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Item 6 of the provisional agenda
Research and systematic observation

Report on the workshop on technical and scientific aspects of ecosystems with high-carbon reservoirs not covered by other agenda items under the Convention

Note by the secretariat

Summary

This document contains the report on the Subsidiary Body for Scientific and Technological Advice workshop on technical and scientific aspects of ecosystems with high-carbon reservoirs not covered by other agenda items under the Convention, held on 24–25 October 2013 in Bonn, Germany. The report summarizes the information provided by scientific experts and representatives of Parties, the Intergovernmental Panel on Climate Change and international and regional research programmes and organizations on the technical and scientific aspects of ecosystems with high-carbon reservoirs, such as coastal marine ecosystems, in the context of wider mitigation and adaptation efforts. It also provides a summary of the main technical and scientific elements arising from the workshop.

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I. Introduction

A. Mandate

1. The Subsidiary Body for Scientific and Technological Advice (SBSTA), at its thirty-seventh session, requested the secretariat to organize a workshop, to be held by SBSTA 39, to consider information on the technical and scientific aspects of ecosystems with high-carbon reservoirs not covered by other agenda items under the Convention, such as coastal marine ecosystems, in the context of wider mitigation and adaptation efforts.[1]

2. The SBSTA invited Parties to submit their views on the content of that workshop.[2] It also noted the views submitted by Parties in document FCCC/SBSTA/2012/MISC.2 and Add.1 and 2.

3. At its thirty-eighth session, the SBSTA recalled its conclusions regarding the organization of the workshop. It took note of the views of Parties on its content and requested the secretariat, in organizing the workshop, under the guidance of the Chair of the SBSTA, to take these views into account. It further requested the secretariat to prepare a report on the workshop, to be made available before SBSTA 40.[3]

B. Scope of the note

4. This report draws upon the information that was provided and the discussions that took place. It contains an overview of the proceedings of the workshop and provides brief summaries of the presentations as well as of the main technical and scientific elements arising from the deliberations at the workshop, including needs and priority areas for further work and research as identified by participants.

C. Possible action by the Subsidiary Body for Scientific and Technological Advice

5. The SBSTA may wish to consider the information contained in this report at its fortieth session as part of its consideration of the matters related to research and the research dialogue. The information may also assist Parties in their consideration of any further actions arising from the workshop, as appropriate.

D. Background

6. The Conference of the Parties, by decision 9/CP.11, requested the SBSTA to regularly consider research and systematic observation relating to the Convention in order to inform Parties about the on-going and planned activities of regional and international climate change research programmes, and to communicate Parties' views on research needs and priorities to the scientific community, as necessary.

7. The SBSTA, at its twenty-sixth session, agreed to develop and maintain a dialogue between Parties and research programmes and organizations, in the context of decision

[1] FCCC/SBSTA/2012/5, paragraph 50.
[2] Views from Parties are contained in document FCCC/SBSTA/2013/MISC.6 and Add.1 and 2.
[3] FCCC/SBSTA/2013/3, paragraph 70.

9/CP.11, and invited relevant research programmes and organizations to regularly inform the SBSTA of developments in research activities relevant to the needs of the Convention.[4]

8. At its thirty-fourth session, the SBSTA requested the secretariat, subject to the availability of resources, to continue to support the research dialogue, including by organizing further workshops, as appropriate, in periodic consultation with the research programmes and organizations, and to be agreed by the SBSTA.[5] The objective of such workshops is to facilitate the in-depth consideration of issues considered under the research dialogue, with a view to providing information in support of the UNFCCC process.[6]

9. At SBSTA 35, Parties and regional and international research programmes and organizations were invited to provide information on technical and scientific aspects of emissions, removals and reservoirs of all greenhouse gases (GHGs), including from coastal and marine ecosystems such as mangroves, tidal salt marshes, wetlands and seagrass meadows, to be considered as a theme at the research dialogue during SBSTA 36. In this context, the SBSTA also noted the views of Parties regarding the importance of other ecosystems with high-carbon reservoirs, in particular terrestrial ecosystems, for example, steppe, tundra and peatlands.[7] At SBSTA 37, Parties and regional and international research programmes and organizations were invited to provide information on technical and scientific aspects of emissions, removals and reservoirs of all GHGs, including from terrestrial ecosystems such as steppe, savannah, tundra and peatlands, to be considered as a theme for the research dialogue during SBSTA 38.[8]

10. At its thirty-seventh session, the SBSTA requested the secretariat to organize the workshop referred to in paragraph 1 above.

II. Proceedings

11. The workshop was held on 24–25 October 2013 in Bonn, Germany, and was chaired by the Chair of the SBSTA. It benefited from financial resources provided by Spain and the United Kingdom of Great Britain and Northern Ireland for activities to be undertaken by the secretariat in the context of research and systematic observation.

12. The workshop was attended by 56 participants, including 27 representatives from Parties, representing 18 Parties not included in Annex I to the Convention and 6 Parties included in Annex I to the Convention, and relevant international and regional research programmes and organizations, as well as intergovernmental and non-governmental organizations that are active in research activities on high-carbon ecosystems in the context of climate change mitigation and adaptation.

13. The workshop, including the agenda and themes for the workshop, was organized under the guidance of the Chair of the SBSTA, taking into account views from Parties[9] and in consultation with relevant research programmes and organizations. The workshop was structured according to the following major sessions, under which the various topics and aspects of ecosystems with high-carbon reservoirs were addressed:

(a) Overview and global context;

[4] FCCC/SBSTA/2007/4, paragraphs 44 and 47.
[5] FCCC/SBSTA/2011/2, paragraph 55(a).
[6] FCCC/SBSTA/2011/5, paragraph 41.
[7] FCCC/SBSTA/2011/5, paragraph 43.
[8] FCCC/SBSTA/2012/5, paragraph 52.
[9] FCCC/SBSTA/2013/MISC.6 and Add. 1 and 2.

(b) Current scientific and technical knowledge of high carbon content ecosystems;

(c) Management of ecosystems in the mitigation and adaptation context;

(d) Research needs: challenges and opportunities.

III. Summary of the presentations and discussions

14. The following section summarizes the technical and scientific aspects of the main topics addressed during the workshop. Further information on the content of the workshop, including the agenda, the presentations and related background information, can be obtained from the UNFCCC website.[10]

A. Overview and global context

15. Under this session presenters provided an overview of the global context and global aspects of high-carbon ecosystems, as well as a generic picture of the methodological developments by the Intergovernmental Panel on Climate Change (IPCC).

16. The first presentation gave **an overview of the global carbon cycle and carbon balance in the environment**, based on results from the contribution of Working Group I to the IPCC Fifth Assessment Report (AR5 WGI), *Climate Change 2013: The Physical Science Basis*,[11] including the latest information on the global carbon budget 1959–2011.[12] Carbon balances, stocks and flows, as well as major sources of anthropogenic carbon dioxide (CO_2) emissions and their regional distribution, were discussed. According to the presenter, cumulative emissions provide the most accurate information to project temperature changes, and the total cumulative emissions for the period 1870–2011 amount to 515 (445 to 585) Gt C, with the largest contributions to CO_2 emissions being fossil fuel use and cement production, followed by land-use change. The main sinks of CO_2 are land based (very variable) and the ocean (about 30 per cent), the latter mostly via physical and chemical processes (figure 1).

17. The AR5 WGI provides information on the emission pathways to keep the future global temperature rise below different limits. The presenter noted that when considering cumulative emissions, for a temperature rise below 2 °C by the end of the century, the required reductions in emissions will have to take into account that historical emissions already count for half of the emission budget corresponding to that temperature rise, and that monitoring vulnerable carbon pools and fluxes is critical as the climate evolves. Further research is needed to identify the potential contribution of permafrost thawing, wetlands and other vulnerable ecosystems to global and regional carbon budgets, and to enhance understanding of the effects of ocean acidification on marine ecosystem services.

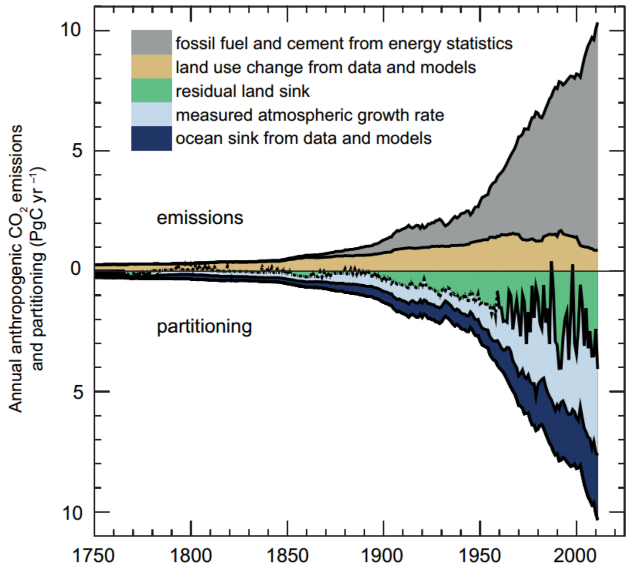
18. Ecosystems store (on land) and sequester (in the ocean) large quantities of carbon. Ecosystems are highly variable in time and space. Models used for the evaluation of carbon flux from ecosystems are currently reproducible only on a global scale. At this level, progress is being made in separating natural variability from anthropogenic causes, and release of carbon stored in permafrost ecosystems and soils, previously not considered in models, is also starting to be integrated. At a regional level, although there are now direct measurements, there is increased uncertainty and a need for better data. Some progress has

[10] <http://unfccc.int/7797>.
[11] Available at <http://www.ipcc.ch/report/ar5/wg1>.
[12] Global Carbon Project. Available at <http://www.globalcarbonproject.org/carbonbudget>.

been made in terms of land-use changes related to forestry and this could be elaborated to include other ecosystems.

Figure 1

Carbon balance in the environment (annual anthropogenic CO_2 emissions and partitioning, 1750 to 2011)



Source: Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, Technical Summary, figure TS.4.

19. A presentation by a representative from the IPCC provided an overview of newly developed methodological guidance for national GHG inventories as set out in the recently released IPCC *2013 Supplement to the 2006 Guidelines for National Greenhouse Gas Inventories: Wetlands* (Wetlands Supplement).[13] The *2006 IPCC Guidelines for National Greenhouse Gas Inventories*[14] (hereinafter referred to as the 2006 IPCC Guidelines) provide guidance for estimating stock changes in carbon pools in six land-use categories, one of which is wetlands. The new Wetlands Supplement takes into account increased scientific knowledge and availability of data, and provides broader coverage than that of the wetlands category in the 2006 IPCC Guidelines. As in the 2006 IPCC Guidelines, the Wetlands Supplement continues to use the "managed land proxy" approach to estimate anthropogenic emissions and removals, that is, those that occur on managed lands. It provides methodological guidance for estimating anthropogenic GHG emissions and removals from wetlands and drained soils, in particular updated and new guidance for: drained inland organic soils; rewetted organic soils (including peatlands); coastal wetlands, including mangrove forests, tidal marshes and seagrass meadows (for specified management activities); inland wetland mineral soils; and constructed wetlands for wastewater treatment. He further explained that oceans are not currently taken into account as GHG inventories are done for individual nations, although GHGs from coastal zones within national borders are taken into account.

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13 See <http://www.ipcc-nggip.iges.or.jp/public/wetlands/index.html>.

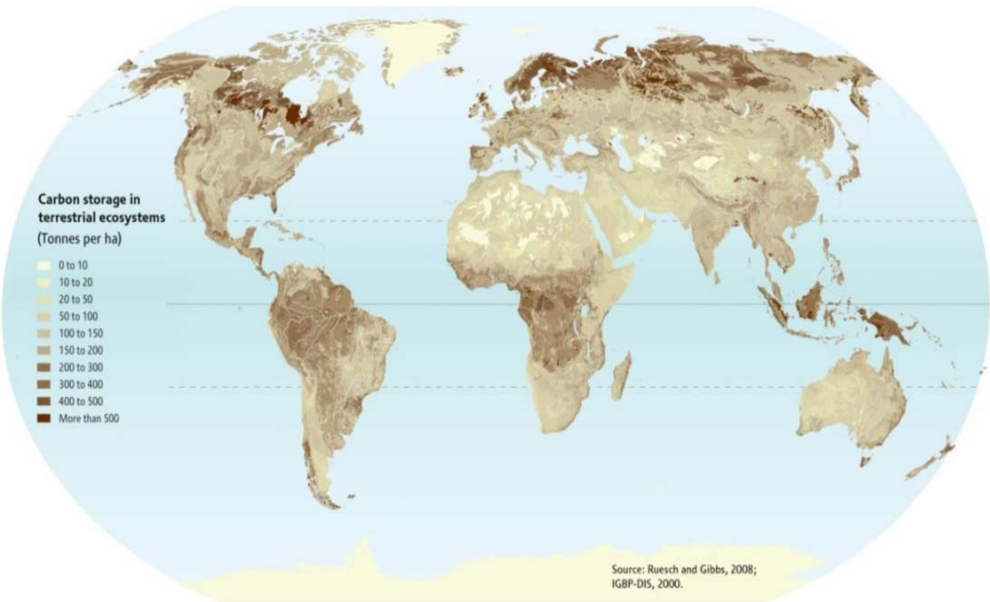
14 See <http://www.ipcc-nggip.iges.or.jp/public/2006gl>.

B. Current scientific and technical knowledge of high carbon content ecosystems

20. Presenters of this session were asked to provide an overview of the current scientific and technical knowledge of various types of high-carbon ecosystems, including indicating technical limitations and uncertainties and further research needs.

21. As an introduction to the themes of this session, the presentation by the World Conservation Monitoring Centre of the United Nations Environment Programme (UNEP-WCMC) looked at global patterns of carbon stocks. The three major carbon pools globally are above-ground biomass, below-ground biomass and soil organic carbon. Mapping is important for quantifying terrestrial carbon stocks and potential emissions, as well as for determining the potential for restoring lost carbon stock. Only a small number of data sets on the global distribution of biomass carbon across different ecosystems currently exist; these include the global map produced by Ruesch and Gibbs (2008)[15] (figure 2). For tropical forests, information with a higher level of detail is available. However, comparisons between data from different sources indicate considerable uncertainties for biomass carbon in tropical forests, and even more so for non-forest ecosystems. Also highlighted in the presentation was a need for improved understanding of spatial variation in soil organic carbon stocks (including coastal sediments). Soil organic carbon stocks are estimated to be two to three times larger than atmospheric carbon content, and data are still highly uncertain, in particular for permafrost, peatlands and some coastal sediments. At the same time, the impacts of different forms of land use on soil carbon need to be better understood.

Figure 2
Carbon storage in terrestrial ecosystems



Source: GRID-Arendal. Available at <http://www.grida.no/publications/rr/natural-fix/page/3724.aspx>.

[15] Ruesch A. and Gibbs HK. 2008. *New IPCC Tier-1 Global Biomass Carbon Map For the Year 2000*. Available at <http://cdiac.ornl.gov/epubs/ndp/global_carbon/carbon_documentation.html>.

22. The global distribution of carbon depends on soil types, climate and ecosystem features, such as species compositions. The map in figure 2 shows that large amounts of carbon are stored in the tropics, mostly as biomass, and in high-latitude ecosystems where the stocks are largely located in permanently frozen layers of soil (permafrost) and in peat.[16]

1. Coastal ecosystems

23. The following set of presentations addressed in detail methodological aspects of some types of high-carbon ecosystems and their ecology, placing particular focus on coastal high-carbon ecosystems: seagrasses, mangroves and tidal marshes.

24. Following the overview presentation on the IPCC Wetlands Supplement, a representative from the IPCC outlined the contents of its chapter 4, "Coastal wetlands", which provides methodological guidance for estimating CO_2 and non-CO_2 emissions from vegetated coastal ecosystems (mangroves, tidal marshes and seagrasses) from different management practices and changes in land uses, using a tier 1 methodology and default emission factors. The presentation highlighted the global distribution and estimated areas of these ecosystems; while mangroves globally cover around 138,000 km^2, mostly in the tropics, salt marshes are more widespread and areal extent ranges between 200,000 and 400,000 km^2, while for seagrass meadows, which are found on all continents (except Antarctica) the areal extent ranges from 200,000 to 600,000 km^2. All of them store carbon in the biomass, both below and above ground, and current losses of mangroves, tidal marshes and seagrasses due to human coastal activities are resulting in losses of biomass and carbon. The "Coastal wetlands" chapter provides: default data for estimating carbon stock changes in mangrove living biomass and dead wood pools for coastal wetlands using tier 1 methodologies, as well as new guidance for estimating CO_2 emissions and removals from organic and mineral soils for management activities of extraction (including excavation and construction of aquaculture and salt production ponds), drainage and rewetting and revegetation; default data for estimating anthropogenic CO_2 emissions and removals for soils in mangroves, tidal marshes and seagrass meadows; and guidance for estimating nitrous oxide (N_2O) emissions during aquaculture use and methane (CH_4) emissions for rewetting and revegetation of mangroves and tidal marshes.

25. An expert from the Department of Environment and Heritage, Australia, gave an overview of the ecological aspects of coastal wetlands, and how these are interconnected. Mangroves require an environment with relatively high salinity and have large root systems generally growing close to the surface and spreading across the area. While mangroves and tidal marsh ecosystems are often found together, with mangroves outcompeting tidal marshes, the latter are also located in colder environments. They are highly diverse, with a number of different distinct ecosystems covered under the term "salt marshes". Seagrass is subaqueous and derives carbon from the ocean itself. All three ecosystems (mangroves, salt marshes and seagrasses) are important for biodiversity, with many unique species, and are linked at the global, regional and local levels for a large number of organisms, for example to enable larval export through mangroves to estuaries. The importance of keeping the ecosystems linked together is one of the greatest challenges to preserve biodiversity. While research is at an early stage, potential impacts of climate change indicate an increase in mangroves, while tidal marshes show decline. In particular, sea level rise can result in mangroves spreading into salt marshes, and a positive response of plants in the mangroves in terms of productivity.

[16] See <http://www.grida.no/publications/rr/natural-fix/page/3724.aspx>; see also <http://www.future-science.com/doi/abs/10.4155/cmt.13.77>.

26. As further elaborated by an expert from the Coalition for Rainforest Nations and Oregon State University, coastal ecosystems (mangroves, salt marshes and seagrasses) provide a large number of different ecosystem services, including biological diversity, water quality, protection from flood and storm damage, timber and non-timber forest products, aesthetic and ecotourism value, fish and shellfish, and carbon sinks, as they store high amounts of carbon. Currently, on average, 1–7 per cent of these types of carbon sink are being lost annually. According to information provided by the presenters during this session of the workshop, the global area covered by, and loss of, carbon from coastal ecosystems can be summarized as indicated in table 1.

Table 1
Global area covered by, and loss of, carbon from coastal ecosystems

Coastal habitat	*Estimated global area (km^2)*	*Annual loss*	*Total loss*
Seagrasses	177 000–600 000	1–3%	29%
Salt marshes	200 000–400 000	1–2%	50%+
Mangroves	137 760–152 000	0.9–1.8%	35%

27. Focusing further on mangroves – a unique type of tropical forest that is found in tropical and subtropical tidal zones in over 123 countries – in the context of climate change, the presenter from the Coalition for Rainforest Nations and Oregon State University outlined their high diversity, both in structure and in the ecosystem services they provide, as well as their economic value. Compared with other types of forest, studies show their high carbon stocks content, especially below ground; at the same time their rates of land cover changes/deforestation are among the highest in the tropics, resulting in a high level of GHG emissions. Conversion of mangroves causes high rates of carbon loss, up to 89 per cent of original stock in some cases, especially the soil organic carbon, which is higher than in rainforest conversion. In terms of estimating and monitoring carbon stocks, emissions and sequestration in mangroves, examples cited in Indonesia, the Dominican Republic and the Federated States of Micronesia, where combinations of remote sensing and field observations were used, indicate the possibility of monitoring mangroves.

28. The presentation by the expert from the Spanish National Research Council and the University of Western Australia detailed the importance of seagrasses, clonal plants with extended life spans adapted to life in the sea and which can be found in all continents. Seagrass meadows have high net primary production, develop significant below-ground biomass and are strong natural carbon sinks (up to 17 t C/ha/year), storing carbon in the seabed, forming raised reefs containing organic-rich materials that are preserved over millennia. A decline of seagrass, which is anthropogenic in origin, is happening at fast rates and represents a significant loss in CO_2 sink capacity and in carbon stored. Seagrass loses carbon through a thin layer of water, and the CO_2 emissions are then emitted to the atmosphere. Technical capacity is available to recover (at least some of) these ecosystems, that is, through revegetation and replanting, and recent models show that seagrass reforestation leads to substantial CO_2 sequestration.

29. At the same time, preserving and replanting seagrasses offers opportunities for coastal protection from erosion, sea level rise and storms, while delivering additional significant ecosystem services and value to society. The presentation further highlighted that approaches to adapt to sea level rise and its impacts are likely to be far more cost-effective when based on marine vegetation, particularly when involving plants, such as

seagrass, with a capacity for clonal expansion and exponential growth,[17] as compared with cement-based solutions with a similar level of efficiency. The presenter further explained that countries can address loss of seagrass, which can be apportioned within national borders, and that current knowledge does not indicate that seagrass can be invasive.

30. Tidal marshes/wetlands exist in a very narrow surface elevation range and are normally part of a larger combined system, which can also contain freshwater, explained the expert from Conservation International. They play an important role for fish production and provide long-term carbon sequestration in their soils; because the soils are wet, sediments are trapped and store high levels of carbon, and, similar to the other coastal ecosystems discussed during this session, most carbon is found in the soil organic carbon pool. Conversion of these coastal wetlands, in particular drainage, which occurs widely in coastal ecosystems, brings loss of historical carbon, resulting in CO_2 and other GHGs being released quickly into the atmosphere, while the soil subsides, causing additional problems, including land subsidence and erosion. Wetlands can be restored, as shown by the wetlands restoration projects that are also being used to model the response of those wetlands to sea level rise and to collect data. Knowledge of the carbon density of the ecosystem can be used to calculate the carbon lost due to conversion and the corresponding CO_2 release, which, as explained by the presenter, have shown to be significant; he referred to a number of case studies in delta regions, for example the Sacramento-San Joaquin River Delta and the Snohomish River Estuary of Puget Sound, Washington, both in the United States of America.[18] Although methods are available to calculate carbon sequestration and losses, more data are needed to use tier 2 methods, which would be needed to better reflect local conditions and improve accuracy in the estimations.

2. Terrestrial ecosystems

31. The following group of presentations looked in detail at high-carbon terrestrial ecosystems, particularly the importance of peatlands and terrestrial wetlands, but also permafrost and others. Methodological aspects of estimating carbon were also addressed. There are many different peatland ecosystems, as recognized by the Convention on Biological Diversity, and they are present throughout the world in the Arctic, temperate and tropical zones. Information on global peatlands is collected into databases, collated from countries' data, and can provide an overview of the extent and condition of global peatlands and mires.

32. A representative from the Center for International Forestry Research presented information on current knowledge of tropical peat swamp forests, which constitute a major terrestrial carbon store, in particular in their below-ground carbon pools. Around 75 per cent of the global carbon stored in tropical peatlands (estimated at 92 Pg C in 2010) can be found in South-East Asia. Tropical peatlands are extensively deforested, drained and degraded, and most of their emissions result from drainage and conversion to acacia. Methodologies for estimating GHGs from peatlands have become available (IPCC Wetlands Supplement), including for drained peatland and rewetted organic soil; however, the further development of higher-tier emission factors and data would be needed, especially for restored degraded peatlands. Country-specific data are therefore needed to improve estimates, as well as better estimation of peat depth/thickness and volume. Airborne and ground penetrating radar may be used in this regard to reduce uncertainties. Fire is also an important factor, as every activity of converting peatland involves fire, which

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[17] See <http://api.ning.com/files/y3-*sRtNa*Fycl5kE3LbC0XDgzjU2ONNDrGFWuWjqH3JgJhorb7gwsIToB2TrQKpHUsgi67IqiTaMPJWy2iJ6d0uPEaEAtcc/Duarteetal.2013theroleofcoastalplantcommunitiesforclimatechangemitigationandadaptation.pdf>.

[18] See <https://www.estuaries.org>.

significantly affects carbon losses. During a UNFCCC workshop on ecosystem-based approaches[19] these wetlands were identified as among the most vulnerable ecosystems that require more attention. Identifying and understanding the ecosystem services provides opportunities for sustainable and adaptive management of these systems and to make use of the co-benefits for both mitigation and adaptation.

33. A representative from the Seventh Framework Programme (FP7) of the European Union (EU) outlined the importance of permafrost, which is being studied under the PAGE21 project,[20] as an ecosystem with high deposits of carbon in its soils, especially in the frozen parts, estimated at 1,672 Gt C globally (or more than twice as much as the current atmospheric carbon). Permafrost underlies 24 per cent of the northern hemisphere, can be over 2.5 million years old and up to 1,600 m deep. It has an active layer which freezes and thaws each year. Warming is causing increased permafrost thaw, and the depth of the active layer in carbon-rich regions is projected to increase, causing land subsidence and coastal erosion, and ultimately increased release of carbon. Although there are large uncertainties involved in current thermal models estimating permafrost extent and thaw, there is clear agreement that permafrost coverage will decrease this century, and fluxes of carbon from thawing permafrost by 2100 are estimated between 1.2 and 1.6 Gt C/year (equivalent to half of all fossil fuel emissions from the industrial age to today). Further research and model development and evaluation are critical to better understand the permafrost–carbon response, including improved model validation, common frameworks for assessment of carbon availability, understanding lateral fluxes and degradation of permafrost between reservoirs, subsea permafrost, gas hydrate CH_4 emissions, as well as the role of nitrogen and phosphorus. A recent UNEP publication on permafrost and the implications of warming[21] highlights the need for further assessments on permafrost emissions, national permafrost monitoring networks and institutionalized arrangements.

34. A representative from Germany, on behalf of the EU, gave a presentation on terrestrial wetlands in Europe, focusing on the importance for GHGs and mitigation, and methodologies for monitoring. According to data for the EU-27 (the 27 member States of the EU), about 7 per cent of the area is peatland, of which 60 per cent is drained (mainly for forest, but also for agriculture), and organic soils constitute a net source of GHGs, although large uncertainties still exist. An EU FP7 project (GHG-Europe)[22] aims to improve knowledge of these critical peatland areas and reduce uncertainties by reviewing and synthesizing existing research activities in natural, managed and restored peatlands across Europe, taking into account the main drivers for carbon fluxes and GHGs from organic soils, that is, land uses and management. The project aims to determine anthropogenic carbon emissions from peatlands, the most practical ways to restore land through rewetting and the effects of restoration on the carbon balance. Rewetting is key to making use of the mitigation potential; however, the needs for various land uses need to be considered. Monitoring of activity data has been supported by historical information from land mapping of peat reservoirs, soil inventories, data on land uses and their changes, as well as on the water table. Different ways of monitoring the soil carbon balances were presented; however, some of them remain highly uncertain. Lessons learned indicate that common

[19] Technical workshop on ecosystem-based approaches for adaptation to climate change, organized under the Nairobi work programme on impacts, vulnerability and adaptation to climate change, and held in Dar es Salaam, United Republic of Tanzania, from 21 to 23 March 2013. Further information is available at <http://unfccc.int/7379>; the report on the workshop is contained in document FCCC/SBSTA/2013/2.

[20] See <http://www.page21.org>.

[21] UNEP. 2012. *Policy Implications of Warming Permafrost*. Available at <http://www.unep.org/pdf/permafrost.pdf>.

[22] See <http://www.ghg-europe.eu>.

terminology and clear methodologies are important for monitoring the high-carbon pool in peatlands, and good documentation and quality control can reduce uncertainty.

35. A representative from the Russian Federation provided details of the peatland, tundra and steppe high-carbon terrestrial ecosystems, showing the estimated carbon pools in biomass and soils in those ecosystems in his country and related characteristics. Tundra contains a large layer of peat, which functions as a protection for permafrost, which buries carbon as well as CH_4 hydrates. However, rises in the temperature and degradation of the permafrost are being observed, and disturbance of peatland causes rapid thawing of underlying permafrost. Peatland areas are the ecosystem with the largest carbon pool in the soil compared with other terrestrial ecosystems (tundra, steppe and forest) in the Russian Federation. Large areas are subject to human disturbances and conversion, including for peat extraction, agriculture, forest drainage and construction and infrastructure (e.g. housing and industrial objects), causing changes in carbon fluxes and release of carbon in the form of CO_2 and CH_4. Furthermore, areas of peatland being abandoned after economic activity are at risk of peat fires. Observation, restoration and rewetting of such abandoned wetlands can make an important contribution to protecting these peatlands and decreasing emissions and the risk of peatland fires. The steppe also contains areas of peatland, and fires in the Russian Federation are mainly concentrated in steppe areas. Significant issues to be addressed were highlighted, in particular the need for assessments of the carbon balance of these ecosystems, taking into consideration human impacts and different kinds of disturbances, the need to develop methods for monitoring GHG emissions and carbon losses, especially from fires, and evaluation of potential multiple benefits that specially protected areas could bring for those ecosystems, including for reducing carbon losses.

36. A representative from the International Centre for Integrated Mountain Development[23] gave details of high-altitude ecosystems with high-carbon reservoirs, focusing on the Himalayan region, one of the largest mountainous areas in the world. Peatlands are mostly found in the Tibetan Plateau, and are one of the most important stores of carbon in the mountain regions, storing 1,500–4,000 t C per ha (or up to 8–20 times more than mountain forests or 50–100 times more than mountain grasslands). In 2008, about half of the total peat area consisted of degraded peat, and regional estimations indicate a total carbon stock of 2,980 Mt C and emissions from degradation of 63.9 Mt CO_2 per year for the region as a whole. The region is experiencing warming and changes in precipitation patterns, and peatlands have become drier or even vanished between 1967 and 2004, causing increased CH_4 emissions. Also, warming-enhanced respiration of subsurface peat may have transformed peatlands from net CO_2 consumers (sinks) into net CO_2 emitters (sources). Significant areas of the Tibetan Plateau are covered by permafrost, which is retreating and thawing, and this trend is expected to continue, in turn resulting in rapid carbon losses through CH_4 and CO_2 effluxes. The impacts of climate change and degradation of peatland and permafrost are exacerbated by human activities (e.g. population increase, unsustainable management, urbanization, tourism, pollution and land-use change). Further work is needed to enhance the availability of observations, data and baseline information. There is a need to promote research to support scientific understanding and long-term monitoring, promote the integration of conservation, restoration and co-management of high-altitude ecosystems into climate change mitigation and adaptation policies and strategies, and develop mechanisms to improve awareness, communication and dissemination of information.

3. High-carbon ecosystem: methodological aspects, monitoring and modelling

37. The final group of presentations of this session focused on methodologies, monitoring and modelling of high-carbon ecosystems.

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[23] See <http://www.icimod.org>.

38. A presentation by an IPCC representative focused on modelling the global carbon cycle, concentrating on the results used in AR5 WGI and the current limitations of the models from the ecosystems' perspective. Comparison of modelling results shows that ocean models agree with a high level of confidence that the ocean will continue to take up more carbon during the twenty-first century, while land models exhibit much greater differences, lack some key processes and ecosystems, and therefore confidence is low, although they still generally show continued carbon uptake. Although there are differences between models when simulating land and ocean carbon uptake, most agree that a peak for carbon emissions at 2020 is required to achieve the RCP2.6 concentration pathway, and that this low-mitigation CO_2 pathway is as likely as not to require negative emissions. According to some models this would succeed in avoiding 2 °C warming. However, any additional carbon source increases the requirement for negative emissions. As permafrost and peatland ecosystems[24] are likely to release additional carbon in the form of CO_2 and CH_4, respectively, this century due to losses in area and biomass as a result of increases in temperature, both will provide additional positive feedback into climate change. Currently there is a need for better evaluation of current models, including in initial conditions such as soil organic carbon and biomass carbon stores. Furthermore, certain ecosystems and processes are not represented in current models, namely: the nitrogen and phosphorus nutrient cycles; carbon storage in permafrost; vegetation cover and carbon from deep organic soils in peatlands/wetlands; and, not included at all, are mangrove, seagrass and tidal marsh ecosystems. Better understanding of carbon storage and the feedback from, in particular, permafrost and peatlands/wetlands play an important role in reducing uncertainties in modelling the global carbon cycle.

39. Following the overview of vegetated coastal ecosystems covered in chapter 4, "Coastal wetlands", of the IPCC Wetlands Supplement, a representative from the IPCC gave details of the methodological guidance provided in that chapter. She also provided information on the generic methodological approaches of the 2006 IPCC Guidelines relevant to the Wetlands Supplement, including methodological tiers, carbon pools in different land-use categories and approaches for estimating carbon stock changes and non-CO_2 emissions, which continue to be followed in the Wetlands Supplement. Methodological guidance on specific management activities in coastal areas of mangrove forests, tidal marshes and seagrass meadows constitutes one of the new elements in the supplement, providing updated default data for estimating carbon stock changes in mangrove living biomass and dead wood pools and new generic and methodological guidance and data on CO_2 emissions and removals for specific management activities. The methodological approach and key features of the default methods were outlined, including with regard to: CO_2 emissions and removals from forest management in mangroves; extraction activities and rewetting and revegetation of mangroves, tidal marshes and seagrass meadows; and drainage of mangroves and tidal marshes. Furthermore, the supplement provides default methods for estimating CH_4 emissions from rewetted soils, based on vegetation and salinity, and N_2O emissions from aquaculture use, which takes into account mass and nitrogen content of fish.

40. A representative from Japan gave a detailed presentation on Japan's Integrated Monitoring-Sensing-Modeling (MSM) system to estimate carbon fluxes and stocks in tropical peatland, in the context of a project on wildfire and carbon management in peat forest in Indonesia. He highlighted the following key elements of the monitoring system: CO_2 flux and concentrations, wildfire and hotspot detection, forest degradation and species mapping, deforestation and forest biomass change, water level and soil moisture, peat dome detection and peat thickness, peat subsidence and water soluble organic carbon. The presenter further outlined how to estimate and model carbon stocks and fluxes, including by

[24] Permafrost and peatland ecosystems are estimated to store about 1,672 Pg C and 600 Pg C, respectively, globally.

oxidation and by fires, through modelling and the use of satellite data. The MSM system integrates these different elements supported by a range of model outputs, including those of VISIT (Vegetation Integrative Simulator for Trace Gases),[25] which aims to model biochemical interactions between atmosphere and ecosystems, to provide the budget for the main GHGs and assess climate impacts and biotic feedbacks. The MSM system is validated by aerial, satellite and ground-based measurements, and provides an integrated, practical carbon budget map at the local level.

41. A representative from the Stockholm Environment Institute explained the challenges involved in monitoring, measuring and modelling carbon stocks and fluxes from soil organic carbon in peatland. There is currently large variability in global soil organic carbon stock estimates largely because there are not enough sample points. Overall, annual mean air temperature and vegetation greenness index together account for about half of the observed variability in global soil organic carbon stock estimates. Furthermore, currently the differences between real and modelled soil carbon fluxes are very large, about three-fold, mainly because models do not capture all component fluxes. The representative outlined that for understanding the terrestrial carbon flux, it is important to understand the different components of the total soil carbon flux, as these components might respond differently to environmental changes such as temperature or management changes, such as nutrient input. In most systems the major components are roots, mycorrhizal fungi and heterotrophic soil decomposers. However, previous invasive techniques used for measuring CO_2 flux may lead to unreliable data due to damage caused to fine plant roots and mycorrhizal fungi. Equipment developed within the last five years enables soil carbon fluxes to be monitored across scales and at high temporal resolution using, for example continuous chamber methods (for CO_2 and CH_4) with minimum interference to the soil environment. To help understand carbon fluxes from peat, it is useful to study how peatlands evolved so as to develop models that can be validated with knowledge of past water tables and age of the peat, and then be applied to current (and future) changes. However, most current models lack information on a number of parameters, and peat modelling still remains a challenge and many uncertainties still exist, such as for peat carbon budgets. Large-scale GHG monitoring networks, improved stock and flux methods and better modelling (e.g. taking into account key organisms) will be important in addressing some of these uncertainties, which would be assisted by using a coordinated approach and a common methodology, as well as through global research platforms.

C. Management of ecosystems in the mitigation and adaptation context

42. This part of the workshop focused on managing ecosystems in the mitigation and adaptation context, including management of their carbon stocks from both an adaptation and a mitigation viewpoint. This was illustrated with examples, case studies and lessons learned. Presentations under this session broadly addressed: ecosystem-based management and its benefits and potential for adaptation and mitigation; sustainable use, conservation and restoration, including enhancing carbon sequestration through managing sinks and reservoirs and carbon stocks; and reducing and minimizing conversion and GHG emissions. Vulnerabilities of, threats to and impacts on the various ecosystems were also discussed, including minimizing risks from threats and increasing resilience (e.g. to disturbances), and the role of stakeholder engagement and that of local communities.

43. As an introduction to the session, a representative from the International Geosphere–Biosphere Programme (IGBP) outlined an approach of considering multiple climate and ecosystem targets, as compared with a single temperature target, referring to Article 2 of

[25] Developed in the National Institute for Environmental Studies and the Research Institute for GlobalChange.

the Convention, which stipulates that “stabilization of greenhouse gas concentrations …should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change”. To address the question of how much CO_2 can be emitted to meet multiple climate targets, a study was outlined that considered, in quantified form, the following six targets: limiting global warming, minimizing the impact of ocean acidification on corals, limiting ocean acidification in the Southern Ocean, limiting the loss of carbon from cropland soils, avoiding decrease in food production and limiting sea level rise due to thermal expansion. Using a Bayesian approach, the climate response and probabilities of staying within the target range were modelled. Results indicate that a single ‘one size fits all’ climate target would not sufficiently encapsulate Article 2 of the Convention and that a combination of multiple targets would require lower allowable carbon emissions, that is, even deeper emission cuts, compared with a single temperature target. The studies referenced by the presenter further indicate that reducing CO_2 emissions appears to be a prerequisite to allow ecosystems to adapt to ocean acidification, and that delay or insufficient emission reductions can make climate targets unreachable.

44. A representative from UNEP-WCMC gave an overview of managing ecosystems for the provision of multiple environmental services, including biodiversity in the context of climate change. Ecosystem services in the context of climate change include mitigation, in particular through carbon sequestration and storage in biomass and soils, and adaptation, as ecosystems can reduce climate change impacts on people. The resilience of an ecosystem to climate change and other pressures plays an important role in that it can ensure continuity of carbon stocks and delivery of services relevant for adaptation. Specific adaptation actions may be needed to enhance ecosystem resilience, as illustrated by a project in a German forest that plans the conversion of planted conifer stands into mixed stands, in order to reduce the risks from climate extremes and, at the same time, protect biodiversity. Integration of ecosystem-based mitigation and adaptation actions offers further potential for synergies, especially in areas with high potential for carbon sequestration and other ecosystem services. A number of examples for ecosystem-based activities that support both adaptation and mitigation were given, as well as examples where possible conflicts between these goals could occur. Spatial analysis based on maps can help facilitate decisions on the management of ecosystems, by showing how the potential and demand for different kinds of ecosystem services vary from one location to another. This can support the identification of important areas for each ecosystem service, as well as possible synergies and trade-offs between services. Although information, approaches and tools for ecosystem service management are increasingly available, further research is needed, for example, for assessments of ecosystems’ resilience to climate change and management options that enhance synergies and reduce trade-offs.

45. Trees outside forests and their role in adaptation and mitigation were the focus of a presentation by a representative from the World Agroforestry Centre. At the local level, trees provide essential environmental services, including for food security, local economic development and biological diversity. The presentation demonstrated tree cover in different types of land covering large areas of the world, including tree cover changes. It also highlighted the role of soil carbon and of trees in the context of agroforestry, at the interface between adaptation and mitigation, especially for sustainable land management, carbon sequestration, reducing vulnerabilities and enhancing resilience and adaptation. The Food and Agriculture Organization of the United Nations recently provided information on international, national and local efforts to manage trees that are not part of a forest for local people’s benefits.[26]

[26] *Towards the Assessment of Trees Outside Forests*. 2013. Rome: Food and Agriculture Organization of the United Nations. Forest Resources Assessment Working Paper 183. Available at <http://www.fao.org/docrep/017/aq071e/aq071e00.pdf>.

46. A representative from Wetlands International highlighted opportunities for joint climate change mitigation and adaptation activities using ecosystems, specifically mangroves, as explained through the project Building with Nature.[27] Studies have demonstrated the role that mangroves can play for adaptation, as they are able to adapt to sea level rise (in some circumstances) by building up soil (1–10 mm per year), provided there is sufficient supply of sediment and soil organic matter, which requires sediment flow between land and the ocean. Mangroves also protect coasts from everyday waves, reduce storm surge and surface wind waves and prevent erosion. Once mangroves are cleared for other land uses (e.g. aquaculture ponds, urban settlements), there follows coastal erosion, saltwater intrusion and increased vulnerability to flooding from storm surges, increasing the exposure of people and their livelihoods. The presentation showed and compared different types of solutions, such as conventional ‘hard’ engineered structures such as dykes and breakwaters, which often have a low cost–benefit ratio as they often fail to provide the required protection, prevent nutrient flow and worsen coastal erosion. Working with natural solutions, which build upon a permeable structure similar to the original mangrove root system and allow increasing the amount of sediment trapped at or near the coast, supports coastline restoration and other ecosystem services, as well as mangrove regrowth and carbon sequestration, as shown by the Building with Nature project in Indonesia. At the same time it is important that such projects be guided by clear objectives and that expectations and different options be explored.

47. Examples of current conservation and restoration approaches in coastal marine ecosystems were highlighted by a representative from Conservation International. Coastal wetlands store large amounts of carbon and provide critical ecosystem services, including fisheries, food, coastal protection, water quality and livelihoods, and are particularly important for local communities. Blue Carbon Initiative[28] restoration projects in coastal wetlands were highlighted; these provide sustained management, conservation and restoration of coastal ecosystems, using available conservation tools. Projects include a community-based mangrove rehabilitation project in the Philippines providing mangrove reforestation and income diversification schemes; developing and supporting policy and management that conserves and promotes sustainable use of mangroves in the Gulf of Nicoya, Costa Rica; Indonesia’s National Plan of Action on Blue Carbon; the world's largest seagrass restoration project, Virginia Coast, United States; and the protection of mangrove and ecosystem services in the Marine Protected Area of Bird’s Head Seascape in Papua Barat, Indonesia, designed to take into account biological features and ecological connectivity, physical and oceanographic features, and socio-economic and cultural criteria, including vulnerable communities. A survey of Blue Carbon field projects addresses the question of how such projects help to improve the management, restoration and conservation of these coastal ecosystems, to increase recognition of their mitigation value, improve their management and provide incentives and resources to conserve and/or restore them.

48. A representative from the Intergovernmental Oceanographic Commission (IOC) of the United Nations Educational, Scientific and Cultural Organization elaborated on the linkages between the oceans and coastal wetlands ecosystems, anthropogenic impacts on these ecosystems and ways to address them. To date most of the world’s coastal areas, where a significant part of the global human population is located, are considerably affected by human activities, with large parts of the shorelines and coastal wetlands being degraded or lost. Technical methods exist that allow the measuring and monitoring of the carbon

[27] Building with Nature is a continuum of concepts, combining engineering with natural systems. Developed by the Dutch Ecoshape Consortium; see <http://www.ecoshape.nl>. See also <http://unfccc.int//7877> for links to relevant work by Wetlands International.

[28] See <http://thebluecarboninitiative.org>.

stored in coastal marine ecosystems, including in the plants and soils, as well as methods to estimate the loss of carbon from these systems if they are degraded or converted. A detailed field guide, *Methods for Assessing Carbon Stocks and Emissions Factors in Mangroves, Tidal Marshes and Seagrasses* is currently in preparation by the Blue Carbon Initiative.[29] However, challenges in calculating carbon fluxes and in the application of certain methods still exist, and more research is needed, in particular on the geographical extent of seagrasses and salt marshes, assessments of carbon sequestration and storage, GHG emissions, human drivers and coastal erosion. In addition, alignment of methods to estimate coastal carbon is needed to ensure comparability of results. IOC works with the Global Ocean Observing System, a collaborative system for sustained ocean observations which aims to provide the sustained observations of the oceans necessary to improve scientific knowledge of ocean climate, ecosystems, vulnerabilities and impacts. Furthermore, IOC has developed a marine spatial planning approach, a tool to operationalize ecosystem-based management by countries and to assist in balancing environmental conservation and sustainable economic development in marine environments.

49. Peatlands, as an example of a carbon-rich ecosystem, and its importance for climate change mitigation through restoration was highlighted by a representative from Wetlands International. Peatlands are a unique ecosystem, which in nature are no longer being created, but can only be maintained or restored, and can be found in almost all countries, according to a global database. The carbon content (kg C/m^2) of peatlands is significantly higher than that of many other terrestrial ecosystems and is largely stored in the soil, and is released in the case of disturbances, such as fires and drainage. In temperate zones, peatlands are widely distributed and used (both directly and indirectly) and their functional characteristics and management practices are well understood, and many projects are ongoing to restore them,[30] with various restoration objectives, including reduction of GHGs, fire prevention, flood control and improving biodiversity. However, only a few peatlands are being rewetted as a result of these activities. Large-scale peatland restoration projects for mitigation in the Russian Federation funded by the International Climate Change Initiative, the Global Environment Facility (GEF) and others consist of various components, including rewetting activities, estimation of GHGs, and monitoring, so as to reduce GHG emissions from the rewetted areas. In the Arctic and semi-arid zones, peatlands are a very vulnerable ecosystem providing essential ecosystem services and posing more challenges for restoration. Most of the Arctic landscapes consist of wetlands, and most of these are peatlands of different types. Disturbing peat as a result of thawing of the ground (e.g. due to infrastructure, industries) results in releasing CO_2 and CH_4. Consideration of the ecosystem functions and services that these peatlands provide, including carbon storage and sequestration and GHG balance maintenance, non-destructive uses (e.g. for renewable energy), water purification, biodiversity and others, can therefore make an important contribution to mitigation efforts.

50. Biodiversity was highlighted as an important component of high-carbon ecosystems, as further elaborated by a representative from the Inter-American Institute for Global Change Research, who explained the role of biodiversity and its importance for estimating carbon stocks. Different components of biodiversity are important for carbon storage, and changes in biodiversity may influence carbon gains and losses in an ecosystem. Studies have shown that the relation between biodiversity and carbon varies across ecosystem types and that biodiversity can have positive and negative effects on carbon storage. A study on tropical forests that was referred to as an example showed that liana abundance can decrease carbon stocks in humid forests, whereas in other ecosystems, depending on the type, a richness of species is accompanied by higher carbon stocks; for example, in mature

29 See also <http://thebluecarboninitiative.org/wp-content/uploads/BC_FAQ_UNFCCC-2.pdf>.

30 See <http://www.wetlands.org/Whatwedo/Savingpeatlands/tabid/837/Default.aspx>.

and secondary savannas, carbon stocks are maximized by mixed-species stands. In addition, the resilience of an ecosystem is a function of biodiversity, which can be altered due to loss of biodiversity. This loss of resilience increases uncertainty and the capacity to recover after perturbation. Considering biodiversity can also help to improve models and to identify tipping points of an ecosystem.

51. There is increasing recognition of the importance of understanding the impacts of ocean acidification, including for the coasts and their ecosystems, as highlighted by a representative of IGBP, who outlined current activities on assessing socioeconomic impacts of ocean acidification. Ocean acidification is caused by CO_2 and is expected to occur more rapidly than other expected climate change impacts. Although there are an increasing number of studies on the biological and ecological impacts of ocean acidification, there have been only a small number of attempts at economic assessment to date, and estimates of the socioeconomic impact of climate change have not sufficiently taken into account the impacts of ocean acidification. This has implications, for example when estimating socio-economic impacts and costs of adaptation. Frameworks for assessing the socio-economic impacts of ocean acidification can help to enhance the understanding of the linkages between changes in the marine environment (fish stocks, coral reefs and marine organisms), the ecosystem services they provide and the impacts on socio-economic activities. However, more data and quantitative information are needed for undertaking an economic assessment and enhancing the knowledge of the relationship between changes in the marine environment and socio-economic impacts; the ecosystem services that have been assessed; the distribution of impacts; and the vulnerability of different populations.

52. The following three presentations under this session focused on national activities and experiences in managing high-carbon ecosystems in the context of adaptation and mitigation.

53. The representative of Maldives outlined ongoing and planned adaptation activities in the country’s high-carbon wetlands ecosystems of varying sizes and rich biodiversity, which have been identified on 41 islands across Maldives. A management project on community-based conservation of wetlands, supported by the Climate Change Trust Fund, aims to protect and minimize the impacts of climate change on mangroves, wetlands, the environment and community existence; to conserve and sustainably utilize biological diversity to ensure maximum ecosystem benefits; and to conserve wetlands and mangrove ecosystems for future water security in the islands. The project currently targets an area of brackish water wetlands and an area of freshwater wetlands. It links wetlands management and adaptation in these areas by improving drainage to reduce flooding; increasing groundwater recharge and sources of freshwater; enhancing coastal protection; improving biodiversity to provide wider ecosystem services; increasing economic diversity; and improving food security as a result of high productivity in these areas. Furthermore, work is being undertaken to monitor coral reefs, including the development of training modules, materials, field guides and a web-enabled database, and to restore coral reefs in selected resorts.

54. A representative from the United States gave an overview of ongoing scientific and technical efforts in regard to carbon in coastal ecosystems, both nationally and internationally. Current science objectives on coastal carbon ecosystems include mapping and modelling geographical distribution of such ecosystems at a sufficient geospatial resolution; improving the understanding of the carbon cycle in these ecosystems, including carbon release from disturbance or conversion; estimating carbon storage sequestration and emissions; and characterizing and mapping threats to these ecosystems. Carbon storage is being studied as part of ongoing science projects, where different types of coastal ecosystems in different locations are addressed, as well as improved management or incentives for wetlands restoration and preservation. A national carbon sequestration

assessment indicates that in the United States the highest level of carbon is found in coastal zones. The United States has initiated a number of activities to address carbon in coastal ecosystems, such as through inter-agency coordination, inclusion in national ocean policies and the development of tools and methodologies for carbon management in coastal and marine ecosystems. Internationally, the United States participates in a Commission on Environmental Cooperation grant to help to build a community of practice for coastal marine carbon and participates, including though co-finance, in the GEF project Blue Forests.[31] International projects include the global science project to map mangrove forest deforestation and degradation using earth observations and the Sustainable Wetlands Adaptation and Mitigation Program project[32] to provide policymakers with scientific information so as to make sound decisions relating to the role of tropical wetlands in climate change adaptation and mitigation. Technical and methodological needs to support the management of coastal marine ecosystems still remain, including methodologies and tools for measuring and monitoring, guidance, capacity and expertise.

55. The representative of the United Republic of Tanzania highlighted her country's initiatives on coastal ecosystem management in the context of adaptation and mitigation. The Tanzanian coastline is economically and ecologically important, rich with estuaries, mangrove forests, beaches, coral reefs, seagrass beds and deltas of large rivers, but detrimental anthropogenic impacts (for example due to destructive fishing, coral and sand mining, wastewater, clearance for commercial and domestic purposes), are threatening these ecosystems and are exacerbated by climate change. She highlighted a number of recent relevant climate change strategies, initiatives and projects in the United Republic of Tanzania, including on the conservation of coastal and marine zones, dams, lakes and rivers; on empowering vulnerable coastal communities to adapt to and mitigate climate change impacts in central Tanzania; on addressing core capacity to address adaptation in productive coastal zones; and on developing core capacity to address adaptation on the coast of Dar es Salaam City. To implement the coastal management initiatives, a number of challenges remain, including lack of scientific information on and knowledge of the coastal ecosystems' carbon sequestration potential and the carbon stored above and below ground; lack of baseline data on the state of coastal ecosystem degradation; and financial challenges.

D. Research needs: challenges and opportunities

56. The final session of the workshop addressed the challenges and opportunities for further research arising from the information provided throughout the two days of the workshop by focusing on the following questions:

(a) What are the key issues that need to be addressed from the scientific and technical viewpoint in order for the countries to make more use of high-carbon ecosystems for mitigation and adaptation (in general/by type of ecosystem)?

- Considering differences in terms of research needs among the various ecosystems and regions;

(b) What is needed in terms of data, observations and methodological tools in order to determine with higher certainty the carbon potential of a country's high-carbon ecosystems?

[31] This project is entitled Standardized Methodologies for Carbon Accounting and Ecosystem Services Valuation of Blue Forests. It is a four-year project, which aims to demonstrate how the incorporation of carbon and other ecosystem services values into local, national and international markets and coastal management plans can ensure the long-term protection of Blue Forest ecosystems.

[32] See <http://www.cifor.org/swamp>.

- At country level;
- Globally/through observation networks;

(c) What role could the SBSTA play in:

- Promoting advances in research on high-carbon ecosystems;
- Enhancing collaboration among scientists, Parties and research institutions.

57. These questions were first addressed by a panel of Party representatives, moderated by the Chair of the SBSTA. The panel included representatives from the following Parties: Brazil, the EU (Germany), Japan, Maldives, Papua New Guinea, South Africa and the United States. Panel members were asked to provide their views and elaborate on the questions from their country's perspective, followed by a discussion with all participants of the workshop. An overview of the key technical and scientific issues and needs identified from the panel discussion and from the presentations is provided in summarized form in annexes I and II.

58. The panel expressed its appreciation for the input from the IPCC and the presenters for sharing their knowledge of technical and scientific advances during the workshop, which constituted an important step towards enhancing the understanding of these aspects of high-carbon ecosystems, including current limitations and uncertainties. They also highlighted the importance of continued support for collaborative work and research on these ecosystems. They emphasized that the SBSTA research dialogue could be further used to elaborate issues in this regard, as well as possible future workshops.

59. The panel noted that availability of guidance on and procedures for estimating and validating carbon in high-carbon ecosystems is vital. It was emphasized that developing common terminology and protocols and setting standards are important to obtain comparable data and results. The need to build capacity and expertise to quantify outcomes of projects was also noted. Further research is needed to better understand these ecosystems and the associated ecosystem dynamics. The importance of interdisciplinary networking was stressed alongside the need for further collaboration among institutions and networks to share information and data, including satellite data. It is important to replicate what is learned in one ecosystem in others and share this knowledge to broaden applicability, where possible, and support global coverage, as currently much of the knowledge and conclusions are based on limited locations.

60. It was noted that advances in the knowledge of the carbon in coastal ecosystems have been made, inter alia with the publication of the Wetlands Supplement, enabling countries to estimate and report on anthropogenic GHGs from these ecosystems. There are methodologies and data sets available to enable such estimations and the move to higher-tier methods, although further work is still needed at the country level.

61. While methodological advances have been made, there are still large data gaps, especially in developing countries. Furthermore, for carbon in soils, remaining uncertainties are still high. For peatland and other soils, the panellists identified the importance of examining carbon fluxes. More information is needed on the fluxes and the timing of emissions. When looking at fluxes it is important to understand what is climatically important. Harmonization of the methodologies is required as well as more information on the drivers, including land use and land-use changes.

62. Precise data mapping of ecosystems was highlighted by a number of speakers as a way to characterize different ecosystems and thus estimate current carbon stocks, emissions and sequestration potential, and to identify where losses are occurring, the current rate of loss and what would happen under different climate change scenarios. Mapping is costly and requires the collection and handling of a large amount of data. For example, for

peatland, more mapping is needed in the tropics; for permafrost, more boreholes are needed for measurement in northern Asia. Historical records used originally for other purposes are also useful and need to be maintained; for instance, information on water tables could be used to improve estimates and support, for example, peatlands rewetting.

63. Some mapping has already been carried out in different ecosystems, using ground and remote sensing data. In this regard, Japan highlighted its work in collaboration with Indonesia to identify and map high-carbon systems. Linking observations and mapping work on ecosystems with the Climate Technology Centre (CTC)[33] was also emphasized.

64. In order to support modelling it is important to understand the interconnectivity of ecosystems and how they interact, as well as fluxes between ecosystems. It was noted that modelling still faces several challenges, in particular on regional and lower scales, and that results from models, including their limitations, should be communicated more clearly.

65. One important challenge to be faced is learning to live and build with nature to balance development and the protection of ecosystems and ecosystem goods. As mentioned by some panellists, the ecosystems addressed during the workshop store high amounts of carbon, which in many instances is being released owing to the ecosystems' degradation as a result of human activities. Hence, these ecosystems play an important role for carbon sequestration and climate change mitigation, but at the same time are also important for adaptation and many other services. It was suggested that a holistic and synergistic approach should be used in identifying and supporting ecosystem services, including through restoration and ecosystem management, and possible co-benefits should be explored.

66. The panellists identified several areas where further knowledge is needed, including the response of the ecosystems to climate change and the impact of various stressors such as ocean acidification, pollution and nitrogen losses on the required ecosystem services. There is also a need for developing countries to have basic methodologies of assessment to identify the risks to ecosystems and how to manage them.

67. Participants indicated that a build-up of momentum on ongoing projects that highlight good practice is vital. Although many projects for mitigation and adaptation are under way, panellists noted that positive incentives are needed to do more on a long-term and sustainable basis and that further work should be carried out on the management of ecosystem services. Stronger linkages with local communities and their knowledge and support need to be promoted, as well as raising awareness as to what is happening to the ecosystems, including from the socio-economic viewpoint and taking into account local circumstances, in order to support the prioritization of requirements and services.

68. Possible roles and next steps for the SBSTA, as identified during the panel discussion, include the following:

(a) Continue to use the research dialogue as a platform for providing up-to-date scientific information and for communicating research needs as identified by Parties, including through further workshops;

(b) Encourage enhanced research in regard to high-carbon ecosystems, especially in developing countries;

(c) Promote and enhance further collaboration, cooperation and networking among research institutions, including regional and international research programmes and organizations and United Nations and other bodies;

[33] See <http://unfccc.int/ttclear/templates/render_cms_page?TEM_tcn>.

(d) Link science and policy communities, including through the Nairobi work programme on impacts, vulnerability and adaptation to climate change and CTCs, and bring together key players for supporting further knowledge enhancement on mitigation and adaptation;

(e) Acknowledge methodological developments by the IPCC on high-carbon ecosystems and consider possible recommendations to the IPCC for further work;

(f) Guide further work on the technical and scientific aspects of high-carbon ecosystems and provide guidance on the use of methodologies; for example, encourage the development of common terminology, data sharing and knowledge platforms.

Annex I

Priority needs and areas for scientific research and technical advancement identified

Priorities relating to all ecosystems	
General: key uncertainties	• Extent of high-carbon ecosystems areas, including degraded areas – improve inventories of ecosystem carbon stocks, sequestration and emissions (mapping needed), especially soil carbon; • Cumulative emissions from land-use change, disturbance, conversion; • Understand threats – in order to characterize and map; • Contribution of permafrost thawing and of wetlands to the global carbon budget and to CO_2 and CH_4 emissions, respectively (positive feedback into climate change); • Effect of ocean acidification and deoxygenation on marine ecosystem services.
General: monitoring/modelling methodologies	• Enhance availability of data and observations; • Cataloguing of the distribution of ongoing and new emissions; • Assessment of historical conversion and degradation patterns; • Monitoring vulnerable carbon pools and fluxes – critical as the climate evolves; • Reproduction of models to evaluate carbon fluxes from ecosystems also at regional scale; • Data to support the use of higher tier 2 methods; • Large-scale greenhouse gas (GHG) monitoring networks (including eddy covariance); • Improved evaluation of models and setting of initial conditions (including soil organic carbon and biomass carbon stores); • Consider biodiversity in carbon stock estimations and models.
Cooperation and training requirements	• Promote research and baseline studies to support scientific understanding, long-term monitoring, conservation and management; • Develop mechanisms to improve the effectiveness and efficiency of communication, education, participation and awareness; • Global research platforms for exchange of data, research, knowledge, etc.
Soil organic carbon	• Unravel plant–soil carbon dynamics – including spatial variation in soil organic carbon stocks; • Impacts of different forms of land use on soil carbon, including coastal soils and sediments; • Data on soil organic carbon is still highly uncertain, especially for permafrost, peatlands and some coastal sediments.
Further priorities as they relate to individual ecosystems	
Coastal	**Mapping:** • Geographical extent of especially areas containing seagrasses and salt marshes; • Additional mapping of converted and degraded coastal marine ecosystems and the quantification of emissions from exposed organic soils, and from disturbed or degraded seagrasses. **Carbon budget, sequestration and storage:** • Align methods to measure and estimate coastal carbon for comparability of results; • Few data are available in the scientific literature on the carbon sequestration and storage rates of habitats in Africa, South America and South-East Asia; • Collection of data and development of tier 2 emission factors to improve regional estimates, taking into account local ecological and activity conditions; • Understanding the fate of carbon exported, e.g. in streams and rivers. **Human drivers:** • Emission rates over time for a range of drivers of ecosystem degradation or loss are

	limited at the moment, especially for seagrasses; • Effect of ocean acidification on ecosystem services, distribution of impacts, vulnerability of different populations and implications for mitigation; • Relationship between ocean acidification changes in the marine environment and socio-economic impacts; • Impact of combined effects which are difficult to detect, e.g. the impact of pollution with ocean acidification and temperature rise with ocean acidification. **Coastal erosion:** • The fate of carbon eroded from coastal and marine ecosystems and carried offshore by ocean waves and currents.
Permafrost	**Mapping:** • Better/more complete inventories of permafrost; • Still large uncertainties in current thermal models estimating permafrost extent and thaw; currently no measurement of the extent of, and the emissions due to, the thawing of permafrost; • Develop national permafrost monitoring networks; • Common framework for assessment of carbon availability; Understanding of carbon exchange between different carbon reservoirs (land, water, air) and measurement of lateral fluxes from permafrost areas (coastal and rivers); • Increased stakeholder engagement. **Carbon budget, sequestration and storage:** • Understanding of emissions from subsea and in situ permafrost and gas hydrate methane; • Role of nitrogen and phosphorus. **Human drivers:** • Impacts of industrial infrastructure on permafrost thawing. **Modelling:** • Increased collaboration with modellers; • More model development to understand the permafrost–carbon climate response; • Improved model validation.
Peatlands	**Mapping:** • Need for coordinated approach and common methodology for measurements; • Improve inventory of peatlands/wetlands; and enhance availability of data and observations; • Improve estimate of peat depth/ thickness and volume (airborne and ground penetrating radar may be used to reduce uncertainties); • Improve measurement of carbon stock and flux methods, including: - mechanical disturbance and pollution in tundra; - drainage and changes of water regime for peatlands; - ploughing, grazing, fallow successions in steppe. **Carbon budget, sequestration and storage:** • The mitigation potential of rewetting; • Improve emission factors for drained peatlands and develop higher-tier emission factors for rewetted and restored degraded peatlands. **Human drivers:** • Development of methods and techniques for monitoring of GHG emissions and carbon losses from natural and anthropogenic fires. **Modelling:** • Improve modelling to include, inter alia, holocene peat accumulation, total peat column dynamics, dynamic water table, vegetation feedbacks, topography effects, key organisms and pedogenesis (soil evolution).

Annex II

Priority issues identified for managing ecosystems in the context of mitigation and adaptation

Priorities relating to all ecosystems addressed during the workshop	
All	• Decisions on the management of ecosystems should consider the impacts on a range of ecosystem services and should conserve and promote sustainable ecosystem use; • Prioritization of ecosystem services is important and should be spatially explicit; • Projects based on ecosystem-based approaches should be guided by clear objectives and expectations, and consider various options; • Promote ecosystem-based assessment approaches to identify the co-benefits of ecosystem services; • Identify, estimate and integrate co-benefits between adaptation and mitigation to provide synergies; • Keep wetlands ecosystems linked together to support local and global migration (trophic linkages) and biodiversity; • While information on the size of carbon stocks is important, identification of possible mitigation actions, information on vulnerability of carbon stocks and restoration opportunities is equally important; • Need for further methodological work and increased availability of tools for ecosystem service mapping, spatial multi-criteria analysis, assessments of ecosystem resilience and vulnerability to climate change impacts, and management options that enhance synergies and reduce trade-offs; • Involvement of indigenous knowledge and people in planning and implementing ecosystem-based approaches; • Support global communication of successful initiatives and lessons learned; • Include biodiversity in planning options for mitigation and adaptation.
Further priorities as they relate to individual ecosystems	
Coastal ecosystems	• Increase capacity-building and technology transfer to address information needs on coastal conservation; • Highlight the importance of carbon in coastal environments for human activities and progress; • Provide tools and mechanisms to facilitate coastal management plans and the development of new technologies.
Permafrost	• Plan for adaptation, including quantifying costs and risks associated with permafrost degradation; • Increase stakeholder engagement.
Peatlands	• Promote the protection and restoration to enhance carbon sequestration and reduce greenhouse gas (GHG) emissions; • Evaluate potential contribution of specially protected areas in the reduction of carbon losses and GHG emissions in tundra, steppe and peatlands; • Promote the integration of conservation, restoration and co-management of high-altitude ecosystems into climate change mitigation and adaptation strategies • Improve awareness, communication and dissemination of information.