SECTION 2

Changing Natural Systems

Both naturally occurring conditions and human impacts are asserting strong pressure on our water resources today, in the form of warming temperatures, rising sea levels, ecosystems damage and increased climatic variability, among others. Human influence is arguably becoming more important than natural factors. The construction of dams and diversions continue to affect river regimes, fragmenting and modifying aquatic habitats, altering the flow of matter and energy, and establishing barriers to the movement of migratory species. Deforestation, increasing areas of farmland, urbanization, pollutants in both surface and sub-surface water bodies and so on, all influence the timing and quantities of flows and are having a huge impact on the quality and quantity of freshwater.

It is against this background that we must assess the state of the water resources. Assessment is a critical and necessary first step to ensuring that the dual goals of water for environmental and human needs are met. This section presents an overview of the state of water resources and ecosystems and explores current assessment techniques and approaches to Integrated Water Resources Management (IWRM).

Global Map 3: *Relative Water Stress Index*
Global Map 4: *Sources of Contemporary Nitrogen Loading*

Chapter 4 – **The State of the Resource** (UNESCO & WMO, with IAEA)

This chapter reviews the main components of the water cycle and provides an overview of the geographical distribution of the world's total water resources, their variability, the impacts of climate change and the challenges associated with assessing the resource.

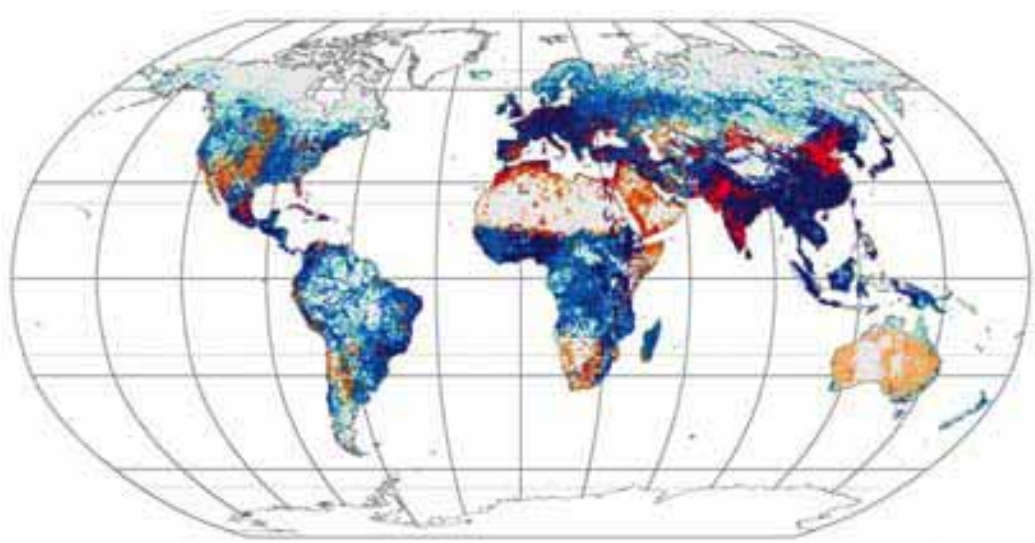
Chapter 5 – **Coastal and Freshwater Ecosystems** (UNEP)

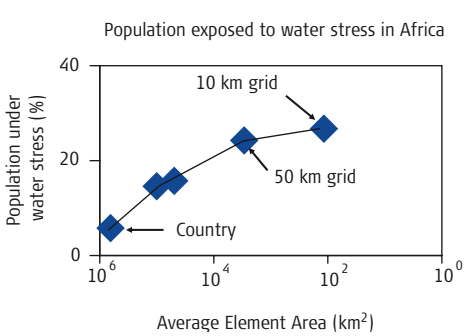
Natural ecosystems, rich in biodiversity, play a critical role in the water cycle and must be preserved. In many areas, a variety of pressures on freshwater ecosystems are leading to their rapid deterioration, affecting livelihoods, human well-being and development. To reverse this trend, protecting ecosystems and biodiversity must become a fundamental component of Integrated Water Resources Management (IWRM).

Relative Water Stress Index

Water stress is commonly evaluated by comparing the volume of renewable water resources per capita at a national level. New mapping capabilities allow the geography of water stress to be better defined. High resolution water stress indices can be computed based on the ratio of total water use (sum of domestic, industrial and agricultural demand or DIA) to renewable water supply (Q), which is the available local runoff (precipitation less evaporation) as delivered through streams, rivers and shallow groundwater. Developed from actual statistics, the Relative Water Stress Index (RWSI), also known as Relative Water Demand, is useful because it is a dimensionless quantity, which can be applied at different scales. The map below shows populations living in water stressed (RWSI ≥ 0.4) and relatively unstressed (RWSI < 0.4) conditions highlighting substantial within-country differences that national estimates often obscure. The map shown below (at approximately 50 km resolution globally) nearly tripled earlier nation-wide estimates of those people living under severe water stress, with obvious impacts on the degree to which water problems can be appropriately identified and managed.

Population (in thousands) above (reds) and below (blues) water stress threshold (RWSI=0.4)





The scale of the analysis is critically important when assessing the level of water stress. For instance, the graph on the left shows that when water stress was computed at the country scale, about 4% of the population in Africa was identified as suffering under severe water stress. However, when evaluated using geospatial data at a 10-km resolution, the percentage of the population experiencing stress increased to 26% (Douglas et al., 2006; Vörösmarty et al., 2005a).

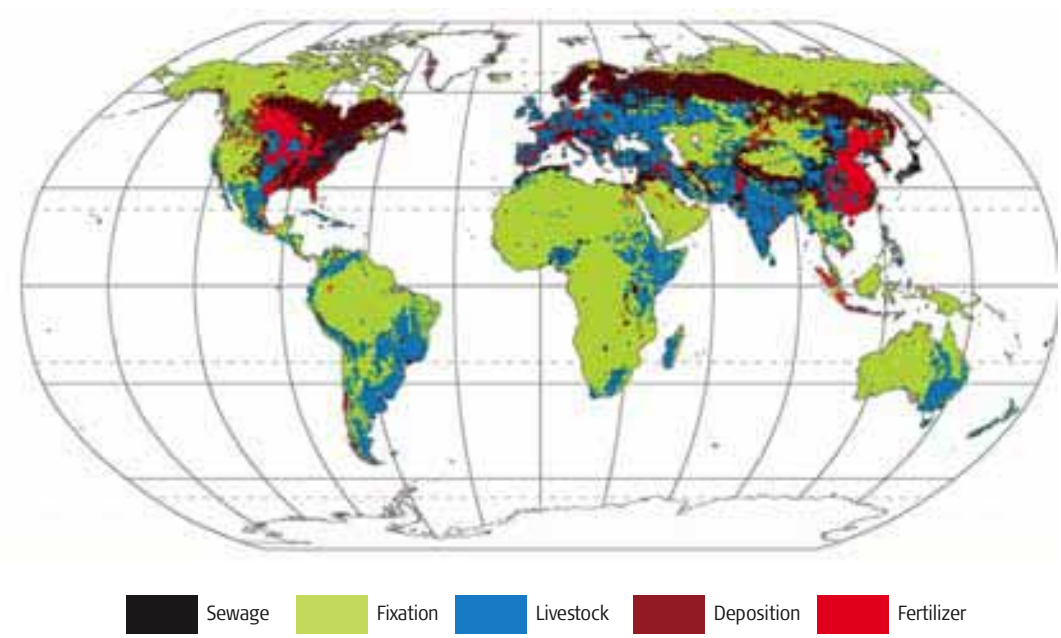
Source: Water Systems Analysis Group, University of New Hampshire. Datasets available for download at http://wwdrii.sr.unh.edu/

Sources of Contemporary Nitrogen Loading

Nitrogen actively cycles through the atmosphere, the continental land mass and the world's oceans, and represents a critical nutrient upon which plant, microbial, and animal life depend. Nitrogen, the most abundant gas in the atmosphere, is delivered to watersheds through natural processes including chemical transformation and washout from precipitation as well as biological fixation. The pathways that nitrogen follows as it travels through the environment are complex. Contemporary human activities have greatly accelerated the transport of reactive nitrogen through river basins that ultimately deliver this nutrient into coastal receiving waters (Galloway et al., 2004). Globally there has been a two-fold increase in the delivery of this nutrient to the oceans, with more than ten-fold increases in some rivers draining industrialized regions (Green et al., 2004). These increases arise from the widespread application of fertilizer, animal husbandry and point source sewage inputs.

These human induced changes to the nitrogen cycle have far reaching impacts on water quality and public health, protein supply for humans, and even the planetary heat balance through the emission on nitrogen-based greenhouse gases. The map below shows the predominant source of nitrogen within each grid cell. Fixation is the primary source throughout South America, Africa, Australia, and the northernmost reaches of Asia and North America. Atmospheric pollution and subsequent nitrogen deposition plays a dominant role throughout the industrialized northern temperate zones of Europe, Asia and North America. Fertilizers are the predominant source across major food producing regions. Livestock constitutes the most important source in Eastern Europe and India. Urban sewage loads create localized 'hotspots' for pollution. Understanding the patterns of such loadings is critical to the design of management interventions to protect society and well-functioning ecosystems.

Predominant Sources of Contemporary Nitrogen Loading



Source: Water Systems Analysis Group, University of New Hampshire. Datasets available for download at http://wwdrii.sr.unh.edu/