Water for an integrative climate paradigm

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Abstract: By the logic of the New Water Paradigm (NWP), it is deforestation, industrial agriculture, and urbanisation that determine climate by draining land, so that more solar energy re-enters the atmosphere as sensible heat, rather than latent heat of evaporation. Human-made 'hot plates' lead to irregular precipitation and other climate destabilisation effects, but these can be mitigated through rainwater conservation and re-vegetation. This integrative paradigm combines the management of climate, water, biodiversity, and land, with implications for agriculture, forestry, engineering, urban design and regional planning.

Keywords: hydrology; deforestation; urbanisation; desertification; climate change; land management; water cycle; evapotranspiration; integrative climate paradigm.

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1 Beyond the 'either/or'

The popular coverage of climate change emphasises two main opinions on the role of humans with respect to climate variability: either human impact is negligible or it is significant, and results from greenhouse gas emissions especially CO_2. The positions tend to be communicated antagonistically, as a debate or even standoff, between 'denialists' and 'believers'.

- Those holding the denialist view are also known as climate sceptics and they are a minority group. They take a perspective spanning geological eons, before humanity existed and when temperatures and CO_2 concentrations did not correlate (Plimer, 2009). The assumption is that the planet was naturally warmer for the greater part of its history and warmer periods are usually more favourable to life than cold ones. Some in this camp expect global cooling to occur in the near future, due to the end of the interglacial period; others anticipate a 'little ice age' as a result of the poor performance of the latest Solar Cycle 24. Denialists are not usually concerned about global warming or human impacts on it.
- Those who believe that climate change is significant tend to argue that anthropogenic impacts exceed natural causes (IPCC, 2007). Experts in this group claim that global warming is irreversible due to the greenhouse effect of a relatively narrow spectrum of gases emitted by human activities. The group predicts a catastrophic environmental scenario in the coming century.
- In the political confusion of ongoing international summits – Copenhagen, 2009; Cochabamba and Cancun, 2010 – and what the media calls 'the climate controversy', attention has been deflected from another scientific approach – one that recognises a range of first-order climate forcings; humanly induced causes at least as significant as CO_2 emissions. These include land and water management practices leading to deforestation, urbanisation and desertification. The loss of vegetation cover to retain rainfall and provide natural evaporation is central to Earth heating. This group agrees that human activity is having a major impact on climate, but their holistic and integrated expertise also identifies potential dangers overlooked by those who prioritise greenhouse gases as the prime cause of climate destabilisation.

The papers in this *IJW* special issue belong to the integrative scientific view. The position is developed by Kravčík et al. (2007), a team of academics and practitioners, pioneers of the New Water Paradigm. The common denominator in their collaboration is an agreement that human distortion of the water cycle is a first-order climate forcing. In December 2009, the group contributed their analysis to the UNFCCC COP15 discussions in Copenhagen, as both expert and NGO voices (Pokorný et al., 2009; Košice Civic Protocol, 2009).

Advocates of this integrative opinion are concerned by the oversimplification of scientific processes in climate change discussions. For example, traditionally, the meaning of 'greenhouse' has referred to a rich environmental mix of water and suspended gases vitally important for the stability of life on Earth. Water vapour is actually the most abundant greenhouse gas and its effects on climates and environments are positive. However, the term greenhouse gas as currently used refers mainly to quantities of CO_2 and methane in the atmosphere and it carries negative implications. The omission of water and simplification of the word greenhouse has serious consequences because water evaporation is the most important agent of energy transformation on Earth.

It is hard to overestimate the role of water in the global climate system. Water has a number of exceptional thermoregulatory characteristics. Water has the largest specific heat capacity of any commonly occurring substance. It can occur naturally in all three states (solid, liquid and gaseous) at temperatures and pressures common on Earth. Water has a large consumption and release of thermal energy upon change of state. The density anomaly between ice and water means that ice flows on water and protects aquatic life during cold weather. The high heat capacity of water represents a great stabiliser of temperatures by large bodies of water on the Earth. Cloudiness limits the entry of solar radiation into the atmosphere and to the surface of the Earth (Pokorný et al., 2009), thus protecting mild and hot zones from overheating. Clouds also capture part of the longwave (thermal) radiation from the Earth, which has a warming effect in cold zones.

Water buffers the gigantic amount of solar energy that is constantly falling on the planet. Thanks to the evaporation of water, solar radiation arriving at the Earth's surface is transformed into latent heat. This moderates the accumulation of sensible or felt heat at the Earth's surface. Later, the same amount of heat will be released by the condensation of water vapour when it comes to a colder place. Water moderates temperature differences between regions of different altitude or geographic latitude, between oceans and land, between day and night, between the annual seasons, and in connection with the melting of glaciers, even between ice ages and interglacial periods.

The relation between climate change and the water cycle works in both ways. So, while most attention thus far has focused on the impact of global climate change on the water cycle, the new integrative climate paradigm recommends attending equally to the determining impact of changes in the water cycle on climate change. This focus is especially valuable on a local and regional scale. Nevertheless, local and regional processes over huge areas inhabited and exploited by human beings exacerbate global climate change. This analysis does not deny other known (and as yet unknown) natural or human climate forcings; rather it draws attention to how the water cycle is closely implicated in huge flows of energy, and by extension, global warming or cooling patterns.

2 Land management, water and climate

When the New Water Paradigm authors refer to water in land, they usually mean not only water as rivers and reservoirs, but also water passing through the atmosphere, soil and vegetation. It is this green – as distinct from blue – water that is usually not only more plentiful and important in a landmass, but also more neglected and damaged by human activities (Falkenmark and Rockström, 2006). The thermoregulatory feedback of green water in a landmass is a very substantial factor in the moderation of climate extremes due to climate forcings.

Following the move from a hunter-gatherer way of life to an agricultural and pastoral one, huge areas of the globe would be cleared for cultivation, and eventually urbanisation and industrial development. This historical process has had a marked effect on rainwater run-off; it has decreased ground and soilwater recharge; it has decreased evapotranspiration. It has also affected the circulation of minerals, nutrients and water, in general. Less water in a landmass means less water in short water cycles. The less water there is in a region and in the atmosphere above it, the weaker the balancing of temperatures, and thus swings in temperature arise, and the weather becomes more extreme.

History provides several examples of land degradation due to human activities. Shortsighted land management has rendered communities and even civilisations vulnerable or close to collapse. When on the ground factors combined with climate instability, vulnerable communities often collapsed (Diamond, 2006). Such was the fate of the ancient civilisations of the Fertile Crescent in the Middle East; the Anasazi Indians of the US Southwest and the pre-European inhabitants of Easter Island. There are examples of land degradation succeeded by climate instability in more modern times too, such as the Dust Bowl of the US Great Plains, which arrived in the 1930s; or the Aral Sea disaster of the Soviet era. The climate change that accompanied the decimation of these territories is at least partially attributable to human land management activities.

Deforestation, agriculture, urbanisation and other anthropogenic transformations of land now affect almost 40% of the world's surface (Foley et al., 2005). The influence of these transformations on the amount of water in the land and its climate merits serious attention (Pielke et al., 2006).

3 Deforestation and agriculture

Anthropogenic influences on local climate began long before the Industrial Revolution. According to Ruddiman (2005, pp.88–94), by forest cutting in the period up to 250 years ago, humans released to the atmosphere approximately twice as much carbon dioxide than has been released during the industrial era. Yet, this increase in the CO_2 radiative effect in the atmosphere is not the largest impact of deforestation.

Deforestation impacts are multiple. Slash-and-burn practices release smoke-borne aerosols with their diverse effects on radiative heating, cloud formation and precipitation processes (Committee on Radiative Forcing Effects on Climate, 2005). Another impact of deforestation is the increase in albedo, which tends to cool the Earth's surface by reducing the amount of solar radiation it can absorb. Evapotranspiration is dramatically reduced on deforested land due to diminished leaf area and root depth, which in turn substantially increases temperature (Foley et al., 2003). These climatic impacts of poor land management are compounded by humanly induced disturbance of the water cycle.

Land clearing is accompanied by an increase in rainwater run-off and soil erosion, a decrease in groundwater recharge and soil moisture and a reduction in the organic material content and water retentiveness of soils. The eminent Austrian hydrologist, Ripl (2003, 2010), has researched lake sedimentation in northern European lakes after the retreat of glaciers about 12,000 years ago. His findings demonstrate very clearly the role of vegetation in regulating water circulation and erosion. The 2–3000 year period of gradual recolonisation of the barren landscape, from pioneer plants to climax forest, is marked by high transport of surface material to the lakes and material that will diminish to one-tenth of its original amount. About 200 years ago, as people started to destroy the vegetation of these same river basins to develop agriculture and towns, the removal of surface material increased by between 50 and 100 times compared with the optimal natural state. Such processes, which began in northern Europe relatively recently, started much earlier in some other parts of the world.

Deforestation results in significant draining of the land by surface run-off. Simulation research using hydrological models suggests that the conversion of forests to cropland has led to an increase in annual run-off by 2.5% in North America and 6% in Asia between 1700 and 1992 (Haddeland et al., 2007). These observations agree with findings from the Brazilian Tocantins River basin, where, from 1960 to 1995, together with forest removal and development of agriculture, river levels rose by 25%, despite the fact that rainfall did not increase during that time (Foley et al., 2005).

Deforestation reduces evapotranspiration and atmospheric humidity, which leads to a reduction in local rainfall. The pioneering Russian scientists, Makarieva et al. (2006), explain the unique mechanism of natural 'water budgeting' in closed-canopy forests of tropical and mild zones. According to their analysis, a temperature inversion (a higher temperature in the crown of the tree than on the ground) during the day helps retain almost 100% of the air humidity above the surface of the soil. The balance of humidity and temperatures under the crowns of trees is directly proportionate to the density and height of the vegetation. Forest self-regulation of water beneath the crowns of trees is so effective that the trees can afford to evaporate large amounts of water from their crowns and so cool the air above them. At night, the temperature inversion above the crowns of trees and above open, unforested ecosystems often leads to condensation and fog. Part of this gravitates down to the ground, and in closed forest ecosystems, unlike open areas, this can remain in the form of moisture for the whole day.

Another anthropogenic factor affecting the drainage of large expanses of land is the choice of crops grown on them. Certain edible grass seeds were ideally suited to agricultural cultivation and formed the basis of the cereal farming, which has become the most extensively produced human food supply. In temperate zones, the cultivation of wheat and barley, believed to be the first domesticated cereals, has been dominant since the Neolithic Revolution. These retain the quality of the annual steppe grasses from which they were first bred and so require steppe-like conditions; to grow them well, the soil must first be drained. This enormous project has been one of the main causes of land drying in the modern age.

Artificial irrigation is not a sustainable solution in the long term. The Sumerian 'discoverers of agriculture' lived in Mesopotamia between the 4th and 2nd millennia BC and intensively cultivated monocultures over great areas of land. Using a system of irrigation canals, they brought water from the Euphrates and Tigris rivers, while a system of drainage canals carried it away. The soil, despoiled of natural vegetation and subjected to an annual cycle of irrigation and drainage, became salty and stopped producing yields. Other great civilisations founded on alluvial agriculture underwent a similar fate. Salinity remains a fatal problem in modern agriculture; the worst examples of dryland salination in the world are to be found in Australia's former wheat belt, which was cleared of its natural vegetation with unprecedented speed following European settlement (Diamond, 2006). Depletion of the Murray River, the city of Adelaide's main water supply, is a further dimension of the problem.

Australian agriculturalist Peter Andrews and his colleague Duane Norris explain the mechanism of soil salinity as follows (Norris and Andrews, 2010). As soon as rainwater touches the ground, it starts dissolving the salts in the soil. The concentration of these salts in surface water, not to mention groundwater, increases many times over compared with rainwater. This is one of the differences between rain and artificial irrigation. Another difference lies in the fact that rain means high air humidity, which reduces evaporation, whereas during processes of artificial irrigation, the opposite is usually true. Salts from evaporated water stay in the ground. As Andrews notes, another aspect of soil salination is the suppression of low vegetation, such as grasses and weeds.

These are, in his opinion, the most efficient means of extracting and eliminating salt from the soil. There is hardly any other defence against salinity. Agriculture with its systematic removal of such vegetation is a way to create a semi-desert with very little vegetation.

4 Other kinds of land draining

European development was influenced by attitudes to nature inherited from the Roman Empire, a culture that regarded forests as the exact opposite of civilised life in towns and cities or the peaceful peasant life of fertile flood plains (Fernández-Armesto, 2002). The expansion of civilisation was, therefore, associated with deforestation. The draining of swamps and wetlands was practised during the Middle Ages by communities of religious orders on a small scale. Though, during the Enlightenment, 'the conquest of nature' took the form of a 'civilised alternative to barbaric warfare'. The draining of the Oderbruch by Frederick II, King of Prussia, in the mid-18th century was thus organised as a military campaign (Blackbourn, 2006).

The alteration of rivers was ruled by a similar spirit. Johann Gottfried Tulla, "the man who tamed the wild Rhine", expressed his enthusiasm for water engineering in his *Principles of Future Work on the Rhine* (1809):

> "In civilised countries, the rule should be that rivers and streams are canals ... [The river should be] directed into single bed with gentle curves ... where it is practicable, a straight line." (Blackbourn, 2006, p.91)

However, shortening the length of rivers increased their slope and discharge. Adjacent fens and swamps connected with river ecosystems were also drained. In Australia, making the Murray River navigable meant deepening its bed, causing it to drain groundwater. According to Andrews (2008), this treatment introduced the exact opposite of healthy landscape, watered by a river flowing in a bed formed of sediments elevated above the surrounding country. The primary negative effect of these human modifications has been the accelerated run-off from the land to the sea, thus lowering the land's ability to retain water. European colonisation exported this ill-informed development paradigm all over the world.

Rapid urbanisation accompanying the Industrial Revolution has meant mass movements of population from country to towns. Modern cities, and to an increasing extent, villages, pave land surfaces with impermeable materials. In the European Union (EU), the area of the soil surface covered with an impermeable material is around 5% of the total area. However, soil sealing through urbanisation reaches 16–20% of the total surface area in countries such as Belgium, Denmark and the Netherlands. Between 1990 and 2000, the sealed area of the EU increased by 6% (EC Commission, 2009). This destructive process increases with the demand for new construction due to increased urban sprawl and better transport infrastructure – despite negative population trends.

As rainwater run-off from paved and roofed urban areas has increased, rainfall over cities and other urban spaces has come to be seen as a burden – wastewater, which must be carried away along with sewage water. By some recent estimates, more than 20 billion m^3 of rainwater is channelled off the landmass of Europe annually. In most cities, rainwater drained off the 'civilised world' runs via drainage channels into rivers and then into the ocean. This water is unable to complete its hydrological cycle:

underground, in the soil, on its surface, in plants, and through evaporation and precipitation cycles in the air.

5 A distorted water cycle influences climate

The fate of solar energy depends on the presence or absence of water. As sunlight falls on the Earth, it is water that determines whether energy will be dissipated as latent heat or sensible heat. As the names suggest, sensible heat is accompanied by an increase in the temperature, which humans can feel. The latent heat of water evaporation is not accompanied by an increase in temperature. It is the amount of energy that water must absorb to transform into vapour of the same temperature. The evaporation of water, then, consumes heat, by which the surface of the Earth is cooled, and this does not involve a small value. The specific latent heat of evaporating water under normal pressure and a temperature of 25°C is 2243.7 kJ/kg. The same amount of heat is released later during condensation of water vapour in colder places, mainly during cloud formation.

Water can be changed into water vapour and cool a region only if it is present there. If it is not present, a large portion of solar energy is changed into sensible heat and surrounding temperatures increase sharply. In a dry region, the majority of incoming radiation changes into sensible heat. In a region sufficiently stocked with water, most radiation transfers into the latent heat of water evaporation, meaning that a much smaller proportion of solar radiation is changed into sensible heat. Pokorný et al. (2010), a group of Czech scientists with great insight into the relation between the water cycle and energy flows, make the following calculation: a drop in evaporation by 1 L/m^2 (700 Wh) during a day initiates a flow of sensible heat several tens times higher (70 W) than the effect of increased atmospheric greenhouse gas concentrations through radiational amplification. The latter, according to the IPCC (2007), is equal to 1–3W m^{-2} over the last 250 years.

Hesslerová and Pokorný (2010) use the example of the Mau Forest in Kenya to demonstrate how deforested land warms up much more rapidly than forested land. The draining and drying out of land releases an extremely large quantity of sensible heat into the atmosphere. Every year about 127,000 km^2 of the Earth's surface is deforested. Considering that evaporation on this kind of surface will fall by about 200 mm per year, then about 17,374,000 GWh of additional sensible heat are generated annually (Schmidt, 2009a). This amount of energy is roughly equal to the annual global production of electricity by the human population. Huge amounts of sensible heat arise in areas turned over to agriculture or urbanisation. Fields, pastures and urban zones on all continents already cover an area of about 55 million km^2 and 'development' is not slowing down.

Drained soil without a functional vegetation cover warms up rapidly, leading to significant divergences of temperature between regions. As air currents increase in frequency and velocity, water vapour is taken further away. The frequency of gentle precipitation decreases, and the move from a short water cycle to a long water cycle sets in. In terms of the Earth's water balance, there is more water in short water cycles than in long ones. Ripl (2003) draws attention to the water microcycle occurring between evaporation and precipitation. The water microcycle manifested by dewdrops on grass is the most abundant and widely occurring sign of water circulation in vegetation and the most important stabilising process for a landmass. The microcycle dissipates solar energy with great efficiency and without negative side effects such as dehydration, desertification and soil erosion.

Furthermore, the diminishing volume of water in short water cycles triggers a chain of negative phenomena. When huge areas of swamp were drained during the 20th century in Florida, a significant drop in rainfall occurred during the hot season, as well as a new phenomenon of frosts in drained areas during the cold season (Pielke et al., 2007). The build-up of sensible heat over land represents a path to desertification. Overheated country inhibits condensation and produces less dew, fog and rain. Droughts become longer and the effects of solar radiation are harsher, as frequent mild precipitation is replaced by occasional torrential rain. The organic content of dry soil is lost due to oxidation processes or washed away, and the soil's capacity to hold water decreases. The crust on the surface of bare drained soil makes the absorption of rainwater more difficult and further increases run-off. Rapid run-off means a higher risk of erosion and floods. Paradoxically, floods may become more frequent, despite a decreasing annual sum of precipitation. Falling levels of groundwater, forest fires and a reduction in biodiversity are further negative consequences of a damaged hydrological cycle.

Wherever a functional water cycle has been lost, the centre of precipitation moves to cooler, neighbouring environments covered by woods or lakes. Alternatively, the precipitation may move to places of higher altitude and latitude. The interaction of dried 'hot plates' such as agricultural or urban land with cooler and damper regions can cause an unprecedented concentration of cloud cover over the latter regions. However, as noted earlier: desertification caused by human intervention in the water cycle, on the one hand, and increased precipitation over natural, cooler regions, on the other, is often mistakenly ascribed to the effects of human emissions of greenhouse gases – other than water vapour. In fact, temperature differences resulting from disturbance to the hydrological cycle provide a more direct and logical explanation for regional climatic extremes than the increase in CO_2 levels in the atmosphere.

Makarieva and Gorshkov (2010) shed new light on relations between vegetation–evaporation–precipitation. They correlate distance from the sea with annual rainfall in forested and unforested regions across several continents – savannah, steppe and semi-desert. Their conclusion is that in the unforested parts of continents, annual rainfall decreases the further regions that are from the sea, whereas in areas covered by natural forest, not only do levels of rainfall not decrease, but in some cases actually rise, even over distances of several thousand kilometres. In other words, a forest functions as a 'biotic pump'.

According to the biotic pump principle, a horizontal flow of moist air arises from a region with lower evaporation and moves into an area of higher evaporation. Thanks to the cumulative evaporating surface of leaves, forest ecosystems during the vegetation period, evaporate several times more water than open water surfaces having the same area. Forests thus provide suction of moist air from the ocean to the mainland. Conversely, if evaporation over the land decreases in comparison with evaporation above the sea alongside that land, the physical mechanism described earlier is reversed and moisture is drawn away from the land. Meadows and agricultural land, with their relatively low levels of evaporation, are unable to create the biotic pump effect, and so their water cycle is critically dependent on their distance from the sea and the fluctuations of rain-bearing weather.

Climatic extremes are the inevitable outcome of human distortion of the water cycle. Andrews (2006) recounts childhood memories of thermal dust storms during the 1940s in outback New South Wales. At certain times of the year, storms came three or four times a week, sometimes even two or three times a day. Violent storms covered grass with dust and sand, buried sheep alive and turned the land into a desert. Andrews dates the origins of this phenomenon in the 1880s when mines were opened at Broken Hill and large-scale destruction of trees and bush fed the smelter furnaces. Grassland that had successfully existed for tens of thousands of years was exposed to winds without protective scrub, and in just few decades, these turned into semi-desert.

Another ecological crisis peaked simultaneously with the Great Depression in the USA in the 1930s. This was the direct result of deforestation of the country to one-eighth of its original forested area, by ploughing up the Great Prairies for cereal monoculture. A change in the hydrological regime brought floods, droughts and water erosion estimated at 3 billion tons of high-quality soils annually. Gigantic dust storms in the Dust Bowl states then turned millions of acres of previously fertile land into desert (Salmond, 1967). In China, similar processes of disturbance of the water cycle following deforestation triggered a chain of negative effects, including droughts and dust storms. Dust storms have increased in frequency and severity as more land has been laid bare. From AD 300 to 1950, these dust storms afflicted north-western China on average once every 31 years; from 1950 to 1990, once every 20 months; since 1990, almost every year (Diamond, 2006).

6 Water and plants for recovery of climate

In the lead up to the 5th World Water Forum held in March 2009 in Istanbul, many participants expected to hear fresh ideas about the relation of water to climate. However, in the panel on Adaptation to Climate Change, only the anthropogenic production of greenhouse gases was discussed. Nevertheless, awareness of the water cycle was very apparent in papers dealing with paddy fields and rice terraces in Asia; Multiple Uses and Functions of water Services (MUFS) in Africa and the increase in hurricane risks after wetland reduction in the USA. A presentation on the 'biotic pump' concept in a session on Ecosystems for Water, Water for People, Ecosystems for People even proposed a paradigm shift.

> "Terrestrial ecosystems fulfil essential functions in the water cycle and provide ecosystem services of great benefit for water management. Realisation of these benefits requires pro-active coordination of land and water management. Sustainable utilisation of ecosystem services may represent a cost-effective strategy with multiple benefits for land, water and climate compared with investments in structural measures."

But, the view has remained a minority voice to now.

Yet, practical instances of humans improving environmental functions can be found. The US President F.D. Roosevelt dealt with the ecological crisis of the 1930s by organising a Civilian Conservation Corps (CCC), and this scheme had the additional benefit of helping the unemployed. The programme, which operated from 1933 to 1942, employed about 3 million young people in planting forests; building reservoirs for fire prevention; ponds for wildlife and dams for drinking water. Other projects included measures for reducing the speed and erosive force of water and the creation of retention spaces for harvesting storm water. The number of trees planted by the CCC is estimated to be 2–3 billion. There is no doubt about the positive impacts of the programme on the lives of people and their habitat. The impact of the programme on the climate can be deduced, for example, from the fact that the occurrence of mid-West dust storms declined. Today, the EU funds similar restoration training and employment schemes in Central Europe (Kravčík et al., 2007).

The way in which these programmes support the water-retaining capability of catchments is particularly inspirational. In order for water and vegetation to fulfil their climatic function, they must be sufficiently present in a region. All fresh water on land comes from rain, therefore the first step is to ensure the harvesting of rainwater where it falls. Humanity has harvested and retained atmospheric water through the millennia, and developed many technologies for this purpose. These include the gathering of water from roofs; on slopes with the help of different types of depressions or terraces; into cisterns, and sheets for fog harvesting (Lancaster, 2006). While, in the past, the purpose was to obtain resources for water for drinking, utility, or irrigation, today the climatic services of water have become indispensable.

In an integrative climate paradigm, evaporation, traditionally considered a loss, has an immensely important function for cooling a region, and balancing temperature differences within it, thereby stabilising weather patterns. On healthy land, most water vapour returns in the form of dew or rain. What is more, as Makarieva and Gorshkov (2007) show, evaporation 'attracts rain' by cooling, encouraging condensation and 'sucking in' moist air due to lower atmospheric pressure. To get regular precipitation, it is necessary to create conditions for sufficient evapotranspiration on a large area.

If agriculture and urbanisation contribute to climate change, then the restoration of water and vegetation on disrupted landscapes is the key to combating that aspect of climate change caused by human drainage of water from land. The primary principle is to allow water to seep into the soil, enabling the saturation of groundwater and surface water reserves. This, in turn, will foster the growth of vegetation, ideally forest, which works as a climatisation valve between the soil and the atmosphere. Surprising as it may seem, the holding capacity of soil and subsoil is usually much higher than the volume of the largest artificial reservoirs in a country.

The measures that need to be taken are simple, effective and cheap, but need to be implemented regionally – in the territory of each community and town, wherever possible. Programmes for rainwater harvesting and conservation need to be carried out comprehensively across continents. The impermeable surfaces of urban areas are no exception, and there is no more effective remedy to the 'urban heat island effect' than to evaporate water. According to the Berlin-based architect and planner, Schmidt (2009b, 2010), vegetated roofs and facades, unpaved or semi-permeable surfaces, rainwater harvesting and recycling, and artificial urban lakes should become the norm in city living areas. The Watergy research group represents a promising trend in the cost saving use of evaporation and condensation for urban cooling and heating. The Watergy approach also provides the possibility of cheap grey water purification to produce distilled water (Zaragoza et al., 2007).

7 Conclusion

Water, especially in combination with functional forests, moderates temperatures and weather extremes. In the words of Lodemann et al. (2010), the New Water Paradigm or integrative climate paradigm represents a model of strong sustainability. The hydrological cycle involves huge energy flows. Yet even experts may fail to recognise what a powerful tool the hydrological cycle is when it comes to modifying climate on a regional scale. Those who emphasise the role of greenhouse gases, and particularly CO_2 emissions in global warming, should support protection of the hydrological cycle, because its destruction leads to diminished carbon sequestration due to reduced photosynthesis (Dolman, 2008). Reduced water content in the ground is also conducive to forest fires, which then release vast amounts of carbon to the atmosphere.

A healthy hydrological regime requires short but intense water cycles. The saturation of short water cycles over a landmass can be achieved through the comprehensive conservation of rainwater by enabling its infiltration and evaporation via vegetation. Rainwater conservation

- stabilises climate and reduces natural disasters like floods, droughts and fires
- enables ecosystems and strengthens biodiversity
- provides quality water for humans, as essential to sustainable development Kravčík et al., 2007).

An integrative climate paradigm contests the narrow scope of contemporary water management, by taking into account not only the water in rivers and reservoirs, but also the much greater volume of water carried in soil, air and vegetation. Such an approach equips conservationists and forestry professionals with strong arguments for the hydrological value of woods, wetlands and ecosystems. It provides insights for farmers about how to protect water and soil on their land, on tree strip planting, organic matter in soil, minimum tillage, anti-erosion measures, the desirability of non-irrigated crops, changes in cropping patterns, and cropland conversion into temporal grassland or even permanent forest. The integrative climate paradigm invites landscape engineers, architects, urbanists, construction engineers and planners to return water and vegetation to denuded and drained land, to reappraise drainage relations and redesign water conservation to approximate optimally water saturated natural land. It challenges developers to include water conservation, evaporation and condensation in their strategies to achieve attractive and valuable living environments.

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