CBD

UNEP

Convention on Biological Diversity

Distr.
GENERAL

UNEP/CBD/SBSTTA/15/8
22 July 2011

ORIGINAL: ENGLISH

SUBSIDIARY BODY ON SCIENTIFIC,
TECHNICAL AND TECHNOLOGICAL ADVICE
Fifteenth meeting
Montreal, 7-11 November 2011
Item 4.2 of the provisional agenda*

BIOLOGICAL DIVERSITY OF INLAND WATER ECOSYSTEMS: IMPLICATIONS OF CHANGES IN THE WATER CYCLE, AND FRESHWATER RESOURCES, IN THE IMPLEMENTATION OF THE THEMATIC AND CROSS-CUTTING PROGRAMMES OF WORK

Note by the Executive Secretary

EXECUTIVE SUMMARY

Changes in water availability (and quality) affect ecosystem functions and service delivery (and hence biodiversity). This aspect is relatively well-known but often with a focus on visible surface waters, whereas "invisible" components of the water cycle, such as humidity, soil moisture and evapo-transpiration of plants, are equally important considerations. The water cycle is also bio-physical process underpinned by ecosystems. Therefore considerations involve not only how water affects biodiversity but how biodiversity affects water (both its quantity and quality). Changes in the water cycle forge a multitude of linkages between different biomes, sectors and programme areas and to human development. Important considerations specific to most programme areas can be easily identified. In view of the human demands on water and its importance for development, there is a need to emphasize the positive role that biodiversity plays in meeting water management objectives. This note provides a brief explanation of this background, illustrated by examples. The most important considerations involve recognition of the cross-cutting nature of water and its importance. Water presents one of the clearest examples of the need to consider the ecosystem approach. The Strategic Plan for Biodiversity (2011-2020) and the Aichi Biodiversity Targets, in which water also has an important cross-cutting role, is a related framework for considering various programmes of work collectively, including for this topic. The needs for more in-depth consideration will vary on a case-by-case basis. Further scientific work on this topic has already been requested by the Conference of the Parties and is ongoing.

*UNEP/CBD/SBSTTA/15/1.

SUGGESTED RECOMMENDATIONS

The Subsidiary Body on Scientific, Technical and Technological Advice may wish to adopt a recommendation along the following lines:

1. *Welcomes* with appreciation the reports prepared by the Executive Secretary (UNEP/CBD/SBSTTA/15/8; UNEP/CBD/SBSTTA/15/9; UNEP/CBD/SBSTTA/15/10; and UNEP/CBD/SBSTTA/15/11);

2. *Takes note* of the implications of the water cycle, and freshwater resources, in the implementation of all the thematic and cross-cutting programmes of work of the Convention and the Strategic Plan for Biodiversity 2010–2020 and its Aichi Biodiversity Targets including, *inter alia,* that:

(a) The water cycle is a bio-physical process underpinned by ecosystems and that changes in water availability (and quality), including *inter alia* humidity, soil moisture and evapo-transpiration of plants, affect ecosystem functions and service delivery;

(b) The implications of the way in which the water cycle functions are many and varied necessitating that water be considered as a "cross-cutting" subject under the framework of the ecosystem approach;

(c) The water cycle forges strong links between the various Aichi Biodiversity Targets and it remains important to adequately capture the relevant aspects of the water cycle through the monitoring framework for the Strategic Plan under further development (decision X/7);

(d) Biodiversity ("natural infrastructure") plays a key role in achieving water security for ecosystems and people and this presents opportunities for the Strategic Plan for Biodiversity 2011-2020 to contribute to improved water security particularly through the potential cost-benefits of natural infrastructure approaches to sustainable land and water management which also capture the other co-benefits on offer;

(e) Water issues and solutions are very much case and locality specific and it is not possible to be prescriptive or exhaustive regarding priorities but some key areas for additional attention can be identified such as: (i) the role of vegetation in sustaining local and regional rainfall and humidity; (ii) the importance of soil biodiversity with regards to soil moisture and water balances and therefore in sustaining land functionality; (iii) the importance of the water cycle in sustaining desirable levels of sediment transfer and deposition and the substantial ecosystem services this underpins (particularly in coastal areas); and (iv) the role of biodiversity/ecosystems in regulating the extremes of water availability (including both drought, through for example soil and land-cover restoration, and flooding, through for example wetlands restoration).

3. *Notes* that the scientific work ongoing on this topic (as described in the progress report on the work in addressing paragraphs 39 to 41 of decision X/28 on review of information, and the provision of key policy relevant messages, on maintaining the ability of biodiversity to continue to support the water cycle (UNEP/CBD/SBSTTA/15/11)) will be a useful basis for considering any further and more specific advice.

I. INTRODUCTION

1. In paragraph 38 of decision X/28, the Conference of the Parties (COP) urged Parties and other Governments to consider the implications of changes in the water cycle, and freshwater resources, where relevant and feasible, in the implementation of all thematic and cross-cutting programmes of work, and with special attention to the links between hydrology, biodiversity, ecosystem functioning and sustainable development, and requested the Subsidiary Body on Scientific, Technical and Technical Advice

(SBSTTA) to consider these aspects. This note provides some guidance to SBSTTA to support this request.

2. One of the outcomes of the in-depth review of the programme of work on the biological diversity of inland waters, considered by the fourteenth meeting of SBSTTA (document UNEP/CBD/SBSTTA/14/3 and supporting information notes; SBSTTA recommendation XIV/2) was the recognition of the need to pay increased attention to water and its "cross-cutting" nature. This was reflected by the Conference of the Parties in decision X/28, for example in paragraph 46(b) "...that there is a clear scientific and technical basis to strengthen attention to water across all relevant interests and programmes of work of the Convention". The needs were also reflected in the Strategic Plan for Biodiversity 2011 – 2020 and the Aichi Biodiversity Targets (decision X/2). This implies that the topic be considered, where relevant, on an ongoing basis by SBSTTA in addition to any specific recommendations SBSTTA deems necessary on a case-by-case basis.

3. "Changes in the water cycle and freshwater resources" refers largely to the subject of changes in water availability (that is, quantity). Water quality is also an important subject. Water quality and quantity are related subjects. The dilution or concentration of pollutants influences water quality and extremes in water availability (flooding and drought) can also impact water quality through, for example, accelerated land erosion and/or interrupting nutrient cycling by soils. These linkages might be born in mind throughout. "Hydrology" is the scientific study of the properties, distribution, and effects of water on the earth's surface, in the soil and underlying rocks, and in the atmosphere. Similarly "hydrologic" means "water related".

4. Section II of this note, as an entry point, briefly explains some of the links between biodiversity and the water cycle and some of the broader linkages to sustainable development. This cross-cutting nature of water forges strong linkages between the various programmes of work and demonstrates that SBSTTA might best consider water in an ecosystem context; that is, applying the ecosystem approach. Not withstanding the need for ecosystem level considerations, there are key considerations for each programme of work. Some of these are outlined further in section III of this note.

5. An information note on possible indicators for water and water related ecosystem services for the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets (UNEP/CBD/SBSTTA/15/INF/10) provides further explanation of the subject of water and water-related ecosystem services for the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets. This identifies some further direct connections between water, biodiversity and human well-being. It also identifies some relevant indicators to support the development of the framework for monitoring progress towards the Aichi Biodiversity Targets (decision X/7). Some of the indicators identified in that document are mentioned below to further illustrate some of the relevant considerations.

6. This note incorporates comments received from the SBSTTA Bureau at a face-to-face meeting held on 5–6 June 2011 in Montreal. An earlier draft of this note was posted for review from 17 June to 14 July 2011 in accordance with notification 2011-123 and the comments received have been incorporated as appropriate.

II. BIODIVERSITY AND THE WATER CYCLE

7. A simplified illustration of the water cycle is provided in Figure 1a. Water moves through the ecosystem at different speeds: for example, rapidly through running surface waters, more slowly through evapo-transpiration and often very slowly through groundwater. This is both a physical and biological process. For example, evapo-transpiration through land cover (vegetation) clearly depends on the presence of biodiversity (plants). Similarly, soil biodiversity plays a key role in how soils function in terms of water retention and regulating erosion. Ecosystems also play a key role in maintaining the quality of water in addition to its quantity. Because water moves across and through the landscape it provides physical and biological connectivity between different parts of the ecosystem (literally mountains to the sea). A key management implication is that land-based activities and the direct use of water can have impacts not only where they occur but also throughout the entire ecosystem. The extent of

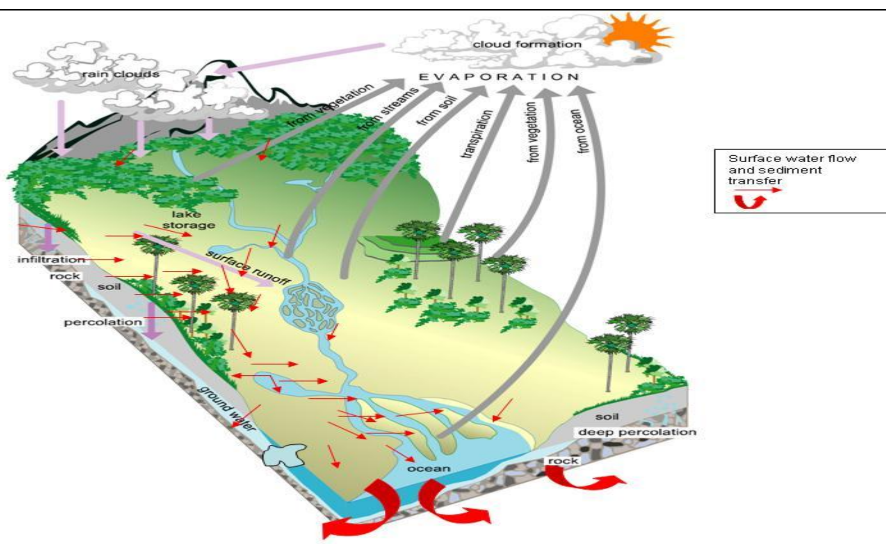
impact obviously varies according to scale. This consideration is widely recognized regarding upstream-downstream impacts through surface water but there is less awareness of soil moisture and groundwater considerations and particularly for the role of land cover in sustaining precipitation through evapo-transpiration.

8. Two frameworks for considering the water cycle are through ecosystem services and/or programmes of work. Figure 1b illustrates some of the important ecosystem services involved, noting this figure is greatly simplified. Many of these are directly water related (e.g, drinking water, flood regulation) but all of them are underpinned by water (e.g. food production). Because of the interconnectivity described for figure 1a, a key management implication is that an impact of an activity on water has an impact on all ecosystem services. Again, the extent of impact obviously varies according to scale. The "programme of work" perspective on the water cycle is illustrated in figure 1c (again greatly simplified). Water creates connectivity between the programmes of work. In addition, the programmes of work themselves overlap in terms of scope (e.g. forests occur in marine and coastal areas etc.). Only the ecosystem approach captures all the necessary elements and considerations.

9. These linkages can be either positive or negative. For example: over-use of water by agriculture can impact downstream components of ecosystems but equally the restoration of soil ecosystems on farmland or improved crop water productivity can contribute to improved overall ecosystem functioning; forests play a critical role in water regulation and combating soil erosion including protecting and supplying water to agricultural systems; some of the water transpired by crops is cycled to contribute to maintaining precipitation and humidity for forests. Everything is connected and inter-dependent. The task is to manage the water cycle so the ecosystem continues to function and deliver its multiple benefits. This involves managing both physical water availability (e.g., "water allocation") and managing the biodiversity to support sustained water availability (and quality).

10. The water cycle (Fig. 1a) is the bio-physical framework. The ecosystem services perspective (Fig. 1b) is what needs to be managed in terms of balanced social, economic and biodiversity outcomes. This perspective is also the one that is the closest and most relevant to the implementation of the Strategic Plan for Biodiversity 2011-2020 and achieving the Aichi Biodiversity Targets. Figure 1b can be expanded to include additional key water related ecosystem services, potential indicators and relevant Aichi Biodiversity Targets (the resulting figure is quite complex but is included in figure 1 of document UNEP/CBD/SBSTTA/15/INF/10). The "programme of work" perspective (fig. 1c) considers policies and management guidance for specific areas which need to be developed and implemented in this broader ecosystem context.

Figure 1a: The simplified water cycle (courtesy of the River Awareness Kit, Mekong River Commission)



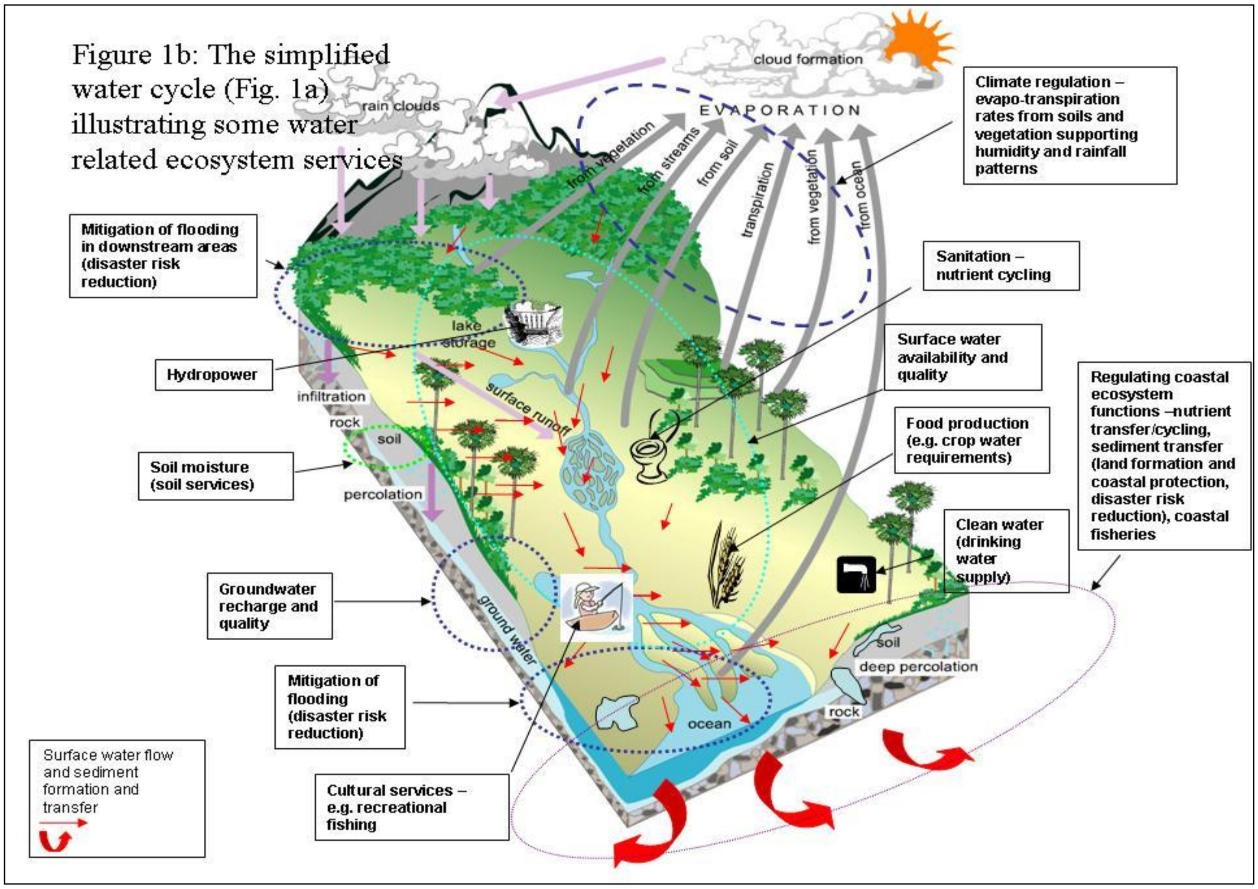


Figure 1b: The simplified water cycle (Fig. 1a) illustrating some water related ecosystem services

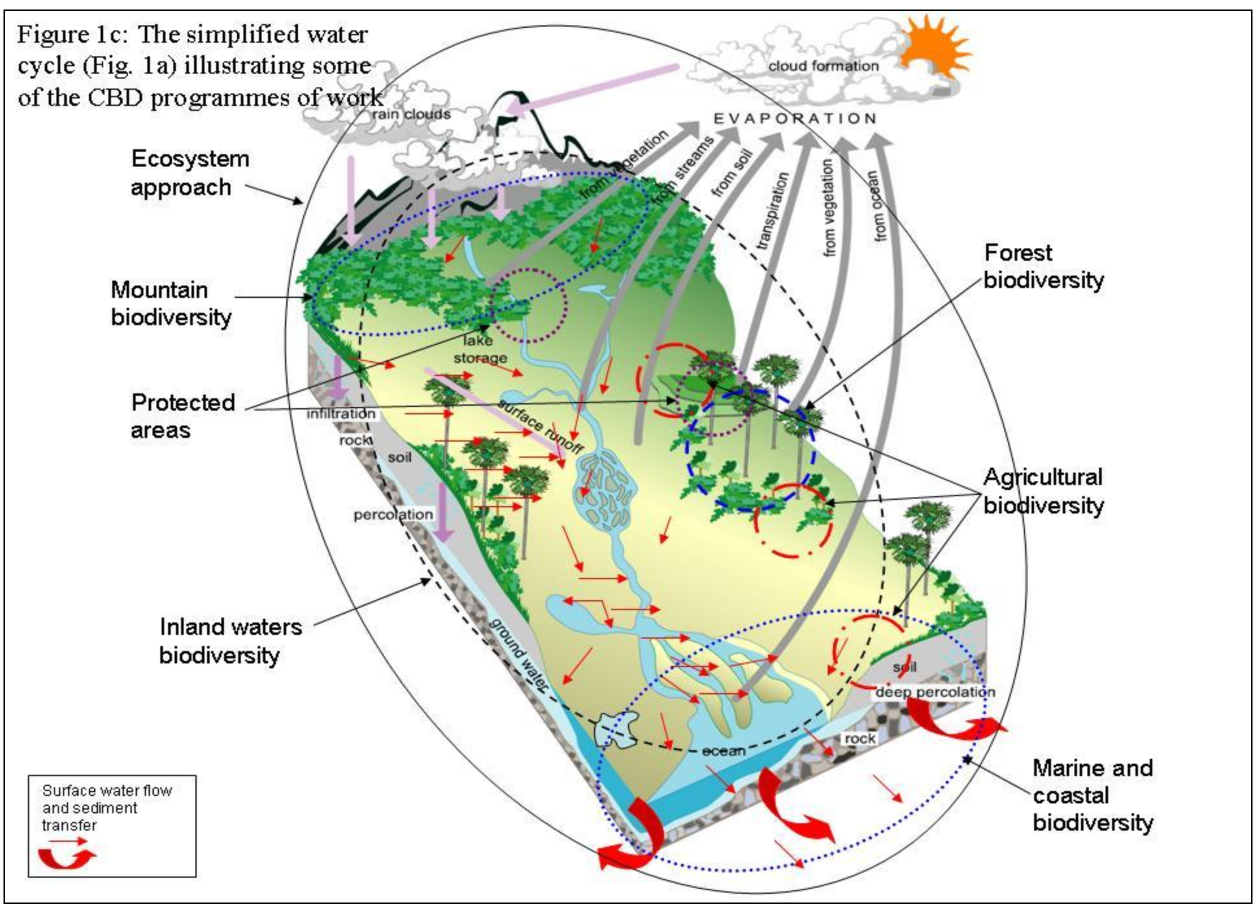


Figure 1c: The simplified water cycle (Fig. 1a) illustrating some of the CBD programmes of work

III. RELEVANT CONSIDERATIONS FOR IMPLEMENTATION OF THE PROGRAMMES OF WORK

11. Implications of changes in the water cycle and freshwater resources for the various programmes of work are complex because of the inter-connectedness of the programmes of work and the relationships between the water cycle and ecosystem functioning and services. The following provides examples of some of the important considerations for some programme areas. Examples of the positive relationship between biodiversity and water are favoured since this approach is likely to be more influential on water policy and management. Unless otherwise stated, source information for the statements in question is provided in documentation for the in-depth review of the programme of work on inland waters (UNEP/CBD/SBSTTA/14/3; UNEP/CBD/SBSTTA/14/INF/3). References to some indicators are from document UNEP/CBD/SBSTTA/15/INF/10.

The Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets

12. The water cycle and changes in freshwater resources are central to the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets. This topic is discussed in some detail in the note on possible indicators for water and water related ecosystem services for the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets (UNEP/CBD/SBSTTA/15/INF/10) which provides a summary of the various linkages, relevant decisions of the Conference of the Parties (including X/2, X/7 and X/28) and monitoring frameworks including indicators. This highlights the fact that (fresh) water is a key determinant of all terrestrial and inland water ecosystem functions, and to a large degree also for coastal systems, and therefore underpins all ecosystem service delivery (except in oceans). Since water availability and quality are ecosystem services in themselves, water-related considerations are cross-cutting throughout the Strategic Plan. Further discussion is also provided in document UNEP/CBD/SBSTTA/15/9.

13. Amongst the Aichi Biodiversity Targets water is explicitly mentioned as an important ecosystem service in target 14. But it also has high relevance to most, if not all, of the other targets. For example water is: a major source of perverse incentives and subsidies (target 3); a major natural resource currently being over consumed (target 4); central to sustainable agriculture, aquaculture and forestry (target 7); the main medium through which pollution occurs (target 8); the key mechanism through which climate change impacts terrestrial ecosystems (target 10); both required by protected areas and a major benefit of them (target 11); influences the carbon cycle (target 15); and, a major potential source of financial resources (target 20).

Agricultural biodiversity

14. Globally, agriculture accounts for about 70 per cent of water used for human needs and is the major pressure on water resources and quality, especially via irrigation and chemical inputs such as pesticides and fertilizers. The Comprehensive Assessment of Water Management in Agriculture (2007) is a major reference. In many areas water availability, not land, is now the major constraint to increasing agricultural production. Serious conflicts are now arising between water for food and other uses (particularly between cities and outlying farming systems). Water security for food production is now a major issue worldwide. The potential issues and linkages regarding biofuels and water, depending on specific cases, are broadly similar to those for agriculture in general. Although the water requirements and water quality impacts of biofuel crops can be significant, this topic is very often absent from biofuel impact assessments. Agricultural water use also obviously affects downstream ecosystems (including coastal areas), likewise for groundwater depletion and impacts on terrestrial ecosystems. Agricultural pressures on water are a major driver of biodiversity loss. The programme of work recognizes the need to ensure harmony with the inland waters programme of work but otherwise attention to the role of biodiversity in sustaining water for agriculture is limited.

15. A key link occurs through soil functionality and therefore the Cross-Cutting Initiative for the Conservation and Sustainable Use of Soil Biodiversity (decision VIII/23 section B) is highly relevant. A

key service provided by soil ecosystems is water retention and recycling (which also underpins nutrient cycling). Loss of this functionality is a key driver of desertification and therefore provides strong linkages to the programme of work on dry and sub-humid lands. Land cover in farmlands is also important: surface vegetation helps sustain soil functions including water retention and crops themselves can alter the local water cycle through changing evapo-transpiration rates. These linkages can be used positively: for example, restoring soil functions is often a primary means to improve water security for agriculture (and combating desertification). "Conservation agriculture" is an example of an approach using the water/biodiversity/ecosystem links to support sustainable agricultural development. The approach essentially reduces land disturbance (tillage) and restores land cover and soil biodiversity – a key benefit being improved water retention (http://www.fao.org/ag/ca/index.html).

16. Promoting food production by agriculture systems, particularly at the interface of wetlands and agriculture, increases provisioning services (availability of fish and rice for example) at the detriment of regulating services (such as flood attenuation or silt control). The importance of the linkages between agriculture and wetlands, with regards to rice paddies, is reflected in decision X/34, paragraph 19, and such linkages are reflected, for example, in production landscapes consisting of wetlands, other habitats and various land uses (see case-studies gathered in the context of the Satoyama Initiative e.g. at http://satoyama-initiative.org/en/).

17. Some key indicators include: *water footprint* (by agricultural commodity or at the river basin level); *water use intensity by economic activity* (for agriculture and by commodity); *crop water productivity* (an important measure of agricultural efficiency); *soil moisture*; *area water-logged by irrigation*; and *area salinized by irrigation.*

Biodiversity for development and business and biodiversity

18. Sustaining the water cycle is central to sustainable development. The role of biodiversity in the water cycle is a key link between the Strategic Plan and development interests (decision X/28). Water is becoming increasingly prominent on the business agenda and business is often at the forefront of leadership (water for example is a priority area for the World Business Council for Sustainable Development).[1] This includes through the incorporation of water footprints into corporate social and environmental responsibility and business taking on board improved ecosystem management to meet its water related goals.

19. Some relevant indicators include: *MDG target 7c, Indicator 7.8: Proportion of population using an improved drinking water source**; *MDG Target 7c Indicator 7.9: Proportion of population using an improved sanitation facility**; *Water quality**; *Wastewater treatment**; *Access to improved drinking water based on change in water quality*; *Water scarcity**; *Water use intensity by economic activity**; *Human and economic losses due to water related natural disasters**; *Percentage of population living in water hazard prone areas**; *Water footprint*; *Trends in number of water related conflicts and number/magnitude of inter-state conflicts*; *Population affected by water-related diseases**; *Incorporation of water related ecosystem services into national planning processes*; *Progress in implementation of Integrated Water Resources Management (IWRM)*; and *Sediment transfer* (* = in use by the MDG process and/or the Commission on Sustainable Development and/or the UN Statistics Division, based on national accounts, the others are in use by various other development processes).

Climate change

20. Paragraph 22 of decision X/28 notes the findings of the IPCC that the relationship between climate change and freshwater resources is a matter of primary concern. This is because the impacts of climate change on ecosystems and people occur largely through changes in hydrologic conditions (the major exception being ocean acidification). The role of biodiversity (ecosystems) in the water cycle is a central consideration regarding adaptation to climate change. A key element of "ecosystem-based adaptation" to climate change, for example, is managing the role of ecosystems in supporting water

[1] http://www.wbcsd.org/templates/TemplateWBCSD5/layout.asp?type=p&MenuId=ODI&doOpen=1&ClickMenu=LeftMenu

security for both ecosystems and people – including managing water related risks: for example, ecosystem restoration is an important component of European policy in response to increasing flooding events or droughts.[2] Not only can it be more cost effective than traditional engineering responses but also provides substantial benefits in terms of fisheries, increased resilience and an improved aesthetic and cultural environment. The water cycle also forges strong linkages between climate change mitigation including because the carbon and water cycles are linked (see comments and examples for the forest biodiversity programme of work below). Accordingly, for example, recent decisions of the Conference of the Parties on climate change (IX/16 and X/33) call on Parties to improve their management of wetlands as a contribution to ecosystem-based approaches to climate change mitigation and adaptation.

21. Some indicators include: *Water scarcity; Human and economic losses due to water related natural disasters; Percentage of population living in water hazard prone areas; Land affected by desertification; Soil moisture; Climate moisture index; Extent of terrestrial carbon storage vulnerable to water insecurity; Sediment transfer; Incorporation of water related ecosystem services into national planning processes*.

Dry and sub-humid lands

22. The terms "dry" and "sub-humid" both relate to the relative amount of water available. Desertification is a main driver of biodiversity loss in dry and sub-humid lands and could be defined by the loss of water from land. Changes to the water cycle and freshwater resources are therefore central to most aspects of the programme of work on dry and sub-humid lands. This is captured in the programme of work itself (decision V/23, section II), for example: "Since water constraints are a defining characteristic of dry and sub-humid lands, effective water management strategies underpin their successful management. This requires an appropriate balance between the immediate water requirements of humans, their livestock and crops, and water required to maintain biodiversity and ecosystem integrity" (para. 6); activity 5 involves the "identification of the local and global benefits, including soil and water conservation, derived from the biological diversity of dry and sub-humid lands".

23. A key positive linkage is the role of biodiversity in supporting local and regional water cycles: for example, soil functions and soil moisture/land cover effects on water retention by land (see examples under the agricultural biodiversity programme of work above). These roles are well recognized by the indigenous and local communities in dry and sub-humid lands who have developed both water and drought management strategies as a core part of sustainable livelihoods. Regional changes in land cover can also change water availability to dry and sub-humid lands through altering regional precipitation and humidity (see examples for the forest programme of work below, noting for those examples that grasslands in dry and sub-humid lands function in a similar fashion to forests in terms of hydrological balance). Because water availability is at a naturally critical level for dry and sub-humid lands, small changes can translate into large impacts on these ecosystems including pushing them past tipping points.

24. Whilst there is general recognition of the importance of drought management in dry and sub-humid lands, attention is drawn to the importance of the opposite extreme – flooding. The IPCC assessments show that both extremes are likely to increase in frequency and severity in many dry and sub-humid lands regions. Some recent catastrophic flood events conspicuously occurred in dry and sub-humid lands (e.g. in Pakistan 2010 and eastern Australia in 2011). Ecosystem-based adaptation is key to responding to such events: examples include conserving or restoring land cover to manage run-off and erosion and in particular restoring the hydrological functions of wetlands.

25. Some key indicators identified are: *water scarcity* (proportion of total renewable water resources used); *human and economic losses due to water related natural disasters*; *percentage of population living in water hazard prone areas*; *land affected by desertification*; *soil moisture*; *climate moisture index* (Aridity index). Document UNEP/CBD/SBSTTA/15/INF/10 refers to the advanced stage of indicators for the United Nations Convention to Combat Desertification (UNCCD 2011) noting that many of the

---

2 http://www.wbcsd.org/templates/TemplateWBCSD5/layout.asp?type=p&MenuId=ODI&doOpen=1&ClickMenu=LeftMenu

indicators adopted by that convention, and/or being considered further by technical specialists, are either direct measures of water availability or contain a strong water related element.

Economics, trade and incentive measures

26. A key source of information on the economics, trade and incentives (subsidies) regarding water use etc. is the World Water Development Report series, particularly the third report (WWDR3 2009). The economic importance of water was noted in the in-depth review of the programme of work on inland waters (UNEP/CBD/SBSTTA/14/3). Assessments of the economic values of ecosystems and biodiversity consistently generate very high overall values for water related services (see examples for the forest biodiversity programme of work below). The scale of current investments in water is illustrated by Vörösmarty et al (2010) who estimate expenditure amongst OECD and BRIC countries alone in water infrastructure to be in excess of US$ 800 billion per annum. Much of this investment is to compensate for lost ecosystem services. Conversely, restoring ecosystems has an increasingly proven track record of delivering cost-effective solutions to water management needs, also delivering substantial other biodiversity co-benefits. Water is one of the most important avenues for financing "biodiversity" through ecosystem restoration. China, for example, recently announced investment of $100 billion in ecosystem restoration, largely motivated by water management needs.

27. As an example of the scale of the topic, Batker *et al*. (2010) in an analysis of values of ecosystem services in the Mississippi River Delta (USA) estimated that restoring river hydrological regimes to restore ecosystem functions results in net annual benefits of $62 billion (including partial values of 11 ecosystem services). This takes into account the opportunity costs of redirecting water allocations and use. Yet agriculture has historically has had a major influence on Mississippi water use policy despite delivering very modest economic returns and water supply to agriculture has tended to involve massive direct or indirect subsidies.

28. Payments for ecosystem services (PES) approaches are increasingly recognised as a means to provide necessary incentives. Document UNEP/CBD/SBSTTA/14/INF/3 noted that PES schemes are particularly advanced regarding water, partly because of the high values associated with it and existing financial mechanisms facilitating the reallocation of investments (OECD 2010 provides further information).

29. There are considerable perverse incentives in play with water. Subsidies for water are often indirect through, for example, not charging for the costs of supply. Related subsidies are also relevant: for example, fuel subsidies are a major driver of unsustainable groundwater pumping in India (WWDR3 2009). The problem is particularly acute with agriculture where various forms of direct or indirect subsidy frequently drive either inefficient use and/or over consumption of water with significant impacts on ecosystems downstream (especially in river deltas). A key problem is that water economics continues to over focus on productivity in terms of goods and services whereas assessments would have better economic and biodiversity outcomes if based on economic values of ecosystem services. The Economics of Ecosystems and Biodiversity study provided further background information on the importance of water subsidies (ten Brink et al. 2011). De Groot et al. (2006) provide further guidance on relevant valuations of wetlands.

The ecosystem approach

30. The way in which water is relevant to most, in not all, of the programmes of work, and forges links between them, is one of the clearest examples of the need to apply the ecosystem approach. This topic is discussed in further detail in Section II above. Included in this would be the necessary consideration of watershed and catchment/landscape level approaches, upstream-downstream linkages and integrated water resources management (etc.). These topics are more explicitly addressed already in the programme of work on inland waters biodiversity. Further discussion on how water necessitates an ecosystem approach is provided in document UNEP/CBD/SBSTTA/15/9.

Forest biodiversity

31. Forests play a very important role in water regulation. TEEB (2009), for example, provided estimates of tropical forest ecosystem service values whereby water related services account for almost half of total forest values, exceeding the combined values of carbon storage, timber, non-timber forest products and tourism. Blumenfeld et al. (2009) provide further information on forest-water (and wetlands) linkages. Further examples are provided for the programme of work on protected areas (below).

32. There is serious concern that deforestation can lead to reduced rainfall which can lead to ecosystem tipping points whereby humid forests, for example, shift to dryland forest with massive implications for ecosystem services (including water regulation and carbon storage). This can be at the regional scale, for example the entire Amazon basin and beyond (World Bank 2010). Nkem et al. (2009) showed that such tipping points have probably already been reached in some areas based on national reports to UNFCCC, also noting that water was a key aspect of forest related climate change adaptation actions. In terms of impacts of changing water cycles and water resources on forests, the significant implications of unsustainable groundwater use (reduced water tables) on forests were noted in document UNEP/CBD/SBSTTA/14/INF/3. The water and carbon cycles are linked and therefore REDD+ activities need to bear in mind the conjunctive issue of trends in local water resources where linkages can be either positive or negative.

33. Despite these and other linkages, the expanded programme of work on forest biodiversity (decision VI/22) mentions water explicitly only once and only with regards to the impact of water pollution on forests (objective 2: activity b.). Subsequent decisions (VII/1; VIII/19; IX/5 and X/36) do not mention water at all.

34. An interesting potential indicator identified is *extent of terrestrial carbon storage vulnerable to water insecurity*, disaggregated for forests (noting other important biomes store carbon, especially peatlands). Some other relevant indicators are identified for protected areas (below).

Gender and biodiversity

35. The gender dimension of biodiversity is particularly prominent regarding water. Women are key stakeholders in sustaining family well-being and water-related ecosystem services are a key component of this. Maternal and infant mortality due to water related impacts, access to safe drinking water and improved sanitation and many other aspects of water quality are some key considerations. Women are also often very prominent in maintaining family food security an important component of which is water security for food production. An example of positive linkages is how better use of ecosystems to deliver water security liberates women and increases educational opportunities for girls (CBD 2009 provides specific examples).

36. UNEP/CBD/SBSTTA/15/INF/10 however notes the difficulty of obtaining indicators for this topic which more directly link gender, water and biodiversity. One approach is to explore opportunities for disaggregating data by gender for other relevant indicators, particularly direct measures of human well-being (e.g. access to drinking water). The gender dimension would be particularly informative regarding indicators of enabling conditions (policies and management approaches etc.) since it is highly likely that women regard “ecosystem services” differently to men and in particular have different awareness of and values for these and therefore regard management of water availability quite differently. For example, gender differences in criteria for Integrated Water Resources Management would be expected. Relevant indicators for water/ecosystems should capture the gender dimension where feasible.

Global Strategy for Plant Conservation

37. Much of what is noted for agriculture, protected areas, traditional knowledge and the Aichi Biodiversity Targets also applies to the Global Strategy for Plant Conservation. In particular these matters apply to targets 4, 5, 6 and13 of the Strategy.

Global Taxonomy Initiative (GTI)

38. Water resources availability affects the functions of ecosystems and therefore the niche of species and species composition. Early detection of changes in the water cycle can be assisted by observation of the distribution of species (Crimmins *et al.* 2011). Invasive alien species, as noted below, can impact water cycles. In addition, information on genetic resources stored in gene/seed banks and museums etc. can also assist with adaptation to water cycle change. Taxonomic capacity, therefore, is necessary to undertake relevant work in order to identify species involved as is the sharing of relevant information on taxonomy. The GTI is designed to address these and other needs.

Identification, monitoring, indicators and assessment

39. This programme area is discussed in more detail in document UNEP/CBD/SBSTTA/15/INF/10 and other comments in the current document regarding indicators, the Strategic Plan (2011-2020) and the Aichi Biodiversity Targets also refer further to this aspect.

Impact assessment

40. The CBD Voluntary Guidelines on Biodiversity Inclusive Impact Assessment (UNEP/CBD/COP/8/27/Add.2; adopted by decision VII/28) incorporate relatively good attention to water. It is important that impact assessments consider not only surface and groundwater flows (quite well covered in the guidelines) but also the broader aspects of the water cycle (Fig. 1) in particular by considering the impacts of land cover, soil moisture and functions and sediment transportation. The guidelines were also adopted for wetlands by the Ramsar Convention in Resolution VIII.9 (http://www.ramsar.org/cda/en/ramsar-documents-resol-resolution-viii-9/main/ramsar/1-31-107%5E21514_4000_0__). Updated information and guidance was also provided through Ramsar Convention Resolution X.17.

Invasive alien species

41. Invasive alien species (IAS) obviously can live in water and changes in it can affect the degree of invasiveness. The in-depth review of the programme of work on the biological diversity of inland water ecosystems (UNEP/CBD/SBSTTA/14/INF/3) noted that there is evidence that freshwaters are particularly vulnerable to IAS. One reason is that IAS tend to do better in degraded environments and freshwaters are amongst the most degraded (water stress being a primary cause).

42. An important consideration is the direct impact of IAS on the water cycle and freshwater resources. For example: fast growing alien tree species are widely planted to combat deforestation but can have significant detrimental impacts of groundwater resources compared to native species (e.g. Fritzsche et al. 2006); one of the important impacts of some IAS is the extent to which they use (transpire) water compared to native vegetation; and invasive plants can also physically impede surface water flows and groundwater recharge (e.g. Shafroth *et al*. 2005).

Island biodiversity

43. This programme of work includes, *inter alia*, implementation of all the other programmes (as relevant) on islands. Comments here on all other programme of works are therefore relevant. The in-depth review of the inland waters programme of work however noted that freshwater is a particularly important and vulnerable resource on islands (UNEP/CBD/SBSTTA/14/3) as addressed by paragraph 13 of decision X/28.

Marine and coastal biodiversity

44. Hydrological factors, and changes in them, are a key determinant of coastal ecosystem functioning. Changes in freshwater inputs into coastal areas impact these ecosystems through changing salinity, sediment and nutrient loads, pollution inputs and in cases water temperature. These factors greatly influence coastal wetland functions and processes. For example, mangroves and estuaries are very

vulnerable to hydrological change and coral reefs to sedimentation. The programme of work on marine and coastal biodiversity (annex I to decision VII/5) addresses this topic largely through its element 1: implementation of integrated marine and coastal area management (IMCAM).

45. The linkages between freshwater and coastal and marine ecosystems are discussed in greater detail in document UNEP/CBD/SBSTTA/15/8. This notes that the coastal zone is a very dynamic area often characterized by the mixing of fresh and salt water and the area can include fully freshwater or saltwater zones and various degrees of salinity in between. The aforementioned document is referred to for further discussion. Document UNEP/CBD/SBSTTA/15/INF/10 also drew attention to the importance of sediment transfer for coastal regions, noting the process supports numerous ecosystem services and is driven by hydrological factors, including the influence of river fragmentation on them.

46. Most indicators for water quantity and quality are relevant: the indicator *sediment transfer* is a particularly important gap in the suite of Aichi Biodiversity Target indicators discussed so far (as of May 2011 – but is proposed in document UNEP/CBD/SBSTTA/15/INF/10).

Mountain biodiversity

47. There is a good deal of attention to water in this programme of work (annex to decision VII/27) and particularly with regards to the role of mountains in supplying water. For example, paragraph 2 of the introduction to the programme of work sets the context for subsequent attention: "Mountains have often been referred to as 'natural water towers' because they contain the headwaters of rivers that are also vital for maintaining human life in densely populated areas downstream. Natural and semi-natural vegetation cover on mountains helps to stabilize headwaters, preventing flooding, and maintaining steady year-round flows by facilitating the seepage of rainwater into underwater aquifers. Mountain biodiversity contributes to human well-being well beyond its immediate vicinity and is essential to the management of water flows over entire river basins." This programme of work involves relevant aspects of all the other programme areas as relevant to mountains. Comments for the other programmes of work are therefore relevant to this programme of work.

48. Hydropower, including dam operation, is widely known to have adverse impacts on inland water ecosystems but it is also an ecosystem service which depends on a sustainable water cycle. For example, there is growing evidence that in some locations deforestation is having negative impacts on water availability for hydropower generation – forging interesting alliances between the sector and conservation interests through landscape scale restoration of vegetation (further discussion is provided in UNEP/CBD/SBSTTA/15/INF/10).

Plan of Action on Sub-national Governments, Cities and Other Local Authorities for Biodiversity (decision X/22)

49. Although not a programme of work, this plan recognizes the important role of these stakeholders in implementation of the Convention. Water security is already a key interest of these stakeholders and much of the subject matter elsewhere in this note is particularly relevant to them. Water issues and management are also often localized and therefore sub-national governments etc. are a key to implementation. They also often have the resources by which to take effective and appropriate action, including both within areas of their jurisdiction and beyond (through, for example, PES schemes). Mobilizing the resources of cities (etc.) to invest in ecosystem based approaches to achieving improved water security is a major source of potential "biodiversity" financing. The in-depth review of the programme of work on the biological diversity of inland water ecosystems (UNEP/CBD/SBSTTA/14/INF/3) (and its background information) provides many case-studies where cities are, for example, playing a major role in investing in improved catchment management in order to achieve more sustainable water management. Resolution X.27 of the Ramsar Convention ("wetlands and urbanization") is also relevant. Because of the immediate and direct interest of these stakeholders in this topic the prospects of achieving action on the ground are particularly promising..

Protected areas

50. Changes in the water cycle have significant potential to change the ecological character of protected areas (PAs) and therefore undermine their effectiveness. Several potential drivers are also not manageable at the PA site level: for example, changes in regional precipitation driven by ecosystem change (e.g. land cover change/deforestation; see examples for the forest programme of work as above); groundwater depletion is now occurring at regional scales and is a serious threat to natural land cover; and alterations of surface water flows obviously impact downstream ecosystem integrity (to which wetland PAs are particularly vulnerable). Changes in hydrological conditions also affect water quality for protected areas (including erosion, sediment and chemical loads). Impacts can also be transferred over a large scale: for example, the impacts of upstream water use on deltas. Potential impacts are identifiable on most PAs including those in marine and coastal areas. There has been much discussion of the impacts of climate change on protected areas globally. As noted earlier, the key mechanism through which climate change threatens PAs is through changes in the water cycle/availability.

51. But there is also a very important positive relationship between PAs and the water cycle. One of the key services provided by PAs is water regulation (both quantity and quality). Mulongoy and Gidda (2008) note the prominence of water related values in the benefits attributable to PAs. Blumenfeld *et al*. (2009) quote, for example, that in the order of 40 per cent of cities obtain their water supply from forested protected areas. Further examples of the use of PAs in drinking water supply are provided in CBD (2010). The role of PAs in regulating water is therefore already one of the key sources of financing for protected area establishment and management.

52. A useful indicator drawing attention to this subject is *Proportion of cities obtaining water supplies from protected areas* (and/or *proportion of protected areas established and managed primarily to protect water supplies*).

Sustainable use of biodiversity

53. Implementation of Article 10 of the Convention (sustainable use) was reviewed at SBSTTA-14 (UNEP/CBD/SBSTTA/14/7). The consideration of sustainable water use, and therefore sustainable changes in water resources, can be complex. Water security for ecosystems is a fundamental requirement for sustaining most ecosystem services, and in many areas is now a major threat to these (UNEP/CBD/SBSTTA/14/3). The sustainability of water is therefore a key criterion for the sustainability of most activities. "Protecting" ecosystems through reducing the "water footprint" is one aspect. An equally important aspect is the proactive management of ecosystems in order to achieve water security (examples are provided elsewhere in this note).

54. Most indicators for water and water-related ecosystem services are relevant and would need to be assessed collectively to illustrate overall trends in sustainability. Given the difficulties of defining the end point of "sustainability" the better option is probably to consider policies and management in terms of the directions they lead to regarding sustainability. For example, due to the projected demands on water, indicators of gross global trends (e.g., *total water used by agriculture*) need to be complemented by indicators of trends in efficiency (e.g. *crop water productivity*) in order to determine whether management towards sustainability is improving.

Tourism and biodiversity

55. The water cycle underpins the biodiversity and delivery of ecosystem services upon which tourism depends. Clean, drinkable freshwater, for example, is a critical requirement for sustainable tourism as is water security more broadly. Tourism in turn can create significant pressures on water resources thereby undermining ecosystem services.

Technology transfer and cooperation

56. There are considerable opportunities for technology transfer and cooperation regarding this subject. There is already much attention by many agencies to technology transfer to reduce the impacts of human activities on the water cycle (e.g. technologies for water treatment, see WWDR3 2009 for this and

other examples). Other key opportunities are with regards to approaches to manage ecosystems (biodiversity) in order to meet water management challenges. That is, proactively using ecosystems to deliver water security. Some examples are provided elsewhere in this note. There are reasons to be optimistic that land and water management is becoming increasingly receptive to what ecosystems have to offer (UNEP/CBD/SBSTTA/14/3). The key requirement is to mainstream relevant approaches into existing institutional arrangements and processes dealing with water.

Traditional Knowledge, innovations and practices (Article 8j)

57. Indigenous and local communities maintain a very close, holistic, cultural and spiritual relationship with essential elements in nature, particularly the water cycle. Many examples exist throughout indigenous and traditional cultures such as the rain ceremonies performed by the Mayan people of Guatemala, or ceremonies in rivers and lakes. The Mayan refer to water as "Old Mother". The centrality of water to indigenous peoples is also demonstrated in many indigenous languages by the quantity of works used for precipitation. Indigenous Hawaiian's have at least 139 different traditional words for different types of rain (http://www.independent.co.uk/life-style/weather-forget-eskimo-snow--here-are-139-hawaiian-rain-words-1142513.html) and the Saami have up to three hundred words for types of snow and ice (http://www.liveinsweden.se/blog/381). For Australian Aborigines and Torres Strait Islanders, as for many hunter-gatherer societies, water sites (such as springs, wells and waterholes) are inextricably connected to life's meaning and as such have powerful cultural associations.

58. Based on their traditional knowledge, indigenous and local communities maintain water management system rules such as customary rules, moral codes, ethical norms, and specific sanctions that help to promote sustainability. This is evident in the Middle East where traditional communities have created and maintained elaborate ways of channelling and storing water underground.

59. The Programme of Work on the implementation of Article 8(j) and related provisions included the importance of water for indigenous and local communities especially in task 9, which requests the Working Group on Article 8(j) to develop, in cooperation with indigenous and local communities, guidelines or recommendations for the conduct of cultural, environmental and social impact assessments regarding any development proposed to take place on sacred sites and on lands or waters occupied or used by indigenous and local communities. The guidelines and recommendations should ensure the participation of indigenous and local communities in the assessment and review." The *Voluntary Akwe: Kon Guidelines* (decision VII/16 F) were developed in response to such needs. However, one implication of potential change in the water cycle is that this can result from activities outside of areas occupied or used by indigenous and local communities (see an example for the Amazon under forest biodiversity above). Again, water demonstrates the need for ecosystem level considerations including with regards to Article 8(j).

60. No existing indicators for this subject area specific to Article 8(j) were identified in the possible indicators for water and water related ecosystem services for the Strategic Plan for Biodiversity 2011-2020 and the Aichi Biodiversity Targets (UNEP/CBD/SBSTTA/15/INF/10) although most indicators identified are also relevant to the interests of indigenous and local communities. Some could be developed to explicitly include indigenous and local communities, for example: equitable access the potable water, the proportion of indigenous and local communities with legal protection of their water rights, the number of national water policies and management plans that include or reflect traditional knowledge, customary rules and regulations, and/or the number of water programmes and projects completed using the Akwe:Kon Guidelines.

III. CONCLUSIONS

61. Changes in water availability (and quality) including *inter alia* humidity, soil moisture and evapo-transpiration of plants affect ecosystem functions and service delivery (and hence biodiversity). The water cycle is also a bio-physical process underpinned by ecosystems. The implications of changes in the water cycle, and freshwater resources, to implementation of the programmes of work of the Convention are many and varied and only some examples of some considerations are provided here. These can be either

positive or negative. But the way in which the water cycle functions, and the role of ecosystems in underpinning it, necessitate that water be considered as a "cross-cutting" subject. This provides additional arguments for moving beyond "programmes of work" to more holistic approaches to implementation as captured through the ecosystem approach and the Strategic Plan for Biodiversity. Water forges strong links between the various Aichi Biodiversity Targets and it remains important to adequately capture the relevant aspects of water through the monitoring framework for the Strategic Plan under further development (decision X/7).

62. The main positive consideration, and the one most likely to influence land and water management, is the role of biodiversity ("natural infrastructure") in achieving water security for ecosystems and people. Key considerations relate to economics and the cost-benefits of natural infrastructure approaches to sustainable land and water management which also capture the other co-benefits on offer.

63. Water issues and solutions are very much case and locality specific. Much depends on local water resources availability, the level of existing ecosystem degradation and socio-economic conditions including local pressures on water resources. Although it is not possible to be prescriptive or exhaustive regarding priorities, some key areas can be identified. For example, much more attention is required to: the role of vegetation in sustaining local and regional rainfall and humidity; the importance of soil biodiversity and soil moisture in water balances and in sustaining land functionality; the importance of the water cycle in supporting sediment transfer and deposition and the ecosystem services this underpins (particularly in coastal areas); the role of biodiversity/ecosystems in regulating the extremes of water availability (including both drought, through for example soil and land-cover restoration, and flooding, through for example wetlands restoration). All of these areas, amongst others, offer very significant opportunities for harnessing the benefits of biodiversity, through improved ecosystem management, to address major global, regional and local issues with high social and economic profiles.

64. One difficulty with water is that it is often "invisible" and therefore easily overlooked. This in particular applies to water vapour (e.g., evapo-transpiration) and water below ground (soil moisture and groundwater), whereas open surface waters (e.g., rivers and lakes) tend to receive more attention. Water is also too often regarded as simply a physical resource and its availability determined by physical processes. A key consideration is that the water cycle is in fact a bio-physical process. This means that not only does water affect biodiversity but biodiversity also affects water. Neither is water a "sector", just as land or the atmosphere are not sectors.

65. Regarding further scientific work specifically on biodiversity and the water cycle, and its further consideration by SBSTTA, attention is drawn to paragraph 39 of decision X/28, (by which the Conference of the Parties established a process to provide key policy relevant messages on maintaining the ability of biodiversity to continue to support the water cycle). Progress in implementing this request is reported in document UNEP/CBD/SBSTTA/15/11. This ongoing work is intended to be a source of more detailed scientific information which SBSTTA can draw upon when considering any relevant issue and/or as a basis of further advice on this topic to the Conference of the Parties.

IV. REFERENCES

Batker *et al*. 2010. Gaining Ground – Wetlands, Hurricanes & Economy: The Value of Restoring the Mississippi River Delta. Earth Economics . www.eartheconomics.org/.../Earth_Economics_Report_on_the_Mississippi_River_Delta_compressed.pdf

Blumenfeld, S., Lu, C., Christophersen, T. and Coates, D. (2009). *Water, Wetlands and Forests*. *A Review of Ecological, Economic and Policy Linkages*. Secretariat of the Convention on Biological Diversity and Secretariat of the Ramsar Convention on Wetlands, Montreal and Gland. CBD Technical Series No. 47.

CBD. 2010. *Drinking Water, Biodiversity and Poverty Reduction: A Good Practice Guide*. Secretariat of the

Convention on Biological Diversity Montreal, 42 + iii pages.

Comprehensive Assessment of Water Management in Agriculture. 2007. *Water for Food, Water for Life: A Comprehensive Assessment of Water Management in Agriculture*. London: Earthscan, and Colombo: International Water Management Institute.

Crimmins, S. M., Dobrowski, S. Z., Greenberg, J. A., Abatzoglou, J. T. and A. R. Mynsberge. 2011. Changes in Climatic Water Balance Drive Downhill Shifts in Plant Species' Optimum Elevations. *Science* 21 January 2011: 324-327.

De Groot, R.S., Stuip, M.A.M., Finlayson, C.M. & Davidson, N. 2006. *Valuing wetlands: guidance for valuing the benefits derived from wetland ecosystem services*, Ramsar Technical Report No. 3/CBD Technical Series No. 27. Ramsar Convention Secretariat, Gland, Switzerland & Secretariat of the Convention on Biological Diversity, Montreal, Canada.

Fritzsche, F., A. Abate, M. Fetene, E. Beck, S. Weise and G. Guggenberger. 2006. Soil–plant hydrology of indigenous and exotic trees in an Ethiopian montane forest. *Tree Physiology* 26, 1043–1054.

ICOMOS. 18 April 2011 – International Day for Monuments and Sites. The Cultural Heritage of Water. (http://www.international.icomos.org/18thapril/2011/18April_2011_STamwoy_essay_EN_final_20110329.pdf

Mulongoy, K. J. and S. B. Gidda (2008). The Value of Nature: Ecological, Economic, Cultural and Social Benefits of Protected Areas. Secretariat of the Convention on Biological Diversity, Montreal, 30 pages.

Nkem J., D. Oswald, D. Kudejira and M. Kanninen. 2009. Counting on forests and accounting for forest contributions in national climate change actions. Working Paper 47. Centre for International Forestry Research. Bogor, Indonesia.

OECD. 2010. Paying for Biodiversity: Enhancing the Cost-Effectiveness of Payments for Ecosystem Services. Organisation for Economic Cooperation and Development. Paris.

Shafroth, P. B., J. R. Cleverly, T. L. Dudley, J. P. Taylor, C. van Riper, E. P. Weeks and J. N. Stuart. 2005. Control of *Tamarix* in the Western United States: Implications for Water Salvage, Wildlife Use, and Riparian Restoration. Environmental Management Volume 35, Number 3, 231-246.

TEEB. 2009. The Economics of Ecosystems and Biodiversity. Climate Change Issues Update. September 2009.

ten Brink, P., Eijs, A., Lehmann, M., Mazza, L., Ruhweza, A., and C. Shine. 2011. Transforming our approach to natural capital: the way forward. In The Economics of Ecosystems and Biodiversity in National and International Policy Making. Edited by Patrick ten Brink. Earthscan, London and Washington.

UNCCD. 2011. Scientific review of the UNCCD provisionally accepted set of impact indicators to measure the implementation of strategic objectives 1, 2 and 3. White-Paper – Version 1 (04 February 2011). The United Nations Convention to Combat Desertification. Unpublished draft. 145pp.

Vörösmarty C. J., P. B. McIntyre, M. O. Gessner, D. Dudgeon, A. Prusevich, P. Green, S. Glidden, S. E. Bunn, C. A. Sullivan, C. Reidy Liermann & P. M. Davies. 2010. Global threats to human water security and river biodiversity. Nature vol. 467: pp 555-561.

World Bank. 2010. Assessment of the Risk of Amazon Dieback. Main Report. February 4, 2010. World Bank, Washington.

WWDR3. 2009. *The United Nations World Water Development Report 3: Water in a Changing World*. World Water Assessment Programme. Paris: UNESCO; and London: Earthscan.
