"We must treat each and every swamp, river basin, river and tributary, forest and field with the greatest care, for all these things are the elements of a very complex system that serves to preserve water reservoirs – and that represents the river of life."

Mikhail Gorbachev

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).

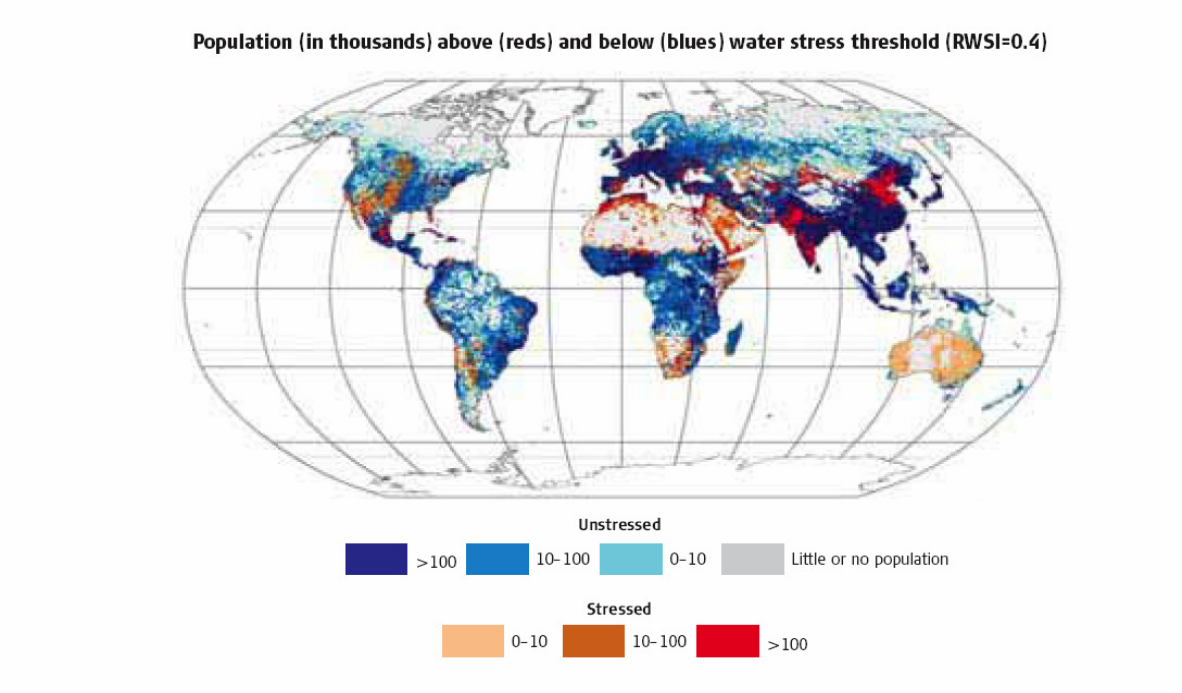
Relative Water Stress Index

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.



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.

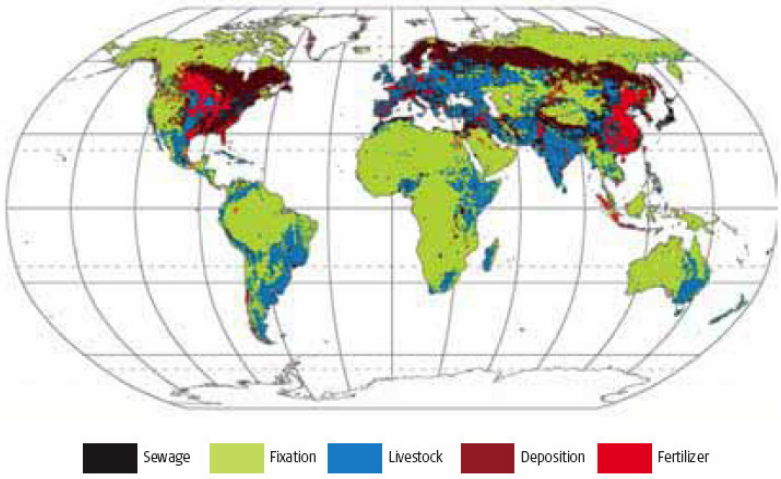
The pathways that nitrogen follows as it travels through the environment are complex. Contemporary human activities have greatly accelerated the transport of reactive nitrogen through river basins that ultimately deliver this nutrient into coastal receiving waters (Galloway et al., 2004). Globally there 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/

Key messages

Coastal and freshwater ecosystems are deteriorating in many areas and at a faster rate than any other ecosystem. Such changes are caused by intertwined factors, making it difficult to identify the problems early on. While progress in integrating these various factors in managing water and ecosystems has been made in some places, the majority of

the world and its inhabitants increasingly suffers from a lack of priority given to environmental protection.

■ Humans depend upon healthy aquatic ecosystems for drinking water, food security and a wide range of environmental goods and services. Aquatic biodiversity is also extremely rich, with high levels of endemic species, and is very sensitive to environmental degradation and overexploitation.

■ Aquatic ecosystems and species are deteriorating rapidly in many areas. This is having an immediate impact on the livelihoods of some of the world's most vulnerable human communities by reducing protein sources for food, availability of clean water, and potential for income generation.

■ People in regions with highly variable climatic conditions are particularly vulnerable to droughts and floods and the resulting deteriorating condition of freshwater ecosystems. Coastal lowland areas, where population densities are usually very high and coastal habitats are fragile, are most likely to be affected by sea level rise in future.

■ The conservation of biodiversity (species, habitats and ecosystem functions) must become an integral part of all water resource management programmes. This will assist poverty reduction strategies by ensuring the sustainability of aquatic ecosystems for future generations.

■ Ecosystem approaches constitute a fundamental element of Integrated Water Resource Management (IWRM) and are essential for safeguarding and balancing the needs and requirements of water resources among different stakeholder groups and ecosystems. Ecosystem approaches are the subject of global and regional targets and policy initiatives, but they have yet to be implemented in practice. This requires awareness raising, tools and methodologies to monitor and negotiate the trade-offs involved in such broad-scale approaches.

■ Our understanding of the properties and functions of many aquatic ecosystems is seriously hampered by inadequate data. Enhanced monitoring efforts are required to provide a better assessment of the status, conditions and trends of global water ecosystems, habitats and species.

Ecosystems and their Capacity to Provide Goods and Services

The majority of us live in temperate and subtropical regions centred around the coast or inland water systems. Coastal waters, rivers, lakes, wetlands, aquifers and other inland water systems such as swamps and fens have in consequnce been subjected to disproportionate human-induced pressures.

These include construction along coastlines for harbours and urban expansion, alteration of river systems for navigation and water storage, drainage of wetlands to increase farmland, overexploitation of fisheries, and multiple sources of pollution. Human population growth and the expansion of economic activities are collectively placing huge demands on coastal and freshwater ecosystems. Water withdrawals, for instance, have increased sixfold since the 1900s, which is twice the rate of population growth (WMO, 1997). In addition, the quality of many water bodies is declining due to increased pollution from agriculture, industry, tourism, urban runoff and domestic sewage.