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SUMMARY REPORT OF THE WORK OF THE EXPERT GROUP ON MAINTAINING THE ABILITY OF BIODIVERSITY TO CONTINUE TO SUPPORT THE WATER CYCLE

Note by the Executive Secretary

I. INTRODUCTION

1. The Conference of the Parties, in its decision X/28 noted, *inter alia*, that water provisioning, regulation and purification are critically important services, essential for the continued functioning of terrestrial, inland and coastal ecosystems and the existence of biodiversity within these, and 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 same decision requested the Executive Secretary, and invited the Secretariat and the Scientific and Technical Review Panel (STRP) of the Ramsar Convention on Wetlands, and other relevant partners, to establish an expert working group, building upon the relevant core expertise of the STRP, to review available information, and provide key policy relevant messages, on maintaining the ability of biodiversity to continue to support the water cycle.

2. The Executive Secretary reported on progress of the work of the expert group to the fifteenth meeting of the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA). In its recommendation XV/5, SBSTTA made a number of observations and recommendations to the Conference of the Parties on this subject. It also requested the Executive Secretary to make the report of the expert group available to the Conference of the Parties at its eleventh meeting. Accordingly, the full report is available as an information document (UNEP/CBD/COP/11/INF/2). The present note provides a summary of the findings of the expert group, as requested in SBSTTA recommendation XV/5, focusing on general policy relevant findings, that the Conference of the Parties may wish to take into account when considering recommendation XV/5.

*UNEP/CBD/COP/11/1.

3. The work of the expert group was based on peer-reviewed scientific or technical literature, supplemented by peer-reviewed examples of practice. Full reference citations are included in document UNEP/CBD/COP/11/INF/2. The expert group included a broad range of scientists and practitioners based on core STRP expertise (for wetlands), supplemented by scientists with additional knowledge of forests, grasslands, soils and agro-ecosystems, urban areas and institutions and enabling mechanisms (a list of contributors is acknowledged in UNEP/CBD/COP/11/INF/2). As requested in decision X/28, the detailed scientific and technical findings of the expert group will be provided to SBSTTA to assist its further work. Subject to further consideration of SBSTTA, some of the gaps identified by the expert group might relate, *inter alia*, to potential work of the Inter-Governmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES).

4. In the subsequent sections, some of the key findings of the expert group are highlighted in bold, followed by further explanation. Section II provides an overview of the processes that underpin ecosystem functions in relation to hydrology, and how these support the delivery of ecosystem services. Specific examples of these relationships, and how they can be managed in practice, are elaborated for agricultural systems and cities in section III. Social and economic aspects of this topic are largely self-evident and briefly discussed in section IV. Section V discusses the recent international policy landscape, highlighting the profile of this topic in the outcomes of the United Nations Conference on Sustainable Development 2012 (Rio+20). It also discusses some institutional constraints to managing the biodiversity – water cycle relationship and identifies simple ways of enabling more rapid uptake of biodiversity-based solutions to water-related problems. Section VI identifies the immediate opportunity available to the Conference of the Parties to strengthen cooperation and partnerships on this subject as a means to enhance implementation of the Strategic Plan for Biodiversity (2011 – 2020).

5. The work of the expert group has been funded by the generous support of Australia, Canada, Finland, Norway and the Republic of Korea.

II. THE ROLE OF BIODIVERSITY IN ECOSYSTEM FUNCTIONS AND SERVICES RELATING TO THE WATER CYCLE

2.1 The importance of hydrological pathways in understanding the relationship between biodiversity and the water cycle

Ecosystem-water interactions are critically important and need to be factored into land and water management

6. Policies need to be underpinned by better understanding of water-ecosystem interactions and their consequences for ecosystem services. There is increasing interest in managing ecosystems to support water-related objectives and evidence of the substantial benefits on offer. This progress needs to be accompanied by more rigorous and impartial analysis if the full opportunities are to be realised through significant shifts in investment.

Policies should be flexible and not overly prescriptive

7. Since the influence of ecosystems on water is subject to a number of variables, policies need to avoid being overly prescriptive. Relevant policies and management need to better incorporate ecosystem-water interactions but enable specific considerations to be made based on more rigorous science and economic-based assessments on a case-by-case basis.

The functioning of ecosystems in relation to the water cycle depends on a number of factors

8. Some ecosystems play a particular role in providing water provisioning and regulating services. Wetlands frequently play an important role in regulation of water availability and their degradation and loss is well substantiated as a contributing factor to increased flood risk, and their restoration an increasingly practiced response to reducing flood risk. However, although the overall influence of particular ecosystem types and water pathways through them can be generalised, there are always exceptions. For example, in some cases, wetlands can in fact increase flood risks; for instance where high water levels are artificially maintained in them, hence reducing their ability to absorb additional water, or

where built infrastructure is poorly located near a wetland prone to rapid expansion during a flood event. Forests may also provide flood regulation functions depending upon the particular forest type, condition and location. Sometimes the benefits attributed to an ecosystem derive less from ecological processes within those ecosystems and more to other factors; for example for water quality an exclusion function is often in play whereby the area excludes activities (such as industry or farming), which would otherwise cause pollution.

9. The Amazon Rainforest illustrates the importance of biodiversity and ecosystem functions to the water cycle. The characterisation of the Amazon as a humid tropical forest is due to its geographic location (tropical), geology (the existence of various regional landscape features, such as the Andean range, which influence regional climates), and the presence of large expanses of forest, which help maintain a regional water balance. It is "rainforest" not simply because it is in an area where it rains a lot – but because the forest contributes to maintaining its own rainfall. This illustrates the nature of "biodiversity and water cycles"; biodiversity is not just influenced by the water cycle, it is an integral part of maintaining it.

Understanding the key hydrological pathways is central to understanding the relationship between biodiversity and the water cycle

10. Figure 1 illustrates the key hydrological pathways involved at the landscape scale. This simplified diagram can be used as a basis for considering ecosystem influences on hydrology in any area (possibly excepting permanently frozen areas), including in forests, grasslands, dry and sub-humid lands, agro-ecosystems and cities (examples of the latter are given below). The precise influence of ecosystems on water availability and quality at any location is subject to three major variables:

(a) Physical features and geology, in particular land slope, elevation, physical infrastructure (e.g., roads, dams) and physical soil/rock structure;

(b) Geographic location, such as latitude and location in relation to coastlines; and

(c) Ecological factors, in particular the nature of land cover, wetlands and soil biodiversity and their relative condition.

"Climatic zones", for example, are largely determined by a combination of these factors.

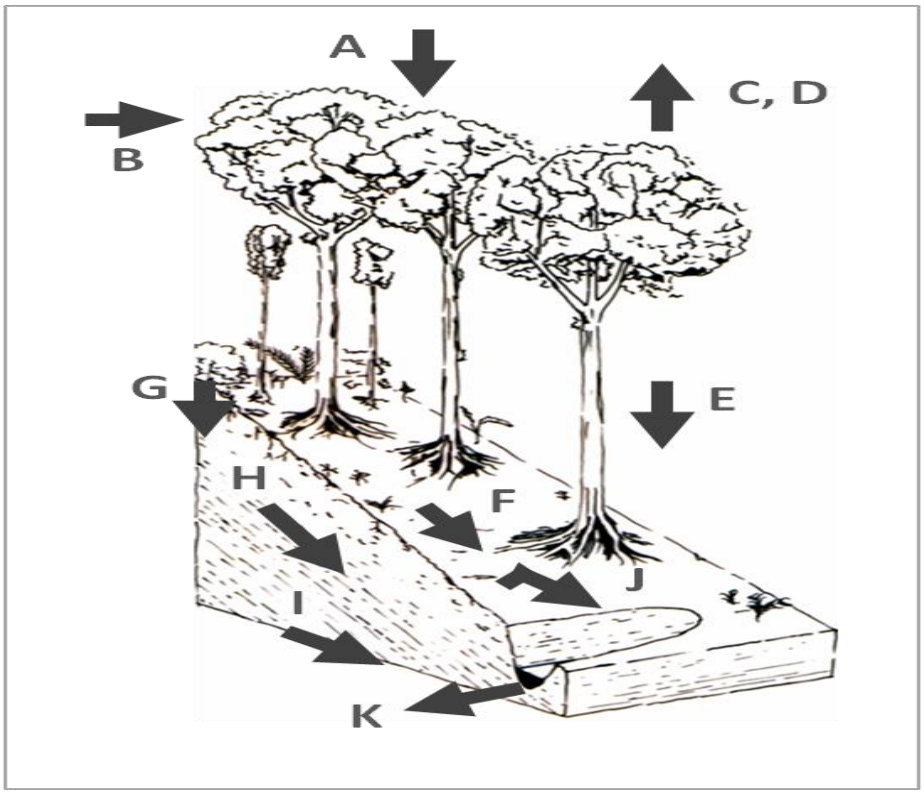

Figure 1: Hydrological pathways within a hillslope schematic, but present at scales from 0.1 km^2 experimental basins to international basins covering millions of square kilometres. This particular figure is based on a forested landscape adapted by N.A. Chappell from the original diagram by Nick Scarle (with permission) published in Douglas (1977) Humid Landforms (see UNEP/CBD/COP/11/INF/2 for further details). The vegetation and physical features of the landscape can vary and be modified (e.g. substitute grassland or farmland for forests) but for current explanatory purposes the basic functioning stays the same. This figure does not reflect the important influence of oceans on precipitation. Hydrological pathways are: A - Rainfall and/or snowfall; B- Horizontal (occult) precipitation capture; C - Wet-canopy evaporation; D - Transpiration; E - Throughfall and stemflow; F - Infiltration-excess overland flow; G - Infiltration; H - Lateral subsurface flow in soil strata; I - Lateral subsurface flow in unconsolidated rock and/or solid rock; J - Saturation overland flow (including recharge by return flow); K - Surface water flow (or channel flow), including standing waters in wetlands.

11. It is essential that the evidence for, and discussion of, the hydrological functions of ecosystems is well founded in a *precise scientific definition* of the *hydrological pathways* underpinning those hydrological functions. Unless the hydrological pathways are defined correctly, accurately quantified, and not confused, then the hydrological functions of ecosystems are likely to be grossly misinterpreted. Such pathways need to be clearly linked and defined, in terms of their implications for the delivery of ecosystem services, and consequently, the levels of benefits offered through appropriate management interventions. In fact, the subject of the interaction between ecosystems and water is plagued by myths, misinterpretations and too hasty generalizations Part of the misconceptions and debate about the interactions between ecosystems and water is due to the ambiguous or even incorrect use of hydrological terms.[2]

[2] This is particularly the case for forest-water interactions with one author[2] remarking over a century ago "(…) it is unfortunate that so many of the writing and talking upon this branch of forestry has had little definite fact or trustworthy observation behind it. The friend and the enemies of the forest have both said more than they could prove (…)". A century later, the expert group has been unable to ascertain whether there has been any overall improvement in this regard.

Biota exert a major influence, directly or indirectly, on hydrological pathways

12. Biota (primarily plants, but also other biota such as microbes, fungi, invertebrates and vertebrates in soils) exert a major influence, directly or indirectly, on all of the pathways in Figure 1. Key influences are land cover (vegetation) which, for example, contributes to humidity and rainfall (pathway A in Figure 1) through evapo-transpiration (pathways C and D) and, through their roots and surface organic matter (e.g. leaf litter), influence infiltration into the ground (pathway G) and hence the availability of water in, and flows through, soils and deeper groundwater (pathways H and I) and these combined influence surface water flows (pathway K). The importance of soils in water cycling, as a living ecosystem underpinned by soil biodiversity, is in particular often neglected. How soils function as ecosystems exerts a major influence on hydrology, including surface and groundwater availability, and also on infiltration and retention of water in soils, and hence is a key determinant of land productivity. For example, the loss of these soil functions, together with degradation of land cover, is a primary cause of desertification.

13. Although all land cover generally functions in the same way irrespective of its composition, there are differences between vegetation types, both within and between biomes, in how these functions quantitatively influence water availability and quality. For example, as a generality, forests function the same way as grasslands, but different types of forest or grassland influence the quantitative flows through hydrological pathways in Figure 1 to different extents, and according to where they are located.

Species richness and composition matters, but not always

14. The extent to which biodiversity, in terms of richness of species, is necessary in order to sustain hydrological functions is, overall, not well studied but likely variable according to specific instances. Diversity of trees in forests influences hydrology: plantations, for example, have different hydrologic profiles to natural forest. But some of the key hydrological properties of some ecosystem components are determined primarily by physical factors. For example, the water storage functions of some wetlands can be determined primarily by local topography – but plants in the catchment influence water supply to them, and plants in wetlands can influence water flowing through them. Biota exerts a key influence on water moving over and through soils, and species diversity of soil organisms has been shown to exert a large influence on this process. For example, a key factor is the role of biodiversity in sustaining soil organic matter content (which significantly influences hydrological pathways), as well as exerting direct physical influences, such as earthworm species richness, which can positively influence soil microstructure and the passage of water through it.

Irrespective of the biome in question, the level of disturbance and degradation of ecosystems is a key factor influencing hydrology and hence water security

15. Human induced changes to ecosystems, including land cover, soils and the functioning of surface waters (wetlands) can exert a major influence on local and regional hydrology. These impacts are, in practice, usually negative in terms of human well-being. Levels of disturbance account for some of the variation in the hydrological impacts between comparable biomes. For example, the hydrologic profiles of the same forest type can differ significantly according to the level of forest soil compaction.

16. There is credible, although incomplete, historical evidence suggesting that degradation of the hydrological functions of ecosystems, in particular loss of land cover through over grazing and farming, was a factor contributing to the demise of a number of ancient civilizations, sometimes triggered by the juxtaposition of climate change amplifying the impact of the loss of hydrological resilience. Parallels could be drawn with the status of ecosystem degradation and climatic shifts in today's world, at least at local and regional scales.

Because ecosystem degradation can increase water insecurity, ecosystem rehabilitation can contribute to improved water security

17. This point is elaborated further throughout the text below.

2.2 The inter-dependence of water quantity and quality

Ecosystem functions in terms of water quality and quantity are interrelated

18. The way in which ecosystems function in terms of regulating the availability of water (water quantity) also has a major influence on water quality. For example, disturbances of land cover influence the extent of overland flow (pathway F in Figure 1) and the physical impact of rainfall on soils, and therefore influences the rate of land erosion and the carriage of sediments across landscapes into surface waters (hence influencing rates of sediment transfer and deposition, land formation and coastal stability). Likewise, the hydrological functions of soils influence the ability of soil biodiversity to regulate nutrients (nutrient cycling) and their availability for uptake by plants. These functions, amongst other factors, determine water quality. Changes in water availability also influence water quality through dilution or concentration effects on dissolved or suspended chemicals and materials. For such reasons, in practice the management of water cycling usually involves both water quantity and quality considerations.

2.3 Water, carbon and nitrogen cycle interactions

The inter-dependency of the water, nitrogen and carbon cycles is an important and currently grossly neglected topic in policies and management

19. The expert group is inadequately resourced to be able to assess this topic to the extent it deserves and there are significant information gaps, but it is important to highlight its relevance. The need to quantify the ability of different types of biome to capture, retain or lose carbon is a major global issue and in particular with regards to carbon and water cycle relationships. Carbon pathways are closely associated with hydrological pathways. For example, the influence, and dependency, of trees on sub-surface water flows (Figure 1) implies that the loss of soil moisture and groundwater through anthropogenic extraction (now occurring at continental scales) threatens carbon storage in forests. There is theoretical analysis linking degradation of land cover (in particular tropical forests) with tipping regional water cycles leading in turn to ecosystem shifts, including projections of massive carbon emissions. There is some emerging evidence of this occurring in reality. In addition, policies accord limited attention to the importance of aquatic carbon source functions. For example, one recent study suggested that CO_2degassing from rivers in the Amazon basin could be in the same order as CO_2 losses from the forest canopy. Therefore, since forest disturbance accelerates the loss of carbon to rivers, the regulating environmental service of better carbon sequestration may apply more to undisturbed natural forests than to managed forests. Similar disturbance of the water related functions of soils is well recognized as a leading contributing factor to carbon loss from farmlands. Apart from climate change implications, such losses also undermine soil functionality in terms of land productivity, which in turn impacts food security.

20. Nutrient cycles are also heavily dependent on and influenced by water cycling. For example, the carbon cycle plays a critical role in maintaining the organic matter content and hence the health of soils. Nitrogen is singled out here because of its dominance as the major cause of non-point source pollution globally, which originates primarily from farming. These topics are discussed further in Section III.

21. There are significant synergies between the water, carbon and nitrogen cycles. Restoring the functionality of ecosystems to support any one of these cycles generally, but not always, offers opportunities to enhance the others. For example, the management of the interlinked cycling of water, carbon and nitrogen by soils is the primary ecological basis for sustainable agriculture (Section III). Furthermore, new schemes to retain carbon in the landscapes, such as REDD+, should also consider the co-benefits of soil carbon and hydrological functions. However, thorough scientific investigation is needed to quantify these co-benefits.

2.4 Influences on ecosystem services

The water related functions of ecosystems underpin the delivery of all ecosystem services across all landscapes

22. Ecosystems depend on water and cease to function in the extreme case of its absence. Because ecosystems are also involved in maintaining water quality and availability, water-related ecosystem

functions influence all ecosystem services delivered by those same ecosystems. Whether caused by direct human impacts on water (e.g., water abstraction) or anthropogenic changes in ecosystem functions and processes (e.g. loss of land cover, drainage of wetlands), changes in water availability and quality, flowing through the various pathways (Figure 1), have a potential, and in most cases a real, impact on the delivery of all ecosystem services.

23. There are specific ecosystem services which are more obviously related to changes in water flows and quality. Prominent, and high value, examples include: the regulation of water availability (including mean availability and in particular the extremes of drought and flood); regulating water quality (including drinking water); land formation and maintenance (determined by sediment transport and deposition functions); nutrient cycling (including with regards to pollution and sanitation); climate regulation (including cooling effects of transpiration); and collectively these and other services directly support food production and hence food security. The social and economic aspects of such ecosystem services are highlighted further in Section IV.

24. The sustained functioning of the water cycle is therefore relevant to most of the Aichi Biodiversity Targets (not only as directly referenced in target 14). Ecosystem processes and services are inter-connected through water and involve multiple elements in the landscape, and therefore, in order to sustain the water cycle, landscape components (such as wetlands, soils, grasslands and forests) need to be managed collectively. Because of its influence on a broad range of prominent ecosystem services, there are very significant interests, beyond "environment/biodiversity" sectors, in the management the biodiversity-water relationship.

25. The nature of the water cycle also illustrates how impacts on biodiversity in one area can influence outcomes in another area and offers one of the most compelling cases for adopting the holistic approach to biodiversity management, as advocated in the in the Strategic Plan for Biodiversity. Similarly, such inter-linkages demonstrate the potential pitfalls of biome and sector based approaches to management.

2.5 The need for simplified communication for non-specialist audiences

26. Notwithstanding the aforementioned need for the consistent and clear use of technical terms amongst specialists, and the identified dangers of generalisations, there is a need for simplicity of communication to some key non-specialist audiences.

Ecosystems are "natural water infrastructure"

27. Water policy remains dominated by interest and investment in hard (physical) infrastructure and planning and management is heavily biased towards engineering approaches. In response, ecosystems are increasingly being portrayed as natural water infrastructure since they offer opportunities to achieve water- related management objectives in the same fashion as physical infrastructure. For example, wetlands, riparian zones, vegetated catchments and improved soils can deliver similar water quality outcomes as artificial physical/chemical water treatment facilities and similar water storage outcomes (including flood and drought risk reduction) as dams, drainage, networks and impoundments. This shift in terminology is helping to break down communication barriers between different interest groups.

28. The implications of shifts in the water cycle in both human and ecosystem terms can be captured by the term "water security", which describes the situation in which the availability of water of the appropriate quantity (including scarcity and over-abundance) and quality is sustained (or, conversely, describes the situation where significant risks from the quantity and quality of water available are absent). Different stakeholders have different interests: for example, health specialists may view water security in terms of disease risk; agriculture may focus on water security as it underpins food security; cities may see it as sustaining drinking water supplies and freedom from flood risk; and biodiversity also relies on water security to survive – but everybody understands what the general topic is, and its importance. For some key non-specialist audiences, interested in solving their own problems, an attractive approach is to portray the current topic as "natural infrastructure solutions for water security".

III. WATER-RELATED ECOSYSTEM FUNCTIONS AND SERVICES IN MANAGED LANDSCAPES: EXAMPLES FROM AGRICULTURE AND CITIES

29. Most of the world's useable terrestrial surface is now impacted by human activity, and overall increasingly degraded. Whilst natural ecosystems have a major role in continuing to provide important ecosystem services, the norm now is trying to manage land and water in a highly modified landscape setting. Depending on scale, these are usually a mix of ecosystem components, the key ones being forests, grasslands, soils and wetlands, including various gradient settings from mountains through to low-lying coastal areas. Usually, they also already contain built (hard) infrastructure elements – often extensively so. The expert group explored ecological processes as they relate to water cycles within the two most important land-use settings: cities and agricultural landscapes. These provide examples of moving the science of ecosystem hydrology into practical land-use settings where there are urgent needs to address water security. With regards to agriculture, the work of the expert group also provided added insights into hydrological processes within soils, and the role of biodiversity in these processes.

30. The key conclusion is that the ecosystem processes and functions identified for natural systems also apply in farming systems and cities. More importantly, an understanding of these processes and functions, and the ecosystem services they underpin, illustrates the significant opportunities to manage the ecosystem-water relationship as a source of solutions to achieve water security, including as a basis for food security and sustainable human settlements.

3.1 Natural water infrastructure and cities

There are significant opportunities to further mainstream natural infrastructure approaches to contribute to sustainable water for cities

31. Few urban authorities do not recognize the importance of water security: water is high on the public and political agenda. Cities are highly motivated to manage water better and already make significant investments in this area. Many are open to solutions that demonstrate cost-effectiveness. Natural infrastructure approaches are not new, but many cities are now adopting natural infrastructure-based approaches more systematically through more innovative and integrated planning. Central to this is a shift from regarding cities as areas which influence ecosystems outside them, to seeing cities as ecosystems themselves, and hence their problems amenable to ecosystem-based solutions. Increasingly, measures are being introduced to increase water efficiencies to work with biodiversity and manage urban water issues; reduce their impact on the hydrological cycle; mitigate and adapt to climate change; and produce water sensitive urban design solutions.

Managing natural infrastructure both at the catchment and local scales is critical to water security for cities

32. Degraded catchments have very significant implications for water security in cities, including regarding resilience to climate change. The good news, therefore, is that restoring catchments offers significant benefits. Cities are increasingly and successfully addressing catchment-based solutions; for example through payments for ecosystem service schemes. There are widespread examples including forest restoration to manage erosion, wetlands restoration to reduce flood risks, and multiple interventions for improving the quality of water delivered by ecosystems to cities.

33. Whilst cities depend on wider ecosystems for the flow of energy, materials and water, they can also benefit from the ecosystem services generated from within municipal boundaries. Any urban area can be considered as a complex ecosystem where it represents a single entity in a state of flux, or as a mosaic of individual ecosystems such as lakes, parks and gardens. There is rapidly increasing attention to biodiversity and cities. But there remains some tendency to regard biodiversity as "furniture and decoration". The real opportunities relate to the functionality of biodiversity in city ecosystems and most of these directly or indirectly involve managing water-related benefits.

34. The hydrological pathways in a theoretical and simplified city (Figure 2) are largely the same as for a natural environment (Figure 1). The ecological processes involved are also largely the same, and depending on scale, so are the ecosystem services involved. Cities influence the quantity and quality of

water flowing through the various pathways, but not the processes involved nor the basic way the ecosystem functions. Enhancing natural infrastructure within cities in conjunction with built infrastructure can therefore deliver water solutions for managers.

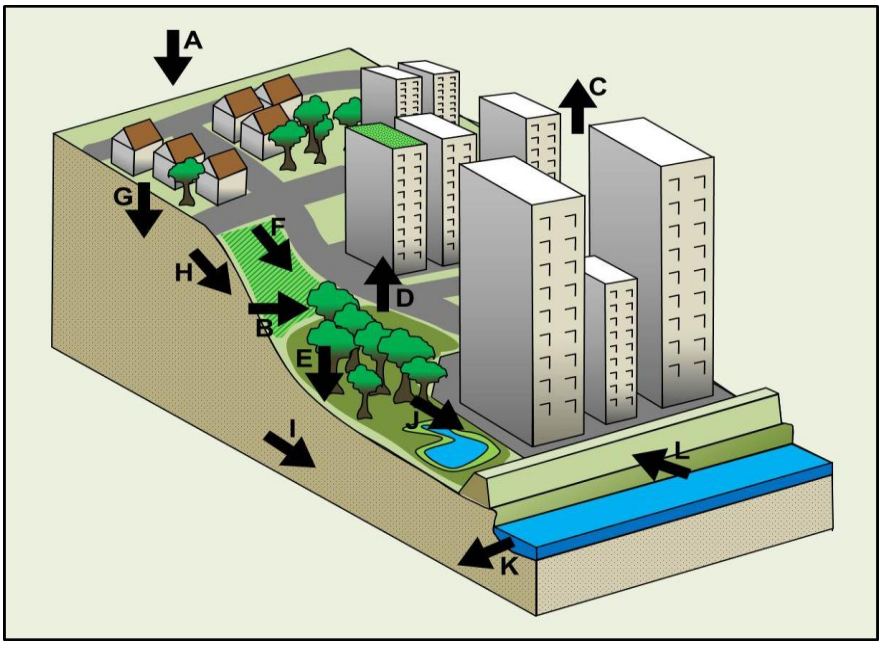

Figure 3: Water flow paths in urban areas. (A=rainfall/snowfall; B=cloud-water interception; C=evaporation; D=transpiration; E=throughfall/stemflow; F=infiltration-excess overland flow; G=infiltration; H=lateral subsurface flow in soil strata; I=lateral subsurface flow in regolith/rock; J=saturation overland flow; K=river/channel flow; L=overbank inundation). (Source: Robert McInnes)

35. The role of evapo-transpiration from plants in cities (pathway D in Figure 2) is currently under-recognised. This function delivers important climate regulation services within cities. Cities possess built structures, such as buildings and roads, which combine to form micro-climatic features, and subsequently agglomerate with other buildings, gardens, car parks and sidewalks to create local-scale climatic regimes. During warm seasons in poorly designed cities, the impacts of built infrastructure can result in significant over-heating. However, evapotranspiration, along with urban albedos, have been shown to decrease summer temperatures in cities by up to 4°C. Vegetated urban spaces have been shown to produce a maximum cooling of 1.6^{o}C from urban parks in Hong Kong and 2°C from urban grasslands in Tokyo. A simulation study of ten cities in the U.S.A. has demonstrated the significance of additional tree planting in metropolitan areas as a method to reduce ambient air temperature through elevating evapotranspiration rates. The same service (climate regulation) has also been demonstrated within rural landscapes; for example, through forests providing cooling effects benefitting crops and livestock.

36. The attention given to biodiversity in terms of charismatic or endangered species can detract attention from the important role of less glamorous biota. For example, the biological action of acidogenic, acetogenic and methanogenic bacteria drives the anaerobic digestion process in septic tanks, assisting in improving urban waste water quality prior to discharge into the ground. Vegetated infiltration basins, grass swales, buffer strips, as well as rain gardens and green roofs, all influence interception and infiltration rates, ultimately assisting in moderating storm-water runoff and climate in urban areas. For instance, trees can intercept and store rainfall on their leaves, branches and root growth, and decomposition can increase the water-storage capacity and infiltration rate of urban soils. In Santa Monica, California, for example, municipal forests intercepted 14.8 per cent of a winter storm event and 79.5 per cent during a summer storm.

37. Vegetated infiltration basins and swales are now routinely applied as elements within urban sustainable drainage systems. These are often used in combination with other elements, such as permeable pavements and wetland systems, in order to achieve water sensitive urban designs. Such approaches to

reducing flood risk, increasing groundwater recharge and improving water quality, have biodiversity at their core even within the highly modified urban landscape. They also help reduce the footprint of cities on biodiversity downstream.

38. There is considerable uptake of such approaches, including through regulatory mechanisms. For instance, in Dublin, Ireland, the use of natural green infrastructure to mitigate storm-water runoff has become mandatory in all new developments. low impact development (LID) is a widely adapted regulatory instrument for urban ecosystem management as an innovative storm-water management approach with a basic principle that is modelled after nature: manage rainfall at the source using uniformly distributed decentralized micro-scale controls. LID is a term used in Canada and the U.S.A. and is similar to: sustainable urban drainage systems (SUDS), a term used in the United Kingdom; water-sensitive urban design (WSUD), a term used in Australia; Natural Drainage Systems, a term used in Seattle, Washington; and Onsite Storm-water Management, a term used by the Washington State Department of Ecology.

3.2 Natural water infrastructure, soils and farming

39. Agriculture is the dominant human use of land and water and its single largest polluter. Growing water scarcity due to over use and increasing competition, greater uncertainty due to climate change and generally decreasing availability of water per capita, due to increasing demand, has prompted widespread recognition of the importance of more sustainable use and better management of water resources in agriculture.

The land management practice in agriculture has a direct and significant impact on short and long term water balances in farming systems and beyond. Most of the major impacts can be linked to degradation of the natural infrastructure provided by soils and land cover.

40. Farming involves converting land cover to crops and is usually accompanied by interference with soils. This potentially alters water flow in all hydrological pathways (Figure 1) and along with it delivers associated impacts on nutrient cycling, carbon storage, erosion and sediment transport through exposing bare land and increasing overland water flow. Most soils in all agro-ecosystems today are degraded physically, chemically, biologically and hydrologically. The main reason for this is tillage which, if not properly managed, pulverises and exposes soils, destroys soil biodiversity, and hence soil health, and has high negative externalities. Most agricultural soils today have low levels of organic matter with poor soil aggregate structure and low soil biodiversity, and exposed soil surfaces. This is effectively the wholesale degradation of the natural water infrastructure of land. Unmanaged, this leads to severe land degradation and, in water scarce areas, finally to desertification.

41. According to recent FAO figures, only some 10 per cent of the global agricultural land is considered to be under improving condition. The rest has suffered some degree of degradation, with 70 per cent being characterized as being moderately to highly degraded. Accelerated on-farm soil erosion leads to substantial yield losses and contributes to downstream sedimentation and the degradation of water bodies, which is a major cause of investment failure in water and irrigation infrastructure. Across Asia, 7,500 million tons of sediments flow to the ocean annually. Nutrient depletion and chemical degradation of soil are a primary cause of decreasing yields, and result in low on-site water productivity and off-site water pollution. Some 230 million tons of nutrients are removed annually from agricultural soils, while fertilizer consumption is 130 million tons, augmented by 90 million tons from biological fixation. Secondary salinization and water logging in irrigated areas threatens productivity gains.

42. Most agricultural soils have lost 25 to 75 per cent of their original carbon pool, and severely degraded soils have lost 70 to 90 per cent of the antecedent pool. Soil organic carbon is, or is produced by, biodiversity. There exists a strong relationship between agronomic production and the soil organic carbon pool, especially in low-input agriculture. Soils with adequate levels of soil organic carbon are able to adapt much better to the adversities of both excess or scarcity of rainfall. There are numerous studies pointing to the capacity of agricultural soils as an effective carbon sink, thus for mitigating climate change. Soil carbon presents an excellent example of how climate change adaptation and mitigation

responses can be mutually reinforcing. Regardless of this knowledge, agricultural land use continues to contribute to the decline of the soil organic pool in vast regions of intensive crop production.

43. The combination of these and other factors is the basis of now well-recognised concerns that the current global model of agricultural production is not sustainable, particularly given future demands for food. This problem is at the forefront of current debate but solutions are available, which focus on achieving sustainable intensification.

Restoring the biodiversity-water relationship in farmlands is key to achieving sustainable agriculture and food security

44. Just as understanding ecosystems and hydrological processes helps us identify solutions to water needs in cities, understanding the root causes of soil and water degradation in farming systems, and how these influence relevant ecosystem services, including nutrient cycling and carbon storage, helps identify solutions for sustainable agriculture. The paradigm needs to shift from looking simplistically at agriculture as an external user of water to recognizing agriculture as an embedded part of a broader water cycle in which natural infrastructure needs to be managed collectively in order to achieve overall water security for food security and other purposes.

45. There is a high correlation between the structural quality of the soil, its organic matter content (carbon) and plant-available water. Soil organic matter promotes soil biological activities and processes, which improve stability and porosity. Directly or indirectly, these organic compounds are related with water holding capacity. Evaporation reduction from a bare soil surface, and improved infiltration and reduced erosion, can be attained through maintaining land cover through either a coarse or disturbed layer (or mulch) overlying the wet subsoil or the introduction of cover crops. The positive role of soil cover in maintaining water quality and quantity has been known for some time. Alongside this, improved water and carbon management in and on soils delivers improved nutrient cycling and retention in soils. In this fashion, paying attention to the natural water infrastructure functions of land simultaneously addresses three of the key natural resource challenges facing agriculture: water, nutrients and carbon (which collectively underpin land productivity).

46. The scientific basis of such approaches is well-established and demonstrated in practice. Three examples illustrate what can be achieved (further details and references in UNEP/CBD/COP/11/INF/2):

(a) The modern successor of no-till farming, generally known as “conservation agriculture”, involves the simultaneous application of four practical ecosystem-based principles centred on locally-formulated practices: limited soil disturbance; maintaining a continuous soil cover of organic mulch and/or plants (main crops and cover crops including legumes); cultivation of diverse plant species; and good crop, nutrient, weed and water management. All contribute to enhance system resilience. In current terms the cornerstone of the approach is restoring natural infrastructure. Such approaches are a central part of FAO’s new sustainable agricultural intensification strategy. Conservation agriculture is now practised worldwide on an estimated 125 million ha: mainly in North and South America, and in Australia, but uptake is increasing in Kazakhstan, Ukraine, Russia and China, and is gaining traction elsewhere in Asia (including on the Indo-Gangetic Plains), and in Europe and Africa where two-thirds of the area is under small-holder production;

(b) Demonstrating that natural infrastructure can be complementary to built infrastructure, the promotion of conservation agriculture in the Itaipu watershed, in the Paraná basin in Brazil, has enabled the reduction of soil erosion and the delivery of clean water to the Itaipu dam to generate hydro-electric power for Brazil, Argentina and Paraguay; importantly, this simultaneously improved farmer livelihoods; and

(c) The “System of Rice Intensification (SRI)” is an alternate way of producing irrigated or rainfed flooded rice that includes better attention to restoring the hydrological functions of soils by keeping the soil just moist but not continuously flooded, thereby promoting aerobic conditions for soil

biodiversity. SRI is reported to increase yields by 25–75 per cent, reduce water requirement by 40-50 per cent, reduce seed needs by 80 to 90 per cent, the use of fertilizer by some 50 per cent and lower cost of production by 20 per cent. SRI changes in the management of crops, soil, water and nutrients have now been demonstrated across some 50 countries by 4-5 million resource-limited small-scale farmers on some 5 million hectares, by using locally-available resources as productively as possible.

47. Not only do these approaches deliver on-farm benefits they deliver wider public benefits including reduced run-off of nutrients and chemicals, reduced erosion, improved surface water management and hence improved water security downstream.

IV. SOCIAL AND ECONOMIC DIMENSIONS

The scale of general social and economic costs of degrading, and benefits of sustaining or restoring, natural water infrastructure is clear and demonstrable

48. The overall social and economic importance of the water-related and dependent ecosystem services, which are largely underpinned by the role of biodiversity in sustaining the water and related cycles, need hardly be highlighted. Sustaining the water cycle underpins food security, water quantity (including how this supports industry and energy), water quality (including drinking water) and risks associated with floods and drought, and its importance is self-evident. Any one of these subjects, and certainly all of them collectively, could easily claim to be at the highest level of importance regarding ecosystems and human well-being. The water-related services provided by ecosystems continue to generate some of the highest net benefits in valuations of the services provided by different biomes including forests, grasslands, farmlands and mountains. In addition, the particularly prominent hydrological functions of wetlands are usually central to why they consistently generate the highest ecosystem values per unit area.

49. An indication of the scale of financial benefits on offer by using natural infrastructure solutions for water management can be realized by considering the current investment in physical (hard engineered) infrastructure, which are variously estimated to be in the order of one trillion dollars per annum in capital costs alone. It is certainly not the case that natural infrastructure can substitute all of this physical infrastructure, but it certainly can make, and in many cases is already making, a significant contribution. The aforementioned example of applying conservation agriculture in the Itaipu watershed in Brazil not only improved the profitability and sustainability of agriculture, but through reductions in erosion and sedimentation, it extended the life of the hydropower dam from 60 to 350 years – roughly equal to five times the capital cost of the dam. Such examples demonstrate there can be common ground between nature and dams, a topic which has for many decades been characterised by conflict rather than complementarity. In cities, many examples involve retrofitting of natural infrastructure approaches into already built landscapes in order to improve overall efficiency. Hence, the debate is not necessarily about whether natural or physical infrastructure approaches are best. Infrastructure approaches for water management need to recognize both natural and built infrastructure, be innovative and harness the benefits that both can offer.

50. Catastrophic flooding events continue to capture news headlines. The economic cost of the late 2011 flooding of Bangkok, has been reported to have shaved 1.7 per cent off GDP and there is recognition that improved wetlands management offers part of the solution to reduce future risks. Better economic assessments of water-related ecosystem services are starting to accompany management interventions and are helping to support investment decisions. Some of the most effective can be at the small scale. For example, in Philadelphia, USA, the added value of working with natural systems as compared to using a sewer tunnel across 50% of the city's impervious surfaces has been estimated at some US$ 2.8 billion over a lifetime of 40 years. Another example is in Sacramento, USA, where the water-related benefits of common trees range from $30 to 389 per tree. There are also obvious co-benefits in terms of amenity values, but often significant less obvious co-benefits. For example, in New Jersey, USA, the cooling effects of trees translate into annual cost savings of $700 per hectare of woodland in the city, and, interestingly, this translates into annual avoided carbon emissions greater than 60 tonnes per hectare. Such values illustrate the potential of carbon credits for forestry in urban areas.

51. The Ramsar Convention Secretariat has commissioned a focussed study on "The Economics of Ecosystems and Biodiversity for Water and Wetlands", which will provide a more detailed review of that topic. This is scheduled to be launched at the eleventh meeting of the Conference of the Parties and will be available also as UNEP/CBD/COP/11/INF/22. The draft report has been developed in coordination with members of the current expert group and for present purposes it can be simply noted that it further strengthens the economic case for attention to the current topic.

Ecosystem service values can be very case specific and more rigorous economic assessments are required at the level of implementation

52. Although the processes and functions of ecosystems, regarding water, are generally similar across biomes and landscapes, the level and values of ecosystem services delivered can vary considerably according to specific cases. In particular, the location of an area is a key determinant of the level and values of ecosystem services delivered – particularly regarding water. For example, where the hydrology of a wetland regulates water flowing towards a city (whether located in or near the city or in its upper catchment) it can deliver enormous ecosystem service values relating to flood risk reduction, whereas the same wetland (functioning the same way), but not influencing human settlements, can have a low or zero benefit for the same service. For these reasons, caution needs to be taken when extrapolating from functions to benefits from one area to another.

53. As a generality, the importance of natural water infrastructure is well established from the hydrological and economic sciences. But some of the copious quantity of "grey" literature, and practice, on the topic is characterised by conspicuous absence of substantiated hydrological and socio-economic evidence. There is a discernible increase in interest in natural infrastructure solutions and a number of important non-traditional audiences (e.g., farmers, banks, civil engineers) are beginning to consider the opportunities seriously. If this impetus is not to be stalled, it is critical that practitioners strengthen attention to the scientific, social and economic justifications for their claims.

V. THE POLICY LANDSCAPE, INSTITUTIONAL CONSTRAINTS AND ENABLING CONDITIONS

The topic is of critical importance with regards to international and national policies

54. The outcomes of the work of the expert group provide a further strengthened science base for the recognition, in decision X/28, of the importance and cross-cutting nature of the topic with regards to the Strategic Plan for Biodiversity and the Aichi Biodiversity Targets, as well as forging one of the strongest links between the objectives of CBD, UNFCCC, UNCCD and Ramsar Convention and the broader sustainable development agenda. These points need not be laboured further here.

55. Since this recognition at the tenth meeting of the Conference of the Parties, the United Nations Conference on Sustainable Development 2012 (Rio + 20) has further strengthened the policy arena. Numerous sections of the outcomes of the conference ("The Future We Want") elevated the importance of water itself on the sustainable development agenda. Importantly, the outcome made the important paradigm shift in the water-environment debate by stating, in paragraph 122, "We recognize the key role that ecosystems play in maintaining water quantity and quality and support actions within respective national boundaries to protect and sustainably manage these ecosystems".[3] This is a long-overdue recognition that ecosystems are not just the victim of water use and abuse but a solution to its sustainable management for development purposes. Decision X/28 and the Strategic Plan for Biodiversity and its Aichi Biodiversity Targets have already strengthened the framework for action in this regard. The outcomes of the work of the expert group are a timely delivery of a more solid scientific and technical basis for such action.

[3] Decision X/28 and the Strategic Plan for Biodiversity, and in particular prominent discussions on water at COP-10 and its incorporation into Aichi Biodiversity Target 14, is thought to have contributed to this outcome.

There can be considerable institutional constraints to implementing natural water infrastructure approaches

56. Uptake of appropriate approaches at local levels can be remarkably swift as illustrated by examples in agriculture. Nevertheless, significant mainstreaming and up-scaling challenges remain. Experience with promoting natural infrastructure approaches demonstrates, perhaps unsurprisingly, that the existence of sound logic, multiple co-benefits with win-win outcomes, cost-effectiveness and simplicity of application on their own do not necessarily guarantee adoption. There can be considerable institutional constraints to implementation. This is particularly the case with water resources management where constraints include fragmented institutional arrangements and responsibilities, limited coordination and a policy and management landscape that is resistant to innovation and change, often despite the existence within them of dynamic and well informed personnel. Institutional change is also well-known to be difficult and needs to be approached at various scales and time-horizons.

57. Integrated Water Resources Management (IWRM) has for a long time been promoted as a framework for integrating land and water management to achieve balanced multiple objectives. However, a recent survey of progress in IWRM undertaken by UN-Water highlights a serious lack of attention to environment, let alone natural infrastructure, in much national implementation of IWRM (see UNEP/CBD/COP/11/INF/2 for details). This partly reflects the ongoing problem that many stakeholders continue to see the "environment" as a separate topic, subordinate to human needs regarding water. The work of the expert group clearly highlights the pitfalls of separating environment/ecosystems and human needs in IWRM. In addition, although there are notable exceptions, there are considerable doubts regarding whether ecosystems, in terms of their hydrological functions, are well integrated into IWRM in practice, including for wetlands and particularly so regarding land cover and soils. This is somewhat flawed since much of the manageable influence on water moving around the water cycle is often via land cover, soils, and wetlands. However, IWRM application continues to improve and most practitioners regard IWRM more as a philosophy and not necessarily a tool for solving immediate local problems.

Success with the application of natural water infrastructure approaches has been most easily achieved where it has delivered demonstrable solutions to real time local problems

58. Whilst institutional and other constraints continue to be addressed, the short- to medium-term opportunities are to identify which stakeholders have water-related problems and to promote, where necessary, the options that natural water infrastructure offer as solutions to their problems. This also requires the use of the terminology of the audience. The level of existing uptake of such approaches should not be underestimated, but there remain considerable opportunities for further mainstreaming and up-scaling.

VI. IMMEDIATE OPPORTUNITIES: STRENGTHENED COOPERATION AND PARTNERSHIPS FOR NATURAL WATER INFRASTRUCTURE SOLUTIONS

There is a significant opportunity for establishing an initiative to promote natural water infrastructure solutions for water management

59. At this stage, action by the Conference of the Parties might focus, *inter alia*, on immediate opportunities to strengthen awareness of the current topic and the further development and uptake of practical measures in response to decision X/28, the Strategic Plan for Biodiversity (2011 – 2020) and the outcomes of the United Nations Conference on Sustainable Development (2012). There are a large number of potential partners interested in implementing natural infrastructure approaches. There are even more potential beneficiaries which would arguably include practically all national and sub-national government agencies and organizations, including at sector level, business, farmers, local communities and the public. Capacity-building is key.

60. The topic of natural water infrastructure solutions for water management was extensively discussed at the Sixth World Water Forum (March, 2012, Marseille, France) over an intensive three day workshop attended by a large and diverse range of stakeholders. There was consensus on the opportunity for an initiative through which a common vision for natural water infrastructure solutions could be

developed and voiced, experiences of practice shared, quality of advice improved and delivery of benefits on the ground enhanced. Discussions between the Secretariats of the Convention on Biological Diversity and the Ramsar Convention on Wetlans, and with many partners, have reached similar conclusions and have identified the Convention on Biological Diversity as an appropriate umbrella under which to develop such support. The initiative should be developed bearing in mind the needs to coordinate with, and mainstream such approaches into, the many on-going international activities regarding water and focus primarily on ways and means to improve the delivery of tangible benefits at national level. This outcome would be a significant contribution to implementation of the Strategic Plan for Biodiversity (2011 – 2020).

61. Decision X/28 also recognised the important impact of climate change on the water cycle, and therefore the role of sustaining and restoring ecosystems in responding to climate change. The subject of the current note, and its underlying technical work, is therefore also relevant to the consideration of ecosystem based adaptation to climate change (agenda item 11), as well as ecosystem restoration (agenda item 9) and other relevant items to be considered at the current meeting of the Conference of the Parties.
