Three global water scenarios

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Abstract: A set of three global scenarios used to initiate consultation on a World Water Vision is presented, derived from alternative evolutions of the major forces driving the global water situation: economic, demographic, technological, social, environmental and governance. The alternative scenarios are the Business-as-Usual scenario (BAU), representing the future trajectory if those who don't believe in the crisis prevail, and no major policy or lifestyle changes take place; the Economics, Technology and Private Sector scenario (TEC), which could result from policies favoured by those who rely on the market, the involvement of the private sector and mainly technological solutions, and largely national/local or basin-level action; and the Values and Lifestyles scenario (VAL), that could materialize through a revival of human values, strengthened international cooperation, heavy emphasis on education, international mechanisms, international rules, increased solidarity and changes in lifestyles and behaviour. A number of general conclusions are derived.

Keywords: future studies; integrated water resources management; water and development; water scenarios.

Reference to this paper should be made as follows: Gallopín, G.C. and Rijsberman, F. 'Three global water scenarios', *Int. J. Water*, Vol. 1, No. 1, pp. 16–40.

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1 Introduction

Over the past decades it has gradually become evident for those directly involved that there is a chronic, pernicious crisis in the water world. The participants in the 1st World Water Forum in Marrakech in 1997 called for a World Water Vision to increase awareness of the water crisis throughout the population and to develop a widely shared plan for bringing about sustainable use and development of water resources.

The World Water Vision draws on the accumulated experience of water sector professionals and regional stakeholders from different sub-sectors that have developed both sectoral visions and integrated regional visions through regional and national consultations in more than 15 regions [1]. As the Vision developed and evolved, more and more networks of civil society groups, NGOs, women, and environmental groups joined the consultations to comment on and contribute to the evolving visions. The global, sectoral and regional visions were presented and discussed during the 2nd World Water Forum and Ministerial Conference in March 2000 in The Hague.

The participatory process that led to the World Water Vision makes it special. Since 1998, about 15,000 women and men at local, district, national, regional and global levels have shared their aspirations as well developed strategies for practical action towards sustainable use and development of water resources. The three global scenarios reported here served to initiate the sectoral and regional consultations and, subsequently, contributed to their improvement over four iterative rounds of scenario development.

2 The scenario methodology

The analysis of the water issue in the context of sustainable development requires the adoption of a long-term view in order to be able to account for the slow unfolding of some of the hydrological and social processes and the necessary time for waterworks investments to yield their fruits. Projections of trends in human affairs may be legitimate over the short-term, but they become unreliable as time horizons expand from months and years to decades and generations. Fundamental uncertainty is introduced both by our limited understanding of human and ecological processes, and by the intrinsic indeterminism of complex dynamic systems. Moreover, social futures depend on human choices which are yet to be made [2].

Water must be viewed in a holistic manner, both in its natural state and in balancing competing demands upon it – domestic, agricultural, industrial, and environmental – in a way that ensures sustainability of the resource.

The approach followed deliberately focused on the development of qualitative scenarios initially, to allow incorporation of the many social, economic, environmental and cultural factors that play a major role in shaping the water future, but may not be modelled quantitatively. The development and discussion of qualitative scenarios served as a platform for consultation among many stakeholders from different disciplinary backgrounds and different stakeholder perspectives. Mathematical simulation models were used subsequently to analyse the consistency and coherence of the qualitative scenarios, explore some of the consequences and help fill in some of the gaps. The scenarios evolved in four

rounds of development, discussion, feedback and subsequent improvement, in interaction between the scenario developers, modellers, reviewers and the groups working on visions for sectors and regions.

Scenarios are not predictions, forecasts or projections. Rather, they are stories about the future with a logical plot and narrative governing the manner in which events unfold [3–5]. A *scenario* is a possible course of events leading to a resulting state of the world (or *image* of the future – it should be noted that some define the image as a situational scenario as opposed to the development scenarios, which represent the trajectories [6]). Originally it was defined as a hypothetical sequence of events constructed for the purpose of focusing attention on causal processes and decision points [7]. The importance of considering scenarios as courses of events is that this directs attention to the unfolding of alternatives and to branching points at which human actions can significantly affect the future.

The scenario approach can also provide a common framework for diverse stakeholders to map and address the critical concerns and identify alternatives, and a forum for discussion and debate.

The development of scenarios generally begins with the characterization of the *current situation.*

An important step is represented by the definition of the *critical dimensions* describing the scenario. Collectively, they define the multidimensional space within which scenarios can be mapped or constructed. Dimensions do not necessarily imply causal assumptions; rather, they are defined in terms of their relevance, as descriptors of the most important attributes of the images of the future. Examples of possible dimensions are economic growth, social progress, environmental quality, conflict level, etc.

Next the major *driving forces* must be identified; they represent the key factors, trends or processes which influence the situation, focal issue, or decisions, and actually propel the system forward and determine the story's outcome. Some of these forces are *invariant* over all scenarios; that is, they are to a large extent predetermined [3].

The major drivers propelling the global water scenarios have been identified as pertaining to the following clusters:

- demographic (population growth in the South; migration pressures; urbanization in the South)
- economic (economic output; trade; prosperity in the South; water works investment)
- technological (hi-tech expansion; water efficiency; unit water pollution; adoption of new crops; water sanitation investment; number of desalination plants; withdrawal efficiency)
- social (global lifestyles; poverty; inequality)
- governance (power structure; level of conflict; globalization)
- environmental (water-related diseases; soil salination; groundwater; ecosystem health).

These drivers influence, but do not completely determine, the future. Thus, while the initial drivers are the same in all scenarios, the trajectory of the global system follows a different course in each of them.

Some of the driving forces may represent *critical uncertainties* the resolution of which fundamentally alter the course of events, as discussed later.

The current state, driving forces, strategic invariants, and critical uncertainties form the backbone of the scenarios. In addition, all scenarios unfold according to an internal logic which links the elements into a coherent *plot.*

The end point of the scenario is an *image of the future situation* resulting from the unfolding of the scenario.

Finally, the construction and interpretation of a scenario will be influenced by the beliefs and theoretical assumptions of the analyst. The account of the mechanisms leading to alternative scenarios and judgment of the efficacy of alternative actions is guided by one's *world view,* although this is rarely made explicit (a notable example was the Latin American World Model [8]. Rarer still is the use of contrasting world-views to show the variation in scenario interpretation [5,9].

The members of the Scenario Development Panel have opted for three scenarios in which the framework for each is organized around the driving forces, and the implications for and response of the water sector are then described. Mathematical simulation models are used to inform the scenarios where quantification is possible. Otherwise the scenarios are qualitative in nature.

2.1 Critical uncertainties

A number of critical uncertainties have been identified. These represent important factors or processes that 1) have an important role in determining the unfolding of the scenarios in terms of the dynamics of the water resources, and 2) have values or outcomes which are very difficult to anticipate today. In other words, they refer to trends or events which could make a major difference in the likelihood of the materialization of one or other scenario, and which are currently very difficult to anticipate. The most important are:

1 *Water productivity trends.* Will progress in water-use efficiency, and more generally, water productivity, continue at historical rates or faster? All scenarios make that assumption, but if for some reason the rate of technological innovation (or the rate of adoption) falls behind historical levels, drastic changes in at least some of the scenarios are to be expected.

2 *The expansion of irrigated agriculture.* With agriculture accounting for 70% of total water use, the future expansion of irrigated lands will be one major factor. Two basic contrasting views exist. On the basis of historical trends and the need to produce food for the growing global population, Shiklomanov [10,11,12], FAO [13], ICID (The International Commission on Irrigation and Drainage) and others, anticipate that total harvested area will increase by about 30% by 2025. Even with optimistic yield and water efficiency assumptions, this would imply an increment of 17% or more in the required water resources above their level in 1995 [14,15]. The second perspective holds that an already detectable slow-down in dam building and irrigation investment, combined with falling water tables will limit the expansion of irrigated land to 5–10% [16]. If the first alternative materializes, the associated large increases in water withdrawal and dam building will lead to severe water scarcity in many regions [10,14]. If, on the contrary, there is a strong reduction in the expansion of irrigated land in the context of business-as-usual policies, then serious food shortages and sharp increases in food prices would result [15–17].

3 *Massive increases in food production from rainfed agriculture.* To date, most increases in food crop yields took place in irrigated land. Progress in rainfed agriculture associated with new crops, supplemental irrigation, deficit irrigation, rainwater harvesting, and some forms of precision irrigation, could lead to fast yield increases in rainfed lands. That would generate an increase in food production without a concomitant increase in water irrigation. On the other hand, the opening of major rainfed areas for more intensive food production could lead to increased deforestation.

4 *Dematerialization of the economies*. Two major factors in the current trends towards dematerialization of the economies are i) changes in the structure of production and consumption, with the generally less material-intensive services sector growing faster than the agricultural and industrial ones; and ii) changes in the technology of production, using technologies which are less material and energy intensive. The intensification or the weakening of these trends could have profound consequences for the future of the water resources. The prospects for dematerialization may be different in the North and theSouth.

5 *National food self-sufficiency vs. global food security.* Continued emphasis on national food security (because of political, cultural or other reasons) could lead to overuse of water resources in some water-scarce countries. On the other hand, a reliable and trusted global food security system would allow a more rational use of water, with the water-scarce countries reserving their water for domestic and industrial use, and fulfilling their nutritional needs through food imports.

6 *Availability of cheap water-purifying technologies.* Developments related to membrane physics, originally geared to desalination processes, promise to deliver cheap ways of water purification for human consumption, by filtering heavy metals and other pollutants. This could have a great impact on human settlements and human health.

7 *Public acceptation of genetically modified crops in the South and the North.* Today an intense debate regarding the acceptability of genetically modified crop varieties is taking place, with Europe leading the opposition on the basis of environmental and health risks. While the debate is today largely confined within the North (essentially USA and Europe) it could develop into a world-wide issue, affecting trade and the adoption of new, drought-tolerant, crops obtained by genetic modification. These positions could shift greatly on the basis of new scientific findings.

8 *Public opposition to large dams.* Opposition to the building of large dams, on the basis of their environmental and social impacts, has been growing in the last decades. Given that the major opportunities for water development are concentrated in the South, the attitudes in the South (as well as of the international financing agencies) will be critical in determining the future alternatives.

9 *Fundamental scientific discoveries*. This is one of the largest uncertainties. The history of scientific progress is marked by fundamental breakthroughs (many of them unanticipated) leading to radically new approaches and technologies. The time-lag between discovery and application has been diminishing. One can speculate about scientific breakthroughs in the areas of biology (e.g. harnessing the process of photosynthesis), climatology

(effective weather management), biochemistry (food from enzymatic conversion of non-edible biomass), physics (effective warm superconductivity for energy storage and transmission, cheap capture of renewable energy), etc. Those are theoretically possible, and some could largely solve the water problem, but they will not be invoked here as an explicit factor in the water scenarios, as the degree of uncertainty is too high. Nevertheless, the possibility (even likelihood) of *some* fundamental scientific breakthrough in the next 25 years should be kept in mind.

10 *Significant changes in human values and lifestyles*. This is one of the biggest critical uncertainties. In the absence of global changes in lifestyles and societal values away from consumerism, it is not at all obvious that purely technological and economic measures will be enough to resolve the water crisis. Conversely, if changes in preferences were to take place, (because of health: e.g. low animal protein diet; water-saving: e.g. transition from water-born to dry sanitation systems; solidarity towards the current and new generations: e.g. voluntary reductions in *per capita* material consumption), the water problem could largely be solved.

3 The period 2000–2005

The initial five years are assumed to be the same for all scenarios because of unavoidable lags in decision-making, the inertia of some processes and the time required for investments to mature.

Awareness of the impending water crisis increases in the first years of the 21st Century. In response, governments start putting water higher on the agenda.

This leads to a triple branchpoint for the World Water Scenarios around 2005:

- *The Business-as-Usual scenario (BAU)*: this represents the future trajectory if those who don't believe in the crisis prevail, and no major policy or lifestyle changes take place.
- *The Economics, Technology and the Private Sector scenario (TEC):* this scenario could result from policies favoured by for those who rely on the market, the involvement of the private sector and mainly technological solutions, and largely national/local or basin-level action.
- *The Values and Lifestyles scenario (VAL):* this is a scenario that could materialize through a revival of human values, strengthened international cooperation, heavy emphasis on education, international mechanisms, international rules, increased solidarity and changes in lifestyles and behavior.

4 Business-as-Usual

The Business-as-Usual scenario describes a world in which current policies on water resources management and development are continued in essence unchanged.

Under this scenario, developments in the world are largely positive during the first 10–15 years. Water demands increase both absolutely and *per capita* due to increased affluence and increased *per capita* food production. Technology improves and water-use efficiency increases at the rates observed over the last few decades. Water supplies are developed following historical trends and known plans for major water infrastructure get implemented. The world initially develops along the lines of official projections of the UN-system concerning population and economic growth.

Global population continues to increase, reaching 8 billion by 2025. Throughout the world, the population is older and more urban.

Pressures for migration to the North build up, as a result of poverty in the South and the income differential between the two regions. These pressures are maintained within manageable levels, however, as income continues to rise in the South and interregional migration toward more prosperous areas increases.

By 2025 global GDP reaches more than $80,000 trillion in purchasing power parity (a real increase of 250% over 1995 levels). An increasing share of growth occurs in the developing world. Much of the new income remains in the hands of a relatively small segment of the world's population, however.

In most (but not all) parts of the world, economic growth combined with technological improvements, result in better living conditions, including increased access to safe drinking water.

Mainly because of private capital flows, investment in water infrastructure grows at the same pace as the economy, except in some subregions.

While improvements in water supply keep pace with population growth, efforts in sanitation lag behind and the total number of people that do not have access increases significantly. The chronic impact of poor water quality, lack of sanitation and personal hygiene remains a major health problem in the South.

Information technologies are widely available, although access to the technologies remains very variable in different regions of the world.

The introduction of crops that are resistant to drought, salt, and pests increases yields and allows expansion of potentially arable land. The quantity of water used for agriculture rises because of the increase in irrigated land during the last few decades of the 20th Century.

Global hydropower production increases initially but eventually levels off, never becoming a significant source of global energy. Alternative sources do not capture a significant share of the energy market.

Lower energy costs and improvements in technology sharply reduce the cost of desalination, and it becomes a local solution in a number of cases for municipal and industrial water supply. Desalination, however, does not make a dent in the overall water problem, mostly accounted for by agricultural water demand.

The moderate gains in water use efficiency and water productivity are not enough to offset the increase in water demand due to economic and demographic growth, and the expansion of irrigation.

Large-scale groundwater withdrawals are concentrated in a relatively limited number of (large) countries. Groundwater levels in many renewable aquifers gradually decline because withdrawal exceeds recharge; in many areas, groundwater becomes polluted.

By 2010 all countries, with the exception of Canada and the Scandinavian countries, suffer water shortage in at least part of their territory; many countries are encountering a high level of water stress. The prevailing response is to build more water infrastructure and increase withdrawals.

Increased technological efficiency and improved management prevent global water crises, but a number of regional crises arise in some of the most arid regions. Continued water degradation, lack of sanitation facilities, reduced groundwater levels, degraded ecosystems, ever-scarcer sites for new dams, and growing costs of developing new water supplies increase the system's vulnerability to crises.

Per capita material and energy consumption increase as lifestyles throughout the world become more like those in the North. Income inequality between and within rich and poor countries increases tensions, but conflicts that do occur remain largely within national boundaries.

Relative poverty decreases; absolute poverty remains at roughly its current level.

Emissions of carbon and other pollutants continue to grow, although they increase slightly less rapidly than the economy. Global greenhouse gas emissions continue to increase, but their impact is minor up to 2025; effects after 2025 become locked in, however. Although climatic variability increases and extreme weather events occur more frequently, no global crises occur as a result of greenhouse gas emissions.

The level of water pollution per unit of production gradually diminishes, but total water pollution rises significantly, driven by economic and population growth.

Changes in land use increasingly affect water resources, particularly as a result of deforestation in moist tropical areas and overgrazing in the dry lands, which accelerates soil erosion and silting of water reservoirs. Salinization continues reducing the existing area under irrigation. Critical watersheds are protected, but conflicts still arise, particularly where rainfed agriculture expands rapidly.

Integrity and health of aquatic ecosystems continues to be degraded by encroaching settlement and pollution. Structural alterations of rivers eliminate aquatic habitat and alter natural flow regimes.

As a result of excessive water withdrawals, physical habitat alteration, and pollution, the precipitous decline in the abundance and diversity of aquatic life continues.

The majority of countries maintains a policy of attempting to achieve national food security. Consequently the investment strategies emphasize local flood production through increases in irrigated areas, rather than a shift towards a reliance on international food production and trade in food.

North-South conflicts proliferate in a number of areas due to illegal migration flows, straining the international governance and negotiation mechanisms. The combination of extreme water stress, environmental degradation, and social conflict turns out to be excessive, and water catastrophes become current in a number of regions.

International conferences on water conservation and sustainable management continue to take place, but little consensus is reached. An increasing number of countries do work to jointly manage water-rich watersheds, increase water use efficiency, conserve water resources, and reduce the risk and level of conflict. However, in water-scarce international basins, cooperative solutions prove hard to find.

Under the influence of the World Trade Organization, most countries reduce water subsidies and increase efforts to make users pay for at least part of the cost of water-related services. In some places this results in increased efficiency of water used for agriculture. Policymakers find it difficult to increase agriculture-related tariffs for water or energy, and large-scale pumping of groundwater for agriculture continues.

In the countries that have privatized their water supply systems, concerns are raised about the lack of necessary investment in infrastructure and the fact that these private monopolies are poorly regulated. Community-based actions and new forms of public-private partnerships show encouraging results locally, but these efforts lack the scale and clout to tackle the water needs of larger areas. The lack of a stable market environment in most countries keeps most private companies out of the sector.

All the time the global system is becoming more and more vulnerable as a result of the increasing scarcity of water resources *per capita*, the diminished quality of water in most of the world, increasing conflicts associated to inequality and water scarcity, and the narrower resource base of healthy ecosystems.

In the second half of the BAU scenario the regional crises become more pronounced and, contingent on specific triggers – a widespread, major multi-year drought, a breakdown in the global food trading system – a major global water crisis could develop.

By the end of the period:

- Economic inequality between countries increased dramatically as has been the trend in the last decades of the 20th Century [18].
- International wealth disparity, combined with demographic growth, increased water stress in poor areas and the persistence of poverty, increased the pressures for international migration. Illegal migration from the poor to the rich countries generates mounting international conflicts.
- Key water problems of today – lack of access to safe drinking water and sanitation, recurrent flood and drought damage, high numbers of deaths from water-related diseases, drastic declines in species diversity, and so on – do not get resolved in the BAU scenario.
- The problems apparent at the beginning of the Millennium become more critical by 2025, and resolution does not appear near. The increased share of total renewable water resources used to meet increased demand, together with deteriorating water quality, added to international conflicts, leave the system more vulnerable to events that may trigger a chain of negative consequences.
- In the unlikely event that none of these triggers materialize, the world at the end of the period can be characterized as a patchy situation including regions with large numbers of people without access to basic water services, as well as regions without obvious signs of water problems.
- If, however, some triggers testing the diminished resilience of the global system exceed the tolerance levels, a global water crisis could arise and establish itself. Triggers could include a major drought (e.g. two to three years of

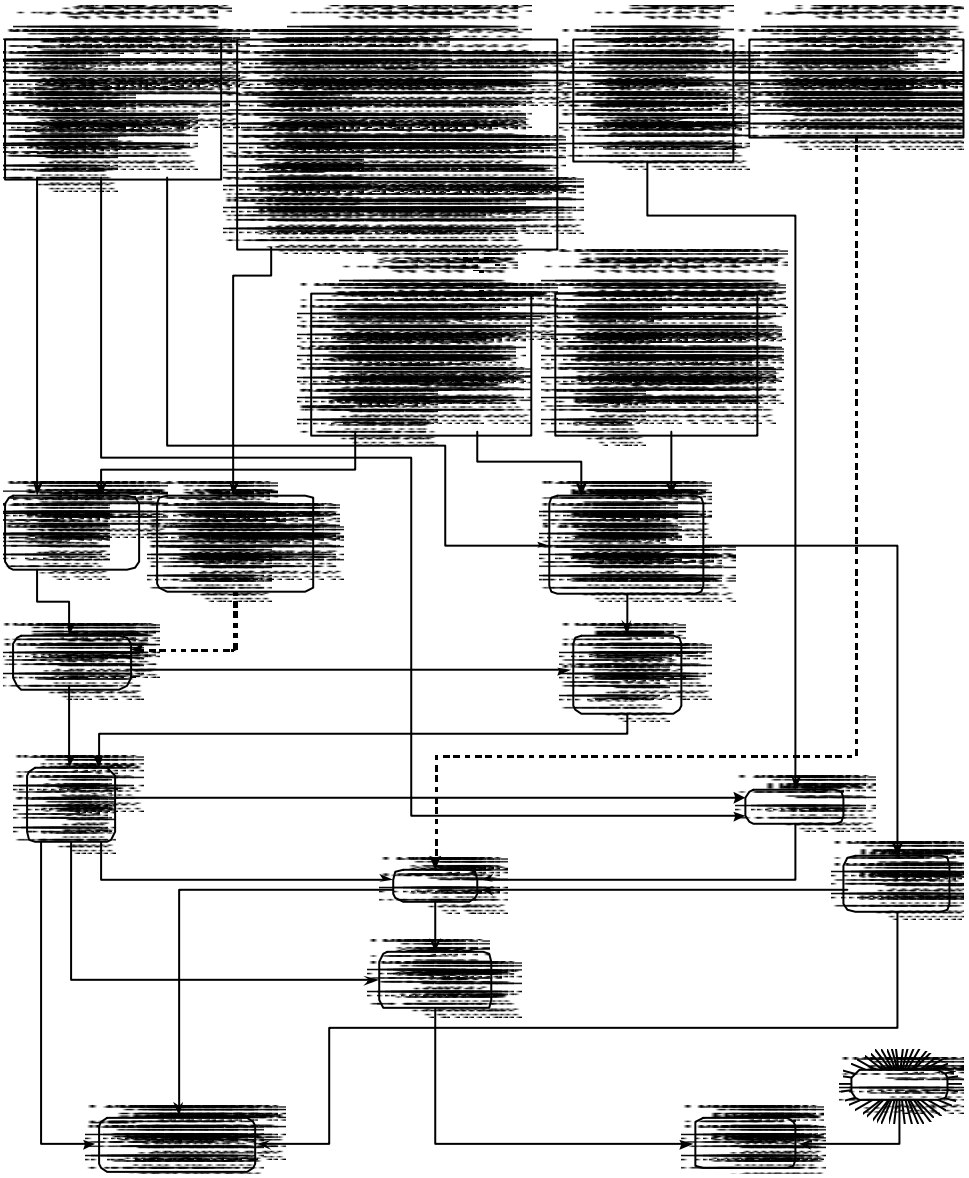
widespread drought – either natural or because of climate change), a flood, or the epidemic outbreak of waterborne diseases. The impact of one such event would initially be felt largely at the regional level, but other triggers may have similar consequences in other regions, setting off a global water crisis.

- The BAU scenario results in increased water stress and a high degree of vulnerability; at best, water crises are confined to a few regions (but involving a large proportion of the population of the world). However, events that were absorbed in the past are now capable of overwhelming the system, resulting in a global water crisis interlacing water, social and economic factors. A vicious, self-reinforcing, circle involving economic instability, inefficiency, social and military conflict, and water stress can become established.
- By 2025 the water sector is likely to be in a crisis situation in many parts of the world.

Figure 1 depicts the unfolding of the BAU scenarios in terms of causal sequences starting from the initial drivers.

In this scenario, there are two alternative images for 2025: high vulnerability with regional water catastrophes, or, contingent on the operation of triggering factors, a generalized water crisis.

Figure 1. The unfolding of the BAU scenario in terms of causal sequences starting from the initial drivers (rectangles at the top). The arrows indicate that the factor(s) in the originating box determine, influence or lead to the situation in the receiving box. Dotted arrows denote causal links that are significantly weaker than those represented by solid arrows. Time unfolds from the top to the bottom of the figure.



5 Technology, Economics and the Private Sector (TEC)

The Technology, Economics and the Private Sector scenario (TEC) is characterized by a worldview that is optimistic about the free market system, the potential of new technologies and the possibilities to regulate or limit the undesirable side-effects of both. Increased water awareness is manifested predominantly through application of economic principles to the water sector. Water pricing – or cost recovery for services provided (drinking water collection and distribution, wastewater collection, treatment, and disposal) – leads to rapid diffusion of technologies, increased capital investment and reduced demand. Increased user participation in, and responsibility for, water management at basin level through decentralized management structures balance the market forces and social and ecosystem values.

The global population follows a trajectory very similar to the BAU scenario.

The general unfolding of the scenario at the branching point in 2005 concerning economic, political and social trends is very similar to that of the BAU scenario. There is rapid economic growth in the North and in the emerging economies, but the poorer nations lag behind.

Reliance on the market becomes globally widespread. Many countries implement economic policies transferring ownership and production of services from the public to the private sector.

The key influence that directs the early changes in this scenario is an increased emphasis on recovery of costs in the water sector and the pricing of water accordingly.

By 2010 public and private utilities are generally applying full cost recovery for industrial and drinking water. Financing by the public sector continues to be required for sanitation.

Full cost recovery for pumping of fossil groundwater leads to more rational use of this resource.

It is much more difficult to get acceptance of the concept of payment of the full cost of irrigation water (the bulk of water diverted for human needs). Indirect subsidies to operation costs such as energy costs are eliminated.

By 2010, it is agreed that water subsidies be added to the World Trade Organization list of unacceptable subsidies for agriculture.

The above mentioned factors lead to a sharp increase in water prices – initially for domestic and industrial use but also, gradually, for agricultural use – that provides the key incentive for both the rapid adoption of water-saving technologies, as well as strengthening demand management on the side of users and consumers.

The higher prices in the water sector, and the widespread adoption of new technologies, increase the number of private companies that include water among their core business, and it stimulates all the economy.

Increased water prices immediately lead to reduced water consumption, limiting waste, but also provide the incentive for rapid adoption of available water saving technologies at the household and industry level. Similar changes take place in agriculture. The overall effect is that household and domestic water use declines in an absolute sense, even as coverage increases.

Desalination rapidly becomes the technology of choice (as prices fall sharply), for domestic and industrial use in water-scarce areas where brackish or salt water is close by. The same membrane technologies also replace chemical treatment for drinking water purposes.

Massive private investment in R&D results in developments in biotechnology and information technology that develop new crops more resistant to drought, salt and pests. A new generation of crops and cropping systems that require less water reduces the water needs for irrigation. As a result, agricultural output rises without dramatically expanding cultivated areas.

Governments in the South generally maintain a focus on national food-self-sufficiency, while richer nations gradually reduce their subsidies to agriculture.

In theNorth local pollution levels are brought under reasonable control.

The clearing of tropical forests for agriculture slows down due to the increases in agricultural yield and the expansion of new crop varieties allowing cultivation in drylands already under use.

Private sector interests, in alliance with environmental NGOs, are protecting large areas of ecosystems in the South to restrict their use.

Environmental quality in urban areas in emerging markets is improving as income levels go up, but, in the absence of strong governmental guidelines and regulation, follows a similar cycle as was observed historically in the North, i.e. qualities first go down to appalling levels before they get better.

Water quality improves in many cities in the North, but the cost of cleaning up rivers running through cities in the South is generally seen as prohibitive. In the latter, increased reliance is put on filtration of drinking water using membrane technology, rather than stopping pollution. This somehow solves the domestic water problem, but leads to widespread destruction of aquatic ecosystems.

The proliferation of multi-stakeholder river agencies leads to more sustainable management of watersheds and the protection of the catchment areas.

Truly global problems such as climate change are not really tackled due to a lack of global leadership. The world is locked into climate impacts that begin to emerge by 2025 but that are becoming inescapable later in the century.

The role of development aid is increasingly taken over by the work of charitable foundations. The total finance flows never approach the historical levels of the official development assistance (ODA) that was previously provided through multilateral and bilateral channels; charitable foundations make a difference in emergency relief, health care and primary education, but cannot prevent an overall decline in the poorer areas of the world.

Large areas in Eastern Europe, Asia and Latin America ‘catch up’ with the North and become integrated in the globalized economy.

Later in the period the poorer countries lag more and more behind. The private sector has only limited interests in their markets and the chronic government instabilities are a serious detractor for private sector investment.

The influence of the national and transnational private sector grows quickly, favoured by increasingly permissive legislation and the opening of the global markets.

The role of the United Nations and international financial organizations is further marginalized as private sector involvement increases, aid-flows dry up, and an effective answer to the problem of fragmentation among the many organizations involved in water remains beyond the grasp of the international community.

The lack of credible organizations at an international level in every sector except trade (WTO) results in regional conflicts among smaller and poorer nations being neither prevented nor resolved. Only when such conflicts arise within, or very near to, the big economic blocks in the North is effective action taken.

Later in the period, consumer reaction to the increasing concentration of power into the increasingly large private sector leads to the establishment of basin-level management structures with stakeholder representation to regulate the private sector. They become the key actors in setting prices and negotiating service contracts with the private sector. However, lacking international governance and guidance, basin-level agencies negotiate interbasin transfers with neighbouring agencies on an *ad hoc* basis.

Enforcement by government regulatory agencies at local, regional and national levels is still required to resolve a number of conflicts such as those between upstream and downstream users. This leads to considerable conflicts and inefficiency.

By 2025:

- Global economic growth is strong, with the emerging markets in Asia and Latin-America catching up with the North, but the poorer nations, particularly in Africa, lag further and further behind.
- Literacy levels are raised on a global average basis, but there are sharp regional variances.
- Poverty is reduced in a number of regions, but increases sharply in some of the regions excluded from the flows of private investment (mostly the poorest of the poor countries). Income inequality, both within and between countries, increases everywhere. Some community and basin-scale NGO and private sector activities begin to redress the balance.
- Food production increases on a global scale, and a beginning is made with irrigation water cost recovery in the North and in middle-income countries, but changes are limited in the low-income countries where food shortages become more serious.
- The influence of the private sector on water supply increases, increasing the number of the urban served, but at the same time excluding those unable to pay for the services. Governments as well as stakeholders are beginning to realize and address the unintended side-effects of privatization (related to the social aspects of water) through strengthening basin-level agencies.
- There is no water scarcity on a widespread basis because the combined effect of water pricing, demand management, water-saving technologies and biotechnological solutions to food production, have sharply reduced the water intensity of most human activities.
- Many of the emerging economies become part of the globalized economy and while these may not enjoy acceptable water qualities in all their urban areas, the trends are encouraging.

- A lack of global leadership and governance leaves many problems of the poorer nations unaddressed and the efforts of the charitable foundations are insufficient to stem the tide for all but a few specifically targeted issues.
- Water sustainability is reached at the cost of social sustainability, since a large section of the poorer nations is left out.
- There is a polarization between upstream and downstream countries in international basins, and a polarization among water rich and water scarce areas, as conflicts multiply in the absence of credible international mechanisms.
- The key trends in the water sector have initially bypassed a considerable number of low-income countries, where local or regional water crises are becoming part of everyday life. Government led initiatives, and international action, are required to amend this.
- Local environmental issues are being adequately addressed in the North and a number of the Southern countries. However, aquatic ecosystems are seriously degraded in many cities in the South, as the quality of drinking water (obtained by membrane filtration) becomes delinked from ecosystem health.
- Global and international environmental problems are not being solved.
- The ultimate success of this scenario will depend on the strength and effectiveness of governmental and societal actions required to correct the negative social trends.

Figure 2 depicts the unfolding of the TEC scenario in terms of causal sequences starting from the initial drivers.

6 Values and Lifestyles scenario (VAL)

The Values and Lifestyles scenario (VAL) assumes that a strong commitment to averting a water crisis emerges early in the new Century, focused on reaching a set of global and regional targets. The emphasis is on a revival of the fundamental human values and changes in lifestyles in accordance with them.

At the national/local levels the key strategic direction is a strong emphasis on education and capacity-building as the pathway to establishing sustainable values and lifestyles. Community-level action gains prominence in managing the watersheds, harvesting rainwater for agricultural and domestic water use, and protecting ecosystems.

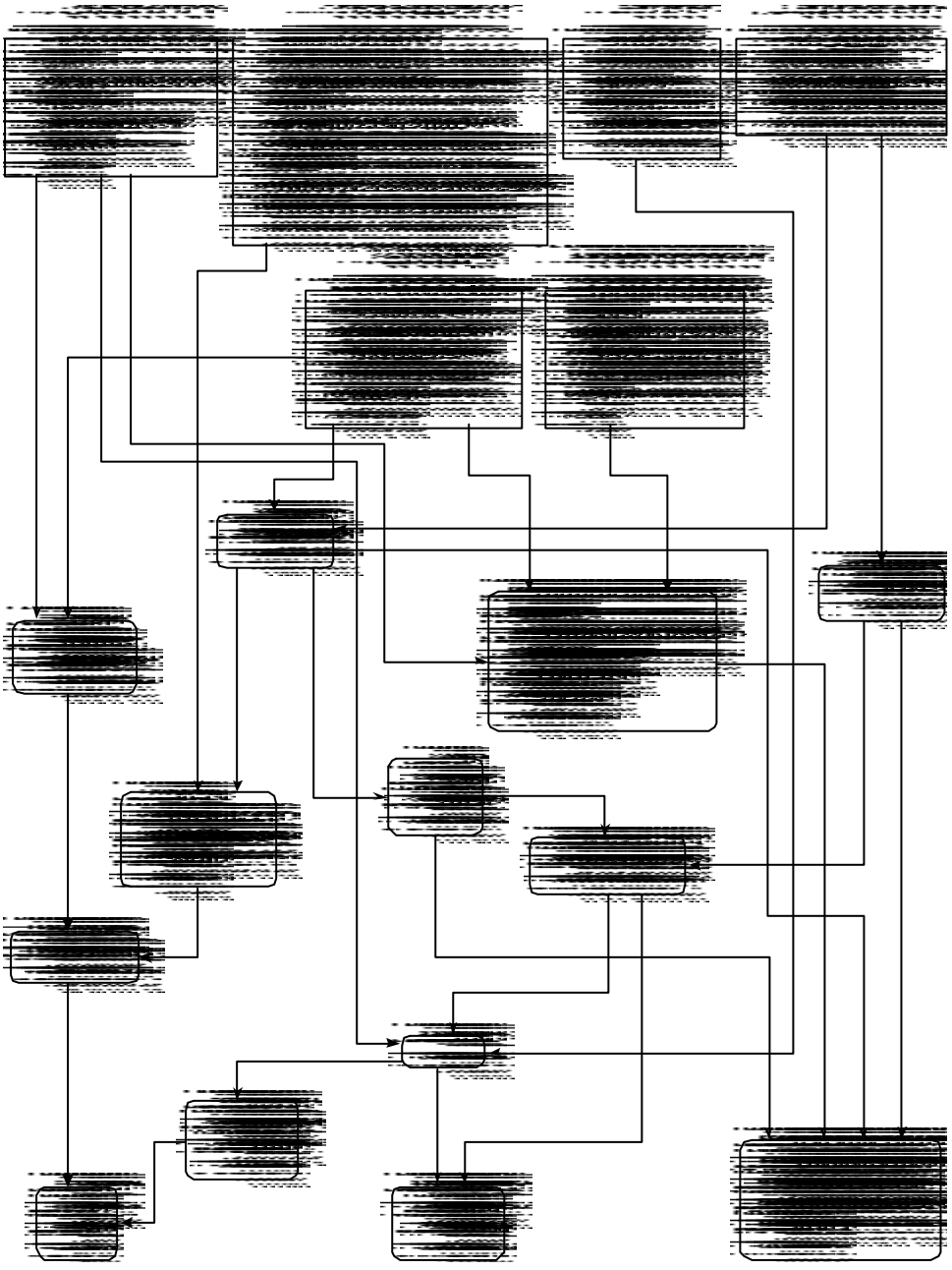
6.1 The motivation

There is little doubt that humanity could solve its major water problems if only it could agree on the task and muster its energies towards it. The major difficulty is identifying a course of events that leads from the current situation of general indifference to a 'take-off' level of global solidarity. Despite many commendable initiatives, the overall trend is towards

reduced cooperation for development and even for emergency relief, with terms like ‘donor fatigue’ popping out with increasing frequency.

A number of alternative developments could result in an increased awareness of the problem – and willingness to act on it – which is required to trigger the transition to a higher stage of human civilization within the time frame considered. Some of them are identified below.

Figure 2. The unfolding of the TEC scenario



6.1.1 Evolving awareness

The process in this case is the increasing awareness of the imminent problems, together with the realization that the solution of the complex set of water issues cannot be achieved without addressing the interlinkages between technological, demographic, economic, social, environmental and institutional issues.

Widespread awareness of the coming water problems combines with new scientific evidence showing that large-scale shifts in the global system are both possible (in fact, had occurred in the geological past) and increasingly likely. This reinforces concern that changes in climate, life-support systems, and public health might already be building up, and will be larger, sooner and more sudden than previously thought.

6.1.2 Confrontation

At the same time that awareness of the water problems increases, perception of other ominous trends starts to spread out: the promises of the globalization process and of prosperity brought by the free market are not for all. Large populations in some of the poorest countries are bypassed by the private flows of capital, are excluded from the global economy, and become increasingly vulnerable to all sorts of environmental stress and health hazards.

Concerns increase sharply when an unusually extended drought affects Southern Europe and North Africa simultaneously. Extended mortality and economic fracas in the African countries contrast vividly with quickly organized safety nets and economic compensation provided for the European population. The situation quickly becomes a symbol for the poorest nations, and particularly those already confronted with water shortages. A wave of rebellion sweeps through the deprived sections of the population, as they feel that they have nothing more to lose. Political leaders join forces with religious movements and start low-key, but escalating, hostile actions against the richer groups and countries.

The world sees itself at the brink of a Third World War, this time a very unequal one, between the desperately poor and the rich. Although there are few doubts about who the winner will be, everybody realizes that the war could be very long, nasty, and will leave deep scars for generations to come.

6.1.3 Plague

A breakthrough of a new disease associated with polluted waters acquires epidemic proportions and sweeps the world. The disease is air-borne, highly contagious, and produces permanent brain damage. Full eradication proves impossible and the only effective control is through the elimination of its breeding habitat (polluted water). This cannot be achieved without addressing the issue of development and coverage of the basic needs of the population.

6.1.4 New understanding

The analysis of the structure and behaviour of complex systems (coupled climate-oceans-vegetation systems, social and ecological systems, large scale transport and communications systems), combined with theoretical breakthroughs in the mathematical analysis of complexity, results in a new understanding of the laws of complexity. At the same time, advances in hydrological modelling and remote sensing produce detailed forecasts showing that the water problem has been underestimated and urgent action is needed.

It becomes evident that human civilization has passed a critical threshold of complexity. The emerging ultra-complex socioecological systems could never be managed in a centralized form; it requires a new style of governance, based on decentralized, co-operating networks. The theory convincingly shows that the existence of large inequalities threatens the functioning and even the survival of the governance network.

6.2 The actors

All major social actors are involved in the process: governments, NGOs, business, unions, religious groups. However, different actors could play the initial leading role, depending on the course of events that resulted in the raised motivation and the particular circumstances of the different countries and regions.

6.3 The response

A growing consensus by governments, business and the public about the threat of environmental and social unsustainability develops. The conviction grows that economic profit and even the broader concept of economic development is not sufficient; for global sustainability, environmental stewardship and social improvement are also urgently needed. The fragmented responsibility for water at UN-level is reorganized and the rejuvenated UN-system regains authority as a catalyst for change at the international level.

NGOs join the discussions, and organize world-wide electronic debates on alternatives to consumerism and antagonism, later attracting the attention of political and religious leaders and business CEOs. The international, multicultural sharing of experiences, aspirations and proposals develops, and this process of sharing and mutual understanding provides a solid platform for reform of water resources institutions at the basin level.

Gradually, a global debate begins to take place, identifying a core of shared goals for the long-term survival of civilization. Major business groups, realizing that the capacity to make sustained profit requires social stability and general economic prosperity, actively participate and make resources available.

A period of effervescence and dialogue ensues, with debates going on simultaneously at all scales from the local to the global.

A growing consensus is expressed by world leaders, UN-agencies and the NGO and business communities that lead more and more governments to adopt a set of principles guaranteeing basic water rights for people and ecosystems, for implementation at basin level.

Three major initiatives gradually take shape supported by governments and citizen groups:

- an *economic bargain*, under which economic growth will accelerate in the developing world, while dematerialization of the economy in the North takes place;
- a *knowledge push* – a global network of scientific research cooperation called Water Science for Sustainable Development is established;
- a *governance process* – in the new economic arrangements, markets are used to achieve production and allocation efficiency, but within the limits of non-market constraints defined by social, cultural and environmental values. Bottom-up, self-organizing, interconnected, governance networks evolve.

Pluralism and decentralization are seen as the cornerstones of the evolving governance systems. Decisions are devolved to the local level as much as possible; only the minimum set of higher-level rules is maintained, as necessary for the operation of the interconnected systems at multiple scales.

6.4 The unfolding of the scenario

Massive access to education by women leads to a voluntary reduction in family size in countries with rapidly growing populations. By the end of the period the global population shows clear signs of levelling off.

Economies in the North intensify the process of dematerialization by increasing the relative share of services, reducing the resource-intensity of technology, and reducing *per capita* material consumption (as part of moving away from consumerism). In the South, material throughput increases initially, in order to satisfy the basic needs of the population, but it never reaches the high levels of the industrial societies in the late 20th Century.

Global economic growth is initially somewhat lower than in the conventional water world, but more resources are devoted to the South, which grows much more rapidly than the industrial countries.

Official development assistance is partly replaced by direct private investment, and partly redirected to the poorest countries. Public–private partnerships become increasingly important in technology transfer.

A global food security system is developed that provides reasonable food-security at affordable prices for countries that do not grow enough food within their borders. This leads many countries to gradually relax their national food self-sufficiency objectives and redirect their investments. Globally, trade in food rises rapidly and food is grown increasingly in areas where the hydrologic and land conditions enable high productivity at low risk and with relatively low input levels.

Multinational and transnational corporations thrive; many NGOs and community-based organizations start to create meaningful alliances, among themselves and with other sectors of society.

By 2025 total water diversions in the developing countries to meet agricultural, domestic and industrial requirements, increase about one fifth over the 1995 levels, in spite of the lower population growth. Diversion to

domestic and industrial uses constitutes two-thirds of new diversions; most is returned after treatment to the ecosystems from which it was drawn.

Governments, watershed organizations, and local communities explore alternative combinations of water pricing, taxation, voluntary contributions, and cost-sharing schemes to foster efficient use of water, based on the principle of integrated management and application of long-term discount rates.

Investment in science and technology—and the greater cross-fertilisation across cultures and historical experiences facilitated by improved telecommunications—yields a new wave of scientific and technological innovations.

These are oriented towards sustainability and durability, as short-term profit is replaced by longer-term economic rationalities. As a consequence, technological growth and adoption is somewhat slower than in the TEC scenario, but the quality of the technology is more appropriate for sustainable development.

The dialogue that is established between scientists and the holders of traditional knowledge forms a cornerstone of many innovative resource management practices.

Innovative agreements that protect intellectual property sufficiently to encourage development of new technology while allowing knowledge to be widely available are made.

Increased reliance on smaller-scale, supplementary irrigation systems to reduce risks combined with seasonal drought forecasting, shift the focus to rain-fed agriculture as a main strategy for increasing food production. Supplementary irrigation starts with community-level catchment management, rainwater harvesting, recharge of aquifers, and uses small farmer-operated pumps, combined with efficient irrigation technologies, to manage water sustainably.

New technologies are generated that incorporate high-tech developments into existing technologies ('technological blending'). As a result, traditional technologies that were socially and ecologically sustainable but not economically efficient become viable. An intensive scientific and technological effort is made directed to the transformation of the current subsistence agriculture into a sustainable peasant agriculture, applying high-tech solutions in combination with traditional techniques.

The application of ecological research to agriculture and industrial production results in new eco-technologies that are used in factories, agro-ecosystems, and watersheds. These technologies embody the principles of ecosystems (using the waste products from one process as raw materials in another, cascading industrial processes so that water is reused, and so forth) and are economically efficient.

Technological innovation starts to concentrate on bio-systems that efficiently produce the resources necessary for life. Increasingly, bio-systems are used to capture water and produce food, medicines, molecules with specific properties, and water-efficient ecosystems.

Strong priority is allocated to the development of non-exhaustible and renewable sources of energy (solar, photovoltaic, hydrogen, biomass, hydro, etc.).

A major effort is made to make the best existing technologies widely available. As a result, water efficiency and, particularly, productivity increases dramatically, particularly in the developing world. Contrary to the TEC scenario,

technological diffusion is deliberately comprehensive, including mechanisms to help poor countries to finance their technological transformation.

Good management, transparency and accountability are standard. Inexpensive water-efficient equipment is widely available. Rainwater harvesting is applied broadly. Cheap and effective solar powered desalination is used in many arid and semiarid countries for domestic water supply and is increasingly affordable even for irrigation.

Water supply and sanitation are de-coupled and waterborne sewerage systems are viewed as only one among many alternatives, rather than the standard design. Municipal water supply is supplemented by extensive use of reclaimed urban wastewater for non-potable uses.

A number of countries by 2025 have developed cost-effective methods for recharging groundwater.

By 2010 the large amounts of water-related information available on the internet are managed by networks of experts and resource managers who categorize information and distribute regular updates on, for example, contacts, projects, laws, methodologies, tools and best management practices. Under the guidance of a United Nations Co-ordinating Committee on Water Resources, hydrological data is routinely collected.

More efficient production processes support lean productive systems that use fewer resources. Ecosystem restoration and rehabilitation becomes a leading sector of the economy. As a result, environmental quality improves significantly. While not all ecosystems can be recuperated, many new, large-scale sustainable ecosystems evolve.

Community level watershed management and rainwater harvesting provide sustainable livelihoods to tribal and indigenous peoples. This also drastically reduces sedimentation of reservoirs, recharges groundwater aquifers and provides increasing protection of biodiversity.

Agreements are reached on international mechanisms that tie redistribution of wealth to meeting globally agreed-upon environmental targets.

Since 2010, investments in the rehabilitation of rivers, lakes and wetlands have increased and now contribute in many places to restoring the environmental goods and services these ecosystems provide. Through various means, including artificial wetland systems and vegetated buffer strips along riverbanks and lakeshores, domestic effluents and agricultural runoff are controlled and purified.

Strong emphasis is placed on education as the pathway to developing sustainable values and lifestyles.

By 2025 almost every woman and man, girl and boy in the cities, towns and villages of the world knows the importance of hygiene and enjoys safe and adequate water and sanitation. People at local level work closely with governments and non-governmental organizations. Everywhere in the world, people live in clean and healthy environments. Communities and governments benefit in terms of economic development as well as by improved health.

By 2015 children are leaving school aware of the interconnectedness of their actions with the environment. The view is commonly held that decisions taken collectively should be made with due consideration, not just for the next generation but for many future generations.

Many of the water-related diseases that were rampant at the end of the 20th Century are finally conquered. Revitalized international efforts to meet people's basic water and sanitation requirements have been combined with

effective promotion of hygiene practices. Improved primary health care and pollution control have greatly reduced both the prevalence and severity of many diseases.

Changes in lifestyle at consumer level lead to dietary changes towards more vegetarian ('Mediterranean') diets and a shift from red meat towards white meat in the North, and increase willingness to pay for ecosystem protection. In the South meat consumption rises initially, and later tends towards stabilization. Food is imported when water scarcity precludes local production.

Trends toward institutional change and social solidarity consolidate, and deeper changes develop. Distributed forms of governance evolve through trial and error, and mechanisms for decision-making are established from local to global scales. Within this bottom-up nested structure, regions and communities have considerable control over socio-economic decisions and approaches to environmental preservation, which are constrained only by the impacts on larger-scale environments and processes. Local energy systems, for example, vary greatly, but they must meet *per capita* greenhouse gas emissions guidelines, which are set by global-level agreements. Local water strategies are required to be compatible with allocation rules and ecosystem goals set at the river basin level.

Negotiation, collaboration, and consensus resolve conflicts. As armies are cut back and defence systems become less costly, a massive peace dividend is channelled towards the transition to sustainability and the eradication of poverty.

Global governance is based on a federation of regions, which, through a renewed United Nations, effectively fosters co-operation, security, and environmental quality.

The governance system gradually becomes a very complex web of networks within networks. There is no global *government*, but rather a distributed function of *governance* based on interacting self-organizing nets at different scales from the local to the global. Some of the nodes of the global web are governments, some are NGOs, some are businesses, some are special interest groups. But most of the nets are pluralistic, comprising different social actors.

As the network of communities evolves and organizes itself at different levels (local, sub-national, national), new ways of managing water and other resources, involving technological solutions combined with structural institutional changes, become possible.

New forms of community-based water management are introduced as pilot schemes. The traditional culture of desert people, and the traditional techniques in monsoon areas, are studied to learn more about efficient water harvesting and patterns of social and individual use of water.

Empowered communities and individuals, both women and men, participate regularly in all levels of decision-making related to water resources management. Laws, markets and regulations increasingly recognize local people's rights and needs, making sustainable use of natural resources possible, and reconciling livelihood needs with ecosystems functions and requirements.

Total water withdrawals stabilize at a sustainable level, as a result of cultural, economic, and technological changes. Effectively available annual renewable water resources increase through catchment management and water harvesting that recharges groundwater aquifers. Water intensity (water use per unit of 'production') reaches an historical minimum.

By 2025:

- Global economic growth is strong, particularly in the developing world.
- Literacy levels are high throughout the world, as education is made a priority.
- A global communication network connects the people of the world.
- Few high-visibility water-related catastrophic events still occur.
- Crops require less water and are more resistant to disease and pests.
- Absolute poverty has been drastically reduced.
- 95% of people have access to hygiene education, and at least a latrine and 40 litres of safe and affordable water. The same percentage have access to affordable minimum nourishment.
- Aquatic (and terrestrial) ecosystems are no longer deteriorating. In many places, they are beginning to recover.
- International co-operation is strong and increasing.
- Public-private partnerships proliferate.
- NGOs and community-based organizations are part of global networks.
- Water withdrawals have stabilized and water intensities have fallen.
- Innovations and participatory ownership, entitlement and management systems for land use and common property resources are in place.

Figure 3 depicts the unfolding of the VAL scenario in terms of causal sequences starting from the initial drivers.

7 Conclusions

The three scenarios analysed here span a wide range of possibilities, and all of them are plausible to a significant degree, according to the experts from many areas who have been involved in their development or commented on them.

Although, as emphasized at the beginning, scenarios are not really predictions, but explorations of the future based on our present understanding and embodying a certain worldview, it is possible to draw some preliminary conditions from this exercise.

First, qualitatively different future trajectories are possible within the next few decades. This contrasts with many discussions and projections of the long term future, which seem to assume that only small variations around the dominant ‘official’ trajectory are worth considering.

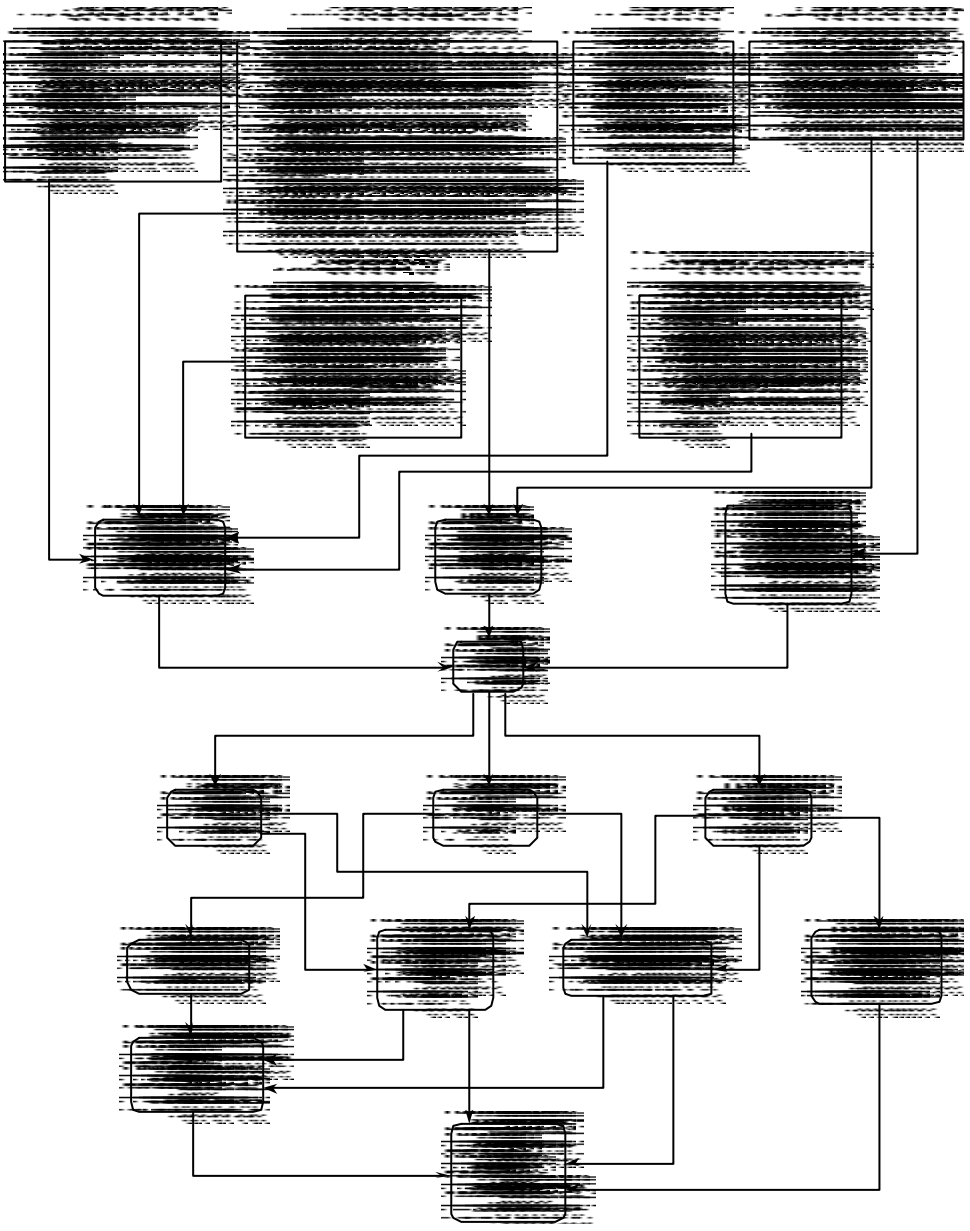
Second, scenario analysis highlights the difficulties involved in solving or even mitigating the water problem. The BAU scenario, even with rather optimistic assumptions on economic growth and water technology, ends, in the best of cases, in a situation with regional water crisis and, in the worst case, in a global water/economic/social crisis.

The TEC scenario, spearheaded by business and trade, would require unprecedented efforts and investments. Even if these are made, the result would be a solution of the water problem at a high social and political cost, and the permanent establishment of a dual society, unless strong and continued governmental actions (which are somewhat at odds with the logic of the scenario) are implemented.

The VAL scenario, although the best in terms of long-term results, would require changes of such magnitude in the currently prevailing consumerist and economical values that unless a sharply increased level of awareness and motivation somehow occurs, they are difficult to imagine The dilemma is, of course, that it may well be that sustainability cannot be obtained without a massive change in lifestyles, reducing the emphasis on material consumption as an overriding goal, and without an effective application of basic human values shared by all cultures among the world.

The common thread is that very important changes are required in all cases to solve the water problem (which may be, after all, only the first of a new generation of global and interrelated problems), and that the possibility that the problem will not be solved but will aggravate cannot be seriously excluded.

Figure 3. The unfolding of the VAL scenario



Another general conclusion of the analysis recognizes the urgent need to change perspective towards an integrated, systematic approach to the water issue, not only in the realm of understanding, but also in the actions.

This implies integrated management in three areas. First, decisions on land use also affect water, and decisions on water also affect the environment and land use. Second, decisions on our economic and social future, currently organized in a sectoral, fragmented manner, affect the hydrology and ecosystems in which we live. Thirdly, decisions at the international, national and local levels are interrelated. Sustainable management of water resources requires systemic, integrated decision-making that recognizes the interdependence of decision-making in these three areas.

The identification of a set of critical uncertainties helps to define strategic areas for understanding and implementation.

Finally, the scenarios presented here may be useful as a common framework for diverse stakeholders to map and address their critical concerns and to identify alternatives, and as a forum for discussion and debate, a forum that is both transparent and comprehensive.

Acknowledgements

A first set of three global scenarios to initiate consultations on a World Water Vision were developed by the Scenario Development Panel at meetings held in September and November 1998 and written by Gilberto Gallopin and Frank Rijsberman. The Scenario Development Panel consists of: Ismail Serageldin (chair), Frank Rijsberman (alternate chair), Gilberto Gallopin (secretary), Jacob Adesida, Joe Alcamo, Nadezhda Gaponenko, Peter Gleick, Jerry Glenn, Stela Goldenstein, Allen Hammond, David Seckler, Igor Shiklomanov, Jill Slinger, Sree Sreenath, Ken Strezpek, Isabel Valencia, and Rusong Wang.

The first set of scenarios was used widely in the World Water Vision development process and discussed at the first meeting of the World Commision on Water for the 21st Century in March 1999. In response to comments received and new information that became available through the Vision process, revised scenarios were developed iteratively through four rounds.

The Swedish International Development Agency provided financial support for the work of the Scenario Development Panel. A number of people other than the panel members provided inputs by attending panel meetings or commenting on earlier drafts of the scenarios. They include William Cosgrove, Wendell Bell, Leslie Martin, Ron Knapp, John Briscoe, Howard Hjort, Asit Biswas, Peter Rogers, Sandra Postel, Malin Falkenmark, Walther Falcon, Wilfried Thalwitz, Guy Le Moigne, Ruud van der Helm, Mike Mesarovic, and Subhrendu Gangopadhyay.

The World Water Vision exercise is a programme of the World Water Council.

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