2016).

22. National level scenarios are also useful in the terrestrial environment. For example they have been used to better understand how land use might change in Australia under different environmental and economic conditions and in response to different domestic biodiversity and climate mitigation policy measures. Three domestic policy scenarios were considered by Bryan et al. (2016): carbon focus, balanced focus, and biodiversity focus. In all a payment was assumed for environmental plantations (plantations of mixed, locally native trees to restore biodiverse native plant communities) with a baseline budget of $125 million per year for such payments. In the balanced and biodiversity focus scenarios, a levy of 15% and 30%, respectively, was placed on payments for carbon sequestration made to "carbon plantations" (monocultures of fast growing high carbon sequestering Eucalyptus species) and this money boosted the funds available for payments for environmental plantings. In a future with no climate mitigation effort (i.e. with no carbon price) then little change in the total areas of different land uses, and therefore no reforestation of agricultural land, was projected. However, if efforts are made to mitigate climate change there could be up to 50 million ha of land, mostly currently used for beef or sheep production, converted to carbon plantations. Balancing incentives for restoring habitat through a tax on carbon plantations could result in 9-30 million ha of the carbon plantations being replaced by environmental plantations. The projections indicate that although significant reductions in the area of agricultural land use are possible, agricultural production can nonetheless increase the least productive land is converted and productivity improvements are possible on the remaining agricultural land. Economic returns to land owners in Australia can be increased while climate mitigation and biodiversity co-benefits are enhanced, however to achieve extensive reforestation, water resource use must be carefully managed. The study demonstrates that policy options exist to promote environmentally and economically sustainable future landscapes in Australia. However, there will be trade-offs, such as the replacement of beef and sheep production by carbon and environmental plantations. Such transitions have implications for policy, for example in the regulation of plantations and payments for them, and the reskilling or relocation of workforces as farming practices change.

23. Suriname provides a further example on the use of scenarios in the terrestrial environment. Forested areas covered over 90% of Suriname's land area and contain high levels of biodiversity. Reforestation of agricultural land is therefore not a critical issue. The concern in Suriname is that historically low deforestation rates may not be sustainable in the future as palm oil, sugarcane, other plantations and mining become increasingly prominent. The question of how to develop sustainable agriculture sector in Suriname that enable agricultural growth whilst preventing widespread habitat conversion is therefore critical. For example, Suriname has ambitions to increase national production of rice, the country's most important crop in terms of cultivated area, contribution to GDP, foreign exchange earnings and direct employment. If rice productivity remains at present levels (approx. 4.2 ton/ha), to increase total production by 3% per year the required cultivation area would increase by over 20,000 ha by 2022. However, if productivity can be increased to levels in line with estimates of the potential yield of Suriname farms (approx. 6 ton/ha), then total rice production could be increased by 40% by 2022 against 2011 levels, whilst also releasing 15,000 ha of land from rice cultivation. For this

intensification to lead to land-sparing for nature, good governance, law enforcement and increasing the value of standing forests will be needed. Another scenario is that the relinquished area is dedicated to higher value agricultural crops, including organic products, without incurring any deforestation. By developing a framework to stimulate organic farming and by working with smallholder farms, Suriname may increase the value of its national agriculture, create alternative and higher incomes, offer an alternative path for rural people by reducing dependency on external resources and increasing incomes, and achieve food security both in terms of provision and healthier products (Latawiec et al., 2014).

Subnational-scale scenarios

24. Scenario analysis at subnational scales can provide highly specific information on the study location. Participatory approaches, which are most often applied at subnational-scales, can build capacity for using scenarios for strategic decision making and for understanding the importance of biodiversity across sectors. Decisions from participatory local scenarios also have the benefit of "buy-in" from local stakeholders while enhancing the role of indigenous and local knowledge, which can be difficult to achieve when decisions appear to be imposed from the top-down.

25. Some of the research on the Great Barrier Reef World Heritage Area in Queensland, Australia provides an example of the use of sub-national scenarios. Since the settlement of Europeans in the 1860s, suspended sediments, nitrogen and phosphorous entering the water catchment for the Great Barrier Reef World Heritage Area have increased by factors of 5, 2-5 and 2-10 respectively. The impacts of nutrient and sediment deposition on the biodiversity of the Great Barrier Reef include changes in coral and fish species composition, dominance of macro-algal cover, and outbreaks of crown-of-thorns starfish. The greatest threat from land based pollution to the Great Barrier Reef exists in the Wet Tropics bioregion, where fertilisers and pesticides are applied in sugarcane and banana production and sediment run-off is also a concern.

26. The Tully-Murray catchment is located in the Wet Tropics and has seen 80% of native vegetation, 60% of riparian habitat and 69% of wetlands cleared from the floodplain for agricultural production. Recently crop production has doubled resulting in a doubling of fertiliser use. Understanding trade-offs between agricultural production, the provision of ecosystem services on the flood plain and on the Great Barrier Reef, and the impact of future land use on these is crucial. Projections for a scenario in which all native vegetation was permitted to be cleared from the Tully-Murray catchment projected a large increase in agricultural revenues, which rose to $\$_{AUS}119$ million/year. However, nitrogen run-off into the catchment also grew and water quality deteriorated as a result. The valuable ecosystem services provided by the Great Barrier Reef, such as, tourism and fisheries, were projected to decline. Projections for alternative scenarios showed that re-vegetation of riparian and wetland habitats in the catchment area, in line with the Tully-Murray Water Quality Improvement Plan, does not sufficiently reduce nitrogen pollution on the Great Barrier Reef, and so ecosystem service declines there are projected. A complete reforestation of the catchment area could improve the quality of water discharged to the Great Barrier Reef and prevent deterioration of the ecosystem services while also increasing those within the catchment (Butler et al., 2013). The study identifies that different stakeholders (farmers, fishermen, tourists or the public) "win" or "lose" depending on the scenario. Such trade-offs are complicated by the management of the catchment and the Great Barrier Reef, responsibility for which spans several organisations. Aligning the statutory and non-statutory governance structures to the scale of the hydrological ecosystem could help the implementation of a water quality management plan that successfully prevents damage to the Great Barrier Reef while minimising loss to farmers and other stakeholders in the catchment area.

27. Trade-offs amongst beneficiaries from ecosystem services are also evident in the social-ecological system of Costalegre on the Pacific coast of Mexico. The region is biologically diverse with important areas covered by well-conserved tropical dry forest. The main economic activities include agriculture, fishing, forestry and tourism. Recent development plans propose expanding tourism in the area. Assessing how such expansion might impact the social-ecological system is the aim of a scenario analysis conducted by Riensche et al. (2015), which developed a set of four qualitative storylines of how the development of the region is managed.

28. Under a scenario of massive tourism all ecosystem services considered, including freshwater quality and supply, climate regulation, soil erosion control and fisheries, were projected by Riensche et al., (2015) to decline. While some positive aspects were projected to emerge for local communities, the cumulative effects were overwhelmingly negative. A development strategy that focussed on select, high-end tourism, would have some ecosystem service benefits and could be deemed overall positive despite some negative implications for local communities. For a development strategy that was strongly determined by environmental conservation, ecosystem services were strongly increased but local communities were strongly negatively impacted with projected emigration from the region and abandonment of lifestyles. A more balanced development strategy, permitting tourism in an environmentally conscious manner, was projected to be overwhelmingly positive with ecosystems and the services they provide, and local communities benefiting. To enable this balanced approach, enhanced communication between stakeholders is essential and involving tourism associations, scientists and conservationists in social organisations such as the District Council of Rural Development was deemed by the authors to be essential. The study also found that there was a disconnect between those stakeholders in the middle and upper parts of the watersheds of the region who manage vegetated lands that are essential for water provision to the coastal regions, and those in the coastal regions who benefit from the water provision. Despite securing the provision of an essential ecosystem service, the stakeholders managing the water resources are unlikely to receive any benefits. Coastal communities on the other hand benefit from having water and through tourism. A payment for ecosystem service scheme might address this unequal distribution of benefits and help to secure water provisioning services (Riensche et al., 2015).

29. Participatory approaches were employed by Palacios-Agundez et al. (2013) to assist with and build capacity for strategic decision making to create sustainable landscapes in Biscay, Spain on the north of the Iberian Peninsula. Biscay was heavily industrialised in the last two centuries, with large amounts of agricultural land abandonment. A total of 57% of the land area is covered by forests, of which 79% is exotic forest plantations. A total of 39 people took part in the exercise from a range of stakeholder groups including policymakers, researchers, architects, economists, engineers, lawyers and NGOs. These stakeholders collectively identified the most important ecosystem services in the region to address the key drivers of change for the region. Next, the participants described four archetypal scenarios for Biscay and characterised the scenarios in terms of the provision of ecosystem services and human well-being. From these, the participants identified a target, or desirable scenario, in which education and knowledge sharing within society are key, consumption is responsible and there is a tendency towards sustainable production and self-sufficiency. Sustainable management was projected to lead to significant growth in a range of cultural, regulating and provisioning services whilst at the same time most indicators of human well-being were forecast to rise. Participants identified reinforcing local sustainable productivity and conserving Biscay's ecosystems and their functionality as key strategic goals. To achieve these, proactive action from government and NGOs combined with strategic and integrative land use planning were identified as some of the key management actions.

30. Sub-national scenarios can also be used to inform decisions regarding marine resources because benefits from these do not just flow via large-scale industrialised fisheries, but also through small-scale subsistence and commercial fisheries. These smaller fisheries can be of economic, social and cultural importance. This is the case for the species fished by the First Peoples of the Pacific Northwest Coast. Weatherdon et al. (2016) projected the climate change effects on the fisheries of a sample of 16 First Nations identified near British Columbia's coastline. Under climate change the relative abundances of the majority of species fished by these First Nations, are projected to decline and all species would shift poleward at a rate of 10 to 18 kilometres per decade. These changes would cause modest to severe declines in the catch potential for all commercial fisheries with First Nation participation. Establishing equitable resource sharing agreements could address the unequal distribution of relative losses in catch potential associated with regional differences and the poleward shift. Mechanisms to increase the productivity of the fisheries within the First Nations' territorial land, for example through traditional clam gardens, could also mitigate some impacts. Lastly joint management frameworks between First Nations, the Department for Fisheries and Oceans and other economic sectors could yield ecological and political benefits.

III. SYNTHESIS: OPPORTUNITIES FOR SUB-GLOBAL SCENARIOS TO ASSIST IMPLEMENTATION OF THE CONVENTION ON BIOLOGICAL DIVERSITY

31. The case studies of regional, national and subnational scenarios reviewed above illustrate the ways in which scenarios can provide valuable information for the implementation of the Convention. Scenario analyses tailored to regional, national or local circumstances provide information to feed into strategic planning for biodiversity conservation and sustainable use. They can therefore directly support the development of National Biodiversity Strategies and Action Plans. Furthermore, the inclusion of participatory approaches in scenario analysis is a valuable tool for building capacity for decision making that focusses on biodiversity management. It can do this by allowing stakeholders to recognise the relationships between biodiversity and other sectors, and how enhanced benefits can increase human well-being. Full and effective participation of right-holders and other stakeholders in the co-production of scenarios, is a critical element for their success and utility.

32. Sub-global scenario analysis can assist the implementation of the Convention by enabling, in a location specific manner, strategic planning to conserve or sustainably use biological resources. The analyses can explore social-ecological systems taking into account a broad range of uncertainty of future socio-economic and environmental (biotic and/or abiotic) conditions. Analyses can also seek to determine the optimal path to reach a target, such as society in harmony with nature. Conducting such analyses whilst also involving decision makers, practitioners and other stakeholders builds capacity about how a desirable future for biodiversity can be realised and what decisions are likely to achieve this goal.

33. In the marine realm the management of fisheries will be critical for stable future catches under climate change. Overfishing in the Baltic Sea, the Bay of Bengal and the coast of British Columbia, risks collapse of fish stocks, drastic reductions in catch potential and subsequent economic and human wellbeing declines for the societies that rely on the fisheries. Management of land use in river catchments will also be important to avoid excessive nutrient run off that could damage the health of coastal ecosystems. In all cases efficient management will require coordination across national, cultural or management agency jurisdictions.

34. Climate and land use are likely to lead to large changes in terrestrial habitats. Climate mitigation and adaptation strategies have a strong influence on the magnitude and distributions of land use change. Policy decisions can therefore feasibly bring about landscapes that manage the conservation of nature

whilst also meeting other environmental and societal goals. Scenarios analysis can explore these decisions, the resultant trade-offs and policy implications in uncertain future worlds.

35. We note however, that sub-global scenarios can introduce greater complexity to scenarios at larger spatial scales by introducing heterogeneity, especially during integration. For example, a global scale scenario built from an assemblage of regional and national scale scenarios, taking location specific contexts into account, might differ substantially from a scenario derived without that specificity. Incorporating localised or scale-specific context into scenarios that can be used in global processes is a key issue to be considered in scenario analysis to assist implementation of the Convention and its post-2020 biodiversity framework.

IV. REFERENCES

Aleman, J. C., Blarquez, O., Staver, C. A. (2016). Land-use change outweighs projected effects of changing rainfall on tree cover in sub-Saharan Africa. *Global Change Biology*, 22, 3013-3025. http:// doi: 10.1111/gcb.13299.

Bennett, E. M., M. Solan, R. Biggs, T. McPhearson, A. V Norström, P. Olsson, L. Pereira, G. D. Peterson, C. Raudsepp-Hearne, and F. Biermann. 2016. Bright spots: seeds of a good Anthropocene. Frontiers in Ecology and the Environment, 14(8):441–448.

Bryan, B. A., Nolan, M., McKellar, L., Connor, J. D., Newth, D., Harwood, T., King, D., Navarro, J., Cai, Y., Gao, L., Grundy, M., Graham, P., Ernst, A., Dunstall, S., Stock, F., Brinsmead, T., Harman, I., Grigg, N. J., Battaglia, M., Keating, B., Wonhas, A., Hatfield-Dodds, S. (2016). Land-use and sustainability under intersecting global change and domestic policy scenarios: Trajectories for Australia to 2050. *Global Environmental Change*, 38, 130–152. http://doi.org/10.1016/j.gloenvcha.2016.03.002

Butler, J. R. A., Wong, G. Y., Metcalfe, D. J., Honzák, M., Pert, P. L., Rao, N., van Grieken, M. E., Lawson, T., Bruce, C., Kroon, F. J., Brodie, J. E. (2013). An analysis of trade-offs between multiple ecosystem services and stakeholders linked to land use and water quality management in the Great Barrier Reef, Australia. *Agriculture, Ecosystems and Environment*, 180, 176–191. http://doi.org/10.1016/j.agee.2011.08.017

CERES (2016). Exploratory socio-political scenarios for the fishery and aquaculture sectors in Europe. (Ed. Pinnegar, J. K. & Engelhard, G. H.). Deliverable D1.1 – Glossy 'report card' aimed at stakeholders. Centre for Environment, Fisheries & Aquaculture Science (Cefas), Lowestoft, 8pp. https://ceresproject.eu

Dunford, R.W., Smith, A. C., Harrision, P. A. and Hanganu, D. (2015) Ecosystem service provision in a changing Europe: adapting to the impacts of combined climate and socio-economic change, *Landscape Ecology*, 30, 443-461. Doi: 10.1007/s10980-014-0148-2.

Fernandes, J. A., Kay, S., Hossain , M. A. R., Ahmed, M., Cheung, W. W. L., Lazar, A. N. & Barange, M. (2016). Projecting marine fish production and catch potential in Bangladesh in the 21st century under long-term environmental change and management scenarios. *ICES Journal of Marine Science*, 73: 1357-1369.

IPBES (2016). *The methodological assessment report on scenarios and models of biodiversity and ecosystem services.* S. Ferrier, K. N. Ninan, P. Leadley, R. Alkemade, L. A. Acosta, H. R. Akçakaya, L. Brotons, W. W. L. Cheung, V. Christensen, K. A. Harhash, J. Kabubo-Mariara, C. Lundquist, M. Obersteiner, H. M. Pereira, G. Peterson, R. Pichs-Madruga, N. Ravindranath, C. Rondinini and B. A. Wintle (eds.). Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Bonn, Germany. 348 pages.

Kok, M.T., Kok, K., Peterson, G.D., Hill, R., Agard, J. and Carpenter, S.R., 2017. Biodiversity and ecosystem services require IPBES to take novel approach to scenarios. Sustainability Science, 12(1), pp.177-181.

Latawiec, A. E., B. B. N. Strassburg, A. M. Rodriguez, E. Matt, R. Nijbroek, and M. Silos. 2014. Suriname: Reconciling agricultural development and conservation of unique natural wealth. *Land Use Policy* 38:627–2564 636.

Millenium Ecosystem Assessment (2005). Ecosystems and Human Well-being: Synthesis. Island Press, Washington D.C.

Meier, H. E. M., Andersson, H. C., Arheimer, B., Donnelly, C., Eilola, K., Gustafsson, B. G., … Zorita, E. (2014). Ensemble modeling of the Baltic Sea ecosystem to provide scenarios for management. *Ambio*, 43(1), 37–48. https://doi.org/10.1007/s13280-013-0475-6

Niiranen, S., J. Yletyinen, M.T. Tomczak, T. Blenckner, O. Hjerne, B.R. MacKenzie, B. Mu¨ller-Karulis, T. Neumann, et al. (2013). Combined effects of global climate change and regional ecosystem drivers on an exploited marine food web. *Global Change Biology*, 19: 3327–3342. doi:10.1111/gcb.12309.

O'Neill, B. C., Kriegler, E., Riahi, K., Ebi, K. L., Hallegatte, S., Carter, T. R., Mathur, R. and Vuuren, D. P.: A new scenario framework for climate change research: the concept of shared socioeconomic pathways, Clim. Change, 122(3), 387–400, doi:10.1007/s10584-013-0905-2, 2013.

Palacios-Agundez, I., Casado-Arzuaga, I., Madariaga, I., & Onaindia, M. (2013). The relevance of local participatory scenario planning for ecosystem management policies in the Basque Country, northern Spain. *Ecology and Society*, 18(3). https://doi.org/10.5751/ES-05619-180307

Riensche, M., A. Castillo, A. Flores-Díaz, and M. Maass. 2015. Tourism at Costalegre, Mexico: An ecosystem services-based exploration of current challenges and alternative futures. *Futures*, 66:70–84.

Rosa, I. M. D., H. M. Pereira, S. Ferrier, R. Alkemade, L. A. Acosta, R. Akcakaya, E. Belder, A. M. Fazel, S. Fujimori, M. Harfoot, K. A. Harhash, P. A. Harrison, J. Hauck, R. J. J. Hendriks, G. Hernández, W. Jetz, S. I. Karlsson-vinkhuyzen, H. Kim, N. King, M. T. J. Kok, G. O. Kolomytsev, T. Lazarova, P. Leadley, C. J. Lundquist, J. G. Márquez, C. Meyer, L. M. Navarro, C. Nesshöver, H. T. Ngo, K. N. Ninan, M. G. Palomo, L. M. Pereira, G. D. Peterson, R. Pichs, A. Popp, A. Purvis, F. Ravera, C. Rondinini, J. Sathyapalan, and A. M. Schipper. 2017. Multiscale scenarios for nature futures. Nature Ecology and Evolution 1:1416–1419.

van Vuuren, D. P., Edmonds, J., Kainuma, M., Riahi, K., Thomson, A., Hibbard, K., Hurtt, G. C., Kram, T., Krey, V., Lamarque, J.-F., Masui, T., Meinshausen, M., Nakicenovic, N., Smith, S. J. and Rose, S. K.: The representative concentration pathways: an overview, Clim. Change, 109(1–2), 5–31, doi:10.1007/s10584-011-0148-z, 2011.

Weatherdon, L. V., Ota, Y., Jones, M. C., Close, D. A., Cheung W. W. L. (2016). Projected scenarios for coastal First Nations' fisheries catch potential under climate change: management challenges and opportunities. PLoS One 11: e0145285.

WWF, and AfDB. 2015. *African Ecological Futures*. Nairobi, Kenya.

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