On The Verge of a New Water Scarcity

A call for governance and human ingenuity

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- a call for governance and human ingenuity

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In spite of the fact that physical water scarcity is a dire reality for millions of people, it is still not properly understood nor recognised in many front line discussions. An unfortunate confusion regarding an expanding physical water scarcity distorts policy formulation and effective action programmes. The scale and magnitude of the challenge imply that "water scarcity is everybody's business". This paper looks closer into the issue, offers a set of distinctions and concludes in structured policy suggestions.

CONFUSING DEBATE – BACK TO BASICS

Is physical water scarcity an overlooked problem?

A future-oriented debate about water scarcity as a growing global problem of tomorrow's world grew out of some articles in the international journal Ambio in the mid 1980's (Falkenmark 1984, 86, 89). The start of the debate took its point of departure in the natural water scarcity, but during 20 years of debate the focus has been more on the lack of good governance than on the importance of possible constraints in terms of water as such. The latest such example is the recent UNDP:s Human Development Report 2006, "Beyond scarcity: Power, poverty and the global crisis". That report - after looking at scarcity in two senses: lack of safe water provision services and scarce water resources, concluded that the world's water crisis is not a crisis of physical water availability but, rather, is entrenched in asymmetric power relations, poverty and related inequalities. The increased focus on governance has pointed towards issues such as power structures, weakly defined roles, rights and responsibilities that often exacerbate the natural water scarcity. It has been useful in that it has paved the way for and increased our understanding of the need to *manage demand* and not only to *increase supply*. Nevertheless, while the governance challenge is still a key future challenge we need simultaneously to increase our comprehension of the 'water crowding', i.e an increased pressure on a finite, erratically available and vulnerable resource. For proper policy formulation, we should recognize that it is not water that is to blame but the augmented demand on it.

In many regions and countries of the world there is still a tendency to instinctively reach for supply-side solutions such as dams and other large scale infrastructure or desalination rather than to address ones own management/governance problems. Indeed this is often the politically feasible option within the discourse. In certain situations and as elaborated below, supply oriented approaches will be needed. However, as will be argued here any sensible approach to increased physical water scarcity is to, before going into supply side solutions, adapt a range of demand management measures such as decreasing water losses in systems, reconsider the volumes of water allocated to agriculture, reducing water losses in soils (i. e. improved green water use) etc.

The World Bank is presently attracting increasing interest to the escalating scarcity of water in the Middle East-North Africa region (World Bank 2006). Several studies have sounded alarms about how little water is available in the Arab region, warning that the problems may worsen as competition for limited or degraded resources intensifies. Moreover, Rijsberman in his recent overview of global water scarcity analyses (2006) concludes that up to two thirds of the world population will be affected over the next several decades. He raises the final question "whether this debate will help increase water productivity". Arguably, in many instances in the MENA region, as well as in other regions, improved water governance and demand management would effectively address much of the water scarcity problems. However, only governance could not be considered a panacea, at least not in a long-term perspective.

Massive global change adding new dimensions

The ongoing global change has multiple dimensions: it combines climate change, influencing physical water availability with two parallel changes, influencing demand: a massive increase in world population, mainly concentrated to semiarid regions, and an oil-peak-driven emergence of a water consuming biofuel sector.

It is indeed fair to assume that physical scarcity will involve massive challenges for the developing countries located in semiarid regions, subject to rapid population expansion and expectations for poverty eradication and improved quality of life. A fundamental question is to what degree water scarcity might delay or even hinder their socio-economic development. Examples such as Israel (living with a high level of water shortage) suggest that water scarcity in itself is not a limitation to economic growth in itself. The case of Israel rather directs us outside of the water sector. It has been noted that diversification of a country's economy and the related social adaptive capacity is more important than water availability *per se* (Allan, 2001). However, in many poor developing countries, the role of agriculture, large water consumer as it is, represents a backbone in the process leading to decreased poverty and to development. While physical availability to a large degree is the product of climate, demand is the product of size of water-dependent population, of competing sectors of society, and of water productivity.

Climate change may make water short regions even shorter

Although climate change is expected to accelerate global water circulation with precipitation on the average increasing, projections of future precipitation are however seen as too uncertain to incorporate in future water scenarios (Alcamo et al 2000). Severe regional modifications may be expected however by dry climate subtropical zones extending towards higher latitudes, making the MENA region even drier. Moreover, both Vörösmarthy et al (2000) and Wallace (2000) consider that impacts in terms of increasing water stress and water shortage from projected population growth and economic development will dominate over the impact from climate change alone as seen on a global scale. though the expected warming in different regions are still highly uncertain, increasing climate variability will amplify temporary water scarcity (but also floods). Brown&Lull (2006) have recently suggested that water scarcity due to mean hydroclimate conditions should be addressed through water management and institutional measures (soft methods), while scarcity due to variability often requires additional storage (hard methods).

Time to prepare for multiple water scarcity?

Thus, the fact that water is a pivotal element in poverty reduction is generating increased concern for the effects of water scarcity on socio-economic development prospects. At the same time, we know that throughout history, societies have adapted and grown in the face of water scarcity. If we are on the verge of a new and more serious water scarcity era, which can be foreseen as a result of a combination of climate change, demography and new demand (e.g. for bio-fuels), it will involve more and more complex challenges with both water supply to various sectors due to blue water scarcity, and food and biomass production due to green water scarcity. Evidently water governance will have to be flexible enough to allow that best possible use can be made of the factual water resource at every moment in time.

Water professionals and of policy makers and politicians will all need to find out the *possibilities to cope*: Will water scarcity ultimately put a brake on economic development? How large will the food production problems be? How can the intersectoral competing interest for water be managed ('more crop per drop' approaches and 'more money/value per drop' approaches) Where are the impediments to increased demand management? How much can water productivity realistically be increased? How could changing consumption patterns affect the situation? What regions will suffer from food production problems due to water shortage, and what are the prospects for food trade (cf virtual water)? How will the massive global changes influence the situation?

In order to discuss these issues we need a better understanding of the precise challenges, degrees of freedom and potential constraints, physical, environmental, political, social and economic. Against this background SIWI aims in this paper to contribute in generating awareness and analysing the adequate policy responses. The new perspective analysed contains the marrying of both blue and green water scarcity challenges and their related governance and policy responses. It will show the relevance of water scarcity concern, explain the phenomena and the driving forces exacerbating the problems, discuss what the different policies might be, and come up with a set of recommendations to the international community.

WATER DEFICIENCY – SYMPTOMS AND SCALE

Scarcity of what?

Much of the debate has been quite confused by different interpretations of the concept of water scarcity. It has been thought of as related to difficulties to mobilise more of the freshwater resource in view of infrastructural challenges and costs, to the relative size of the population competing for that resource, to household water delivery problems, to food production deficiencies etc. Other studies have claimed that even if water is not physically scarce, societies may suffer from deficiency in their proper use of this resource due to a scarcity of social resources, acting as a bottleneck in making use of the water there is (Ohlsson&Turton 1999).

Water deficiency in relation to water requirements can indeed have many different causes: failing water provision, demand increase, droughts, land degradation, population growth, pollution, emerging sectors of additional demand etc. Experience suggests that water scarcity complicates economic development and limits food production potential.

Soil water deficiency has controlled human life forms in rainfed regions

Freshwater availability originates from rainfall which is therefore the ultimate water resource. In that sense water availability is to a large degree climate controlled. Water in the soil (so called *green water*) is formed by infiltrated rain, and water in the rivers and aquifers (so called *blue water*) by the rainfall that escapes evaporation. Areas vulnerable to water scarcity are primarily low latitude areas with high evaporative demand (**Fig 1**)

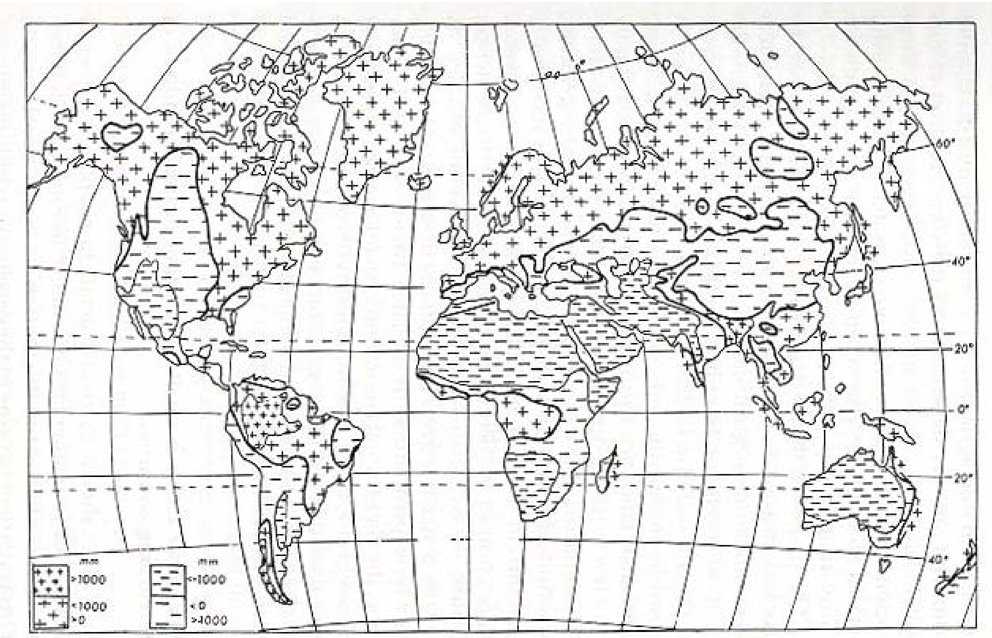


Fig 1.World hydroclimate shown as the surplus of precipitation over evaporative demand. Minus signs indicate arid climate

Water's central role in socio-economic development and production of food puts water at the very centre of life itself. Historically, green water/soil moisture conditions have in fact been decisive for human life forms in the Subsaharan gradient zone between the desert and the rain forest. As long as rainfall could not support a plant cover during the wet season, only nomadism or transhumance used to be possible life forms. Only where there is a surplus of rainfall that allows food to be grown, sedentary agriculture was possible. In the modern world things are different; countries can switch to other types of economy.

Thus, symptoms of green water scarcity may be crop failures, hunger disasters, undernutrition, savannisation of the vegetation etc. It is illustrated by the fact that poverty and hunger tend to be largest in arid climate regions, dominated by unreliable rainfall, monsoon climate, and high evaporative demand, i.e. regions with savanna type climate, see **Fig 2**.

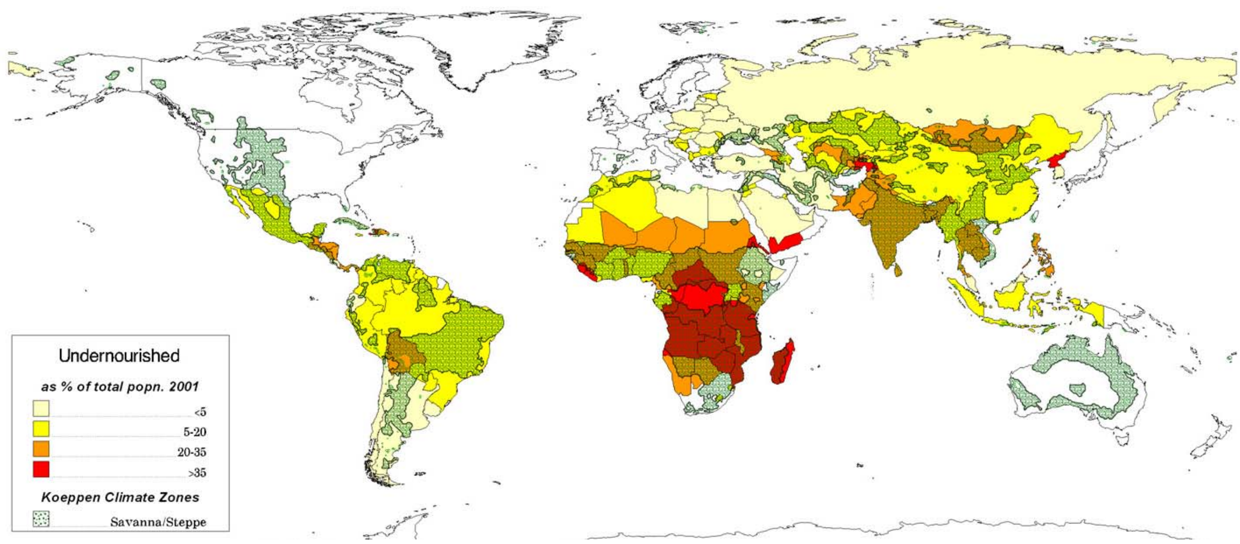


Fig 2. Undernutrition is to a large degree concentrated to the region with savanna and steppe type hydroclimate

Blue water scarcity – growing competition for water in rivers and wells

Symptoms of blue water scarcity are different and may take the form of water supply collapses, crop failure on irrigated fields, closing river basins, increasing costs in the national economy for infrastructures needed to make more water accessible for economic use, stakeholder disputes, increasing water pollution due to lack of dilution water, etc. A contributing factor to blue water scarcity is the fact that consumptive/depletive water use (Lannerstad 2002; Falkenmark&Lannerstad 2003) has been expanding so that in many regions there is now no water surplus left, while population continues to grow and expectations are escalating. Many rivers are going more or less dry in the downstream end, indicating that the Aral Sea trauma may in fact be duplicated in many regions unless the problem is properly analysed and countered. At the Third World Water Forum in Kyoto, IWMI/IUCN/WRI presented a map showing that over 15 percent of continental land, the rivers were already overappropriated in a broad belt all the way from NE China to Mexico and SW USA (Smakthin et al 2003). Recently, a similar analysis resulted in a global map with a 0.5 times 0.5 degrees resolution (Oki&Kanae 2006).

As already stressed, strong driving forces are at work that can be expected to escalate further water scarcity and its different symptoms. From a blue water perspective, population growth and the increased water demand that follows, will form a ”thumbscrew” on the available water. As population increases, the number of people sharing each flow unit of water grows, pushing the country to higher and higher levels of water shortage. Wallace (2000) sees the population-driven water scarcity as it tends to expand year by year as an analogue to the famous climate change curve showing the relentlessly growing CO2 content of the atmosphere.

The large degree of uncertainty of predictions of climate change gives of course equally uncertain projections of populations concerned. **Fig 3** compares a set of assessments of the number of people who will by 2075 live in regions with blue water scarcity as defined in this paper. The number of people in regions with chronic water shortage are assessed to be between 3 and 7 bln, depending on the IPCC scenario applied, those in regions with high water stress between 4 and 9 bln. The combined implications of massive population growth and climate change foreseen are therefore all but neglectable.

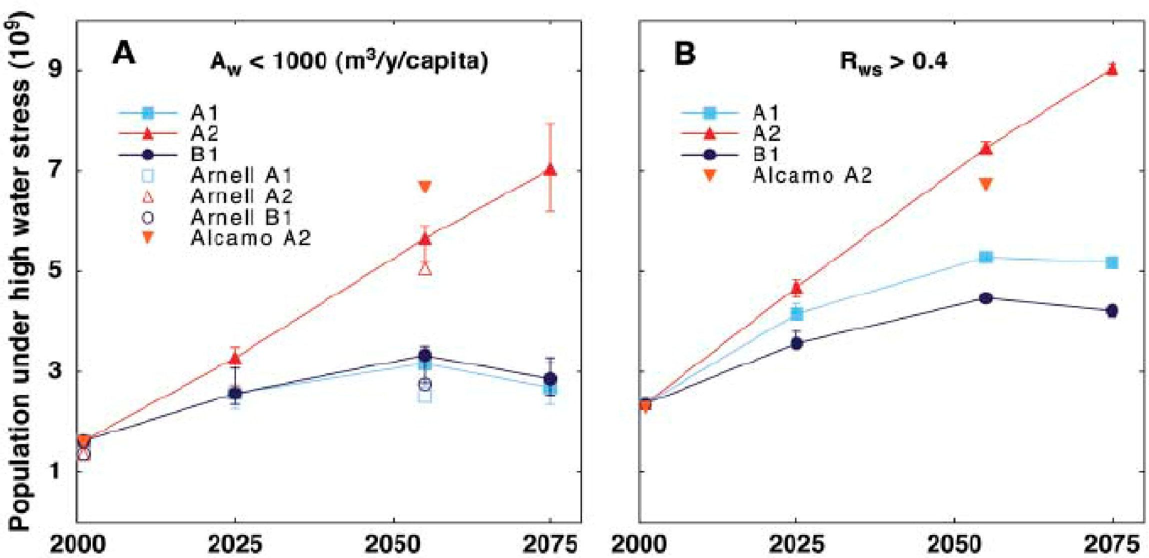


Fig 3. Current and future projections of population under chronic water shortage (left) and high water stress (right) under six different climate scenarios. From Oki&Kanae 2006

CAUSES, PROSPECTS, IMPLICATIONS

Water for plants and water for humans

In facilitating a meaningful future debate on the huge challenges for humanity of *coping with water scarcity*, it will be essential to be clear about the origin and main forms that water scarcity may take. As already indicated, water scarcity may refer both to scarcity of water in rivers and aquifers accessible for direct use (blue water), and to scarcity of water in the soil to rely upon for crop production and biofuels (green water). Each of them may appear in different forms, both *climate-driven* and *human-induced*.

As will be illustrated later, water scarcity may be *apparent* in the sense that there is plenty of water but perceived as scarcity because of either large losses or high water demand. Such scarcity may in other words be linked to low water use efficiency, losses and wasteful use.

In contrast, water scarcity may in other situations be *real* in the sense of lack of rain or large populations dependent on a limited resource. These situations are reflected in arid climate and closing river basins. Water scarcity may finally be *temporary* and limited to part of the year only, i.e. to water resource variability/seasonality;

Green water scarcity – the classic cause of famines

We are not used to think of the water in the soil as a form of water – it tends conventionally to be treated as a sort of soil. What we are referring to is the water in the root zone that controls plant growth, including crop and biofuel production. This water is now referred to as green water. But it originates from the rain and determines rural life form in rainfed areas.

Green water may be scarce for several reasons, some climate-related, others human related.

- ❖ there may be too little rain to allow plant production
- ❖ all rain may evaporate, leaving the soil dry in spite of rainfall
- ❖ there may be problems with infiltration, a situation often referred to as desertification
- ❖ there may be problems with water holding capacity of the soil, so that all the infiltrated water percolates and forms groundwater.

The multiple dimensions of water scarcity is demonstrated by the maps of Africa on **Fig 4** (Falkenmark&Rockström 1993**)**. Here, green water scarcity may take on different forms

- ❖ it may be natural and climate-driven and refer to low rainfall or high evaporative demand, leaving only very little surplus to infiltrate into the soil, or to the monsoon climate (map 2). This is the typical situation in southern Africa for instance.
- ❖ it may be human-induced and be an effect of. soil degradation (map 4), showing the areas where most of the rain does not reach the root zone due to land degradation.

Blue water scarcity is indicated by map 5*,* showing the runoff generation in cm/year. Map 3 shows the climate variability in terms of drought frequency linked to El Nino and other atmospheric disturbances.

- ❖ The congruence between the zone with severe famine during the 1984-85 drought (map 1), green water scarcity (map 2 and 4), blue water scarcity (map 5), and drought vulnerability (map 3) suggests that a complex water scarcity severely complicates both local food production and other kinds of economic development in the rural parts of Subsaharan Africa.

Apparent versus real blue water scarcity

Blue water scarcity may be referring to at least four different phenomena. It may be *climate-driven* in terms of limited runoff generation, cf Fig 3, map 5; *pollution-driven* in the sense of water quality degradation, making the water unusable; *demand-driven* in terms of high water demand in relation to water availability, involving more or less costly infrastructure in terms of pipelines and storages to mobilise the water required; or *population-driven* in terms of high population pressure on the physically available amount, leading to water shortage on a per capita level, deficiency of dilution water, and dispute proneness.

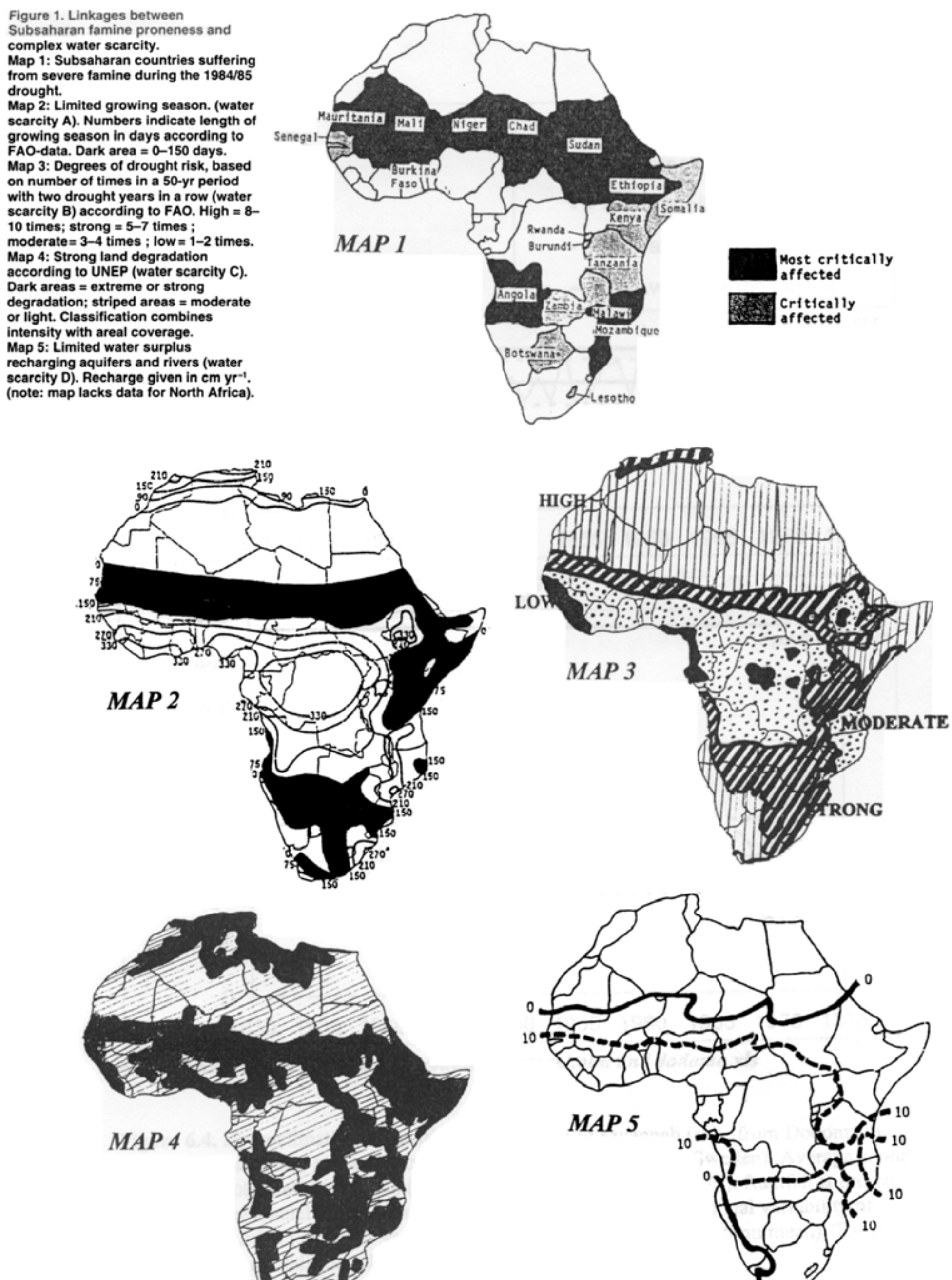


Fig.4. Linkages between Subsaharan famine during the 1984-85 drought (map 1) and a complex water scarcity, composed of both green water (maps 2 and 4) and blue water scarcity (map 5). From Falkenmark&Rockström 1993.

Two of these four blue water scarcity perceptions tend to dominate the debate:

- ❖ the demand driven apparent scarcity, causing water stress and indicated by how much of the resource that is already being withdrawn from rivers and aquifers. This is referred to by the indicator use-to-availability and expressed in percent of the water availability (in recent literature such as Alcamo et al (2000) referred to as criticality ratio). In the Comprehensive Assessment of the Freshwater Resources of the World presented in 1997, UN introduced the level 40 percent as the border between high water stress and low/moderate water stress
- ❖ the population driven real water shortage linked to how many people have to share the available freshwater resource. This is referred to by a water crowding indicator,

expressing in number of people sharing each flow unit of blue water, or inverted as per capita water availability. An empirically based set of severity intervals introduced by Falkenmark (1989), later referred to as standard indicator, are still being broadly used in the literature: beyond 600 p/flow unit of 1 million cubic meters per year water shortage, and chronic water shortage beyond 1000 p/flow unit . Should these empirical water shortage intervals have been determined today, they would probably have been higher in view of water productivity improvements in the last 20 years.

Although both indicator groups, when used for coarse country averages, are of course misleading, they are still widely used and therefore evidently considered to remain valid. They are both simple and fairly easy to grasp for a broader audience in awareness raising campaigns, aimed at raising interest in water scarcity, and therefore "too important to be replaced by a complex dimensionless index" (Rijsberman 2006). By combining these two water scarcity indicators into a diagnostic diagram, see **Fig 5,** a comparative idea can in fact be arrived at of the degree of blue water scarcity in a country or basin.

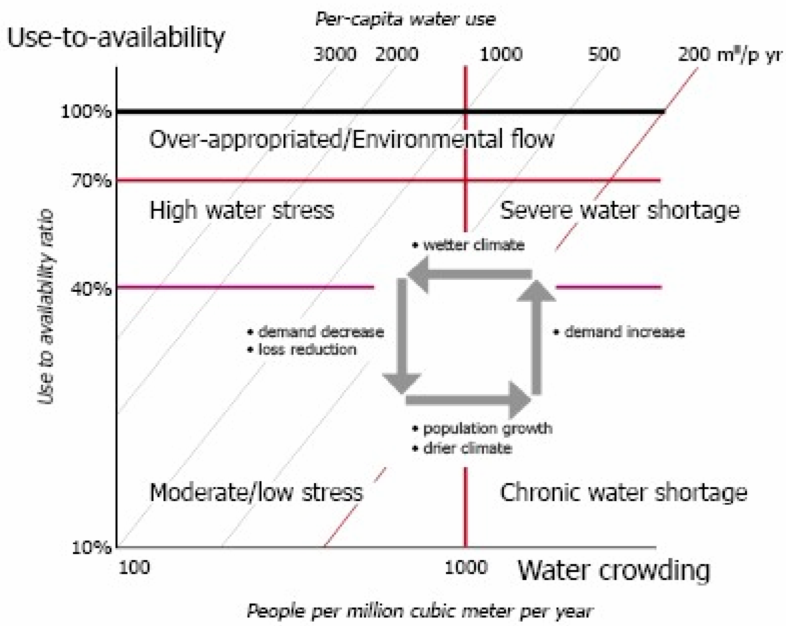


Fig 5. Two types of blue water scarcity with their indicator intervals. Diagonal lines show per capita water use. (logaritmic scales on both axes).The diagonal lines show per capita demand levels. The grey arrows indicate how the position in the diagram would change with demand reduction or increase, population growth, and climate change.

Wasteful use or large population? Blue water examples

As already indicated, water scarcity may in many situations be apparent rather than real and quite straightforward to cope with, This refers to situations where the scarcity is the result of large water losses or highly wasteful water demands, as can be seen by river basin examples in **Fig 6.** It shows a selected number of river basins in China (blue), in India (green), in Africa (red) and in USA(black),based on river basin data from IFPRI. The first observation is that the Chinese basins have a reported demand level of only 500 m3/p yr, the Indian ones some 700 and the USA ones some 1000-3000. If 500 m3/p yr would be seen as a moderate blue water demand level, many of the river basins in India and especially in USA can be seen as cases of wasteful water use, and the water scarcity basically apparent only and possible to address by demand management.

It is also evident that a number of large basins are already overused not only beyond the environmental flow reserve level (taken as 70 percent in dry climate regions) but also beyond the 100 percent level. (Since the diagram is based on stream flow data, groundwater that does not feed a river is not included). These basins therefore exemplify cases of a severe water scarcity that is real, and will exacerbate further as population continues to increase.

As population and water demands grow, degrees of freedom will be limited in view of blue water use constraints. The diagram indicates a certain minimum blue water requirement beyond which there is no additional blue water that can be used for irrigation - only rainfed agriculture will be possible.

Also permanent green water scarcity may be apparent only

Turning now to green water scarcity with focus on semiarid tropics**,** it may in fact to a considerable degree be apparent only due to large water losses, see **Fig 7**, which shows a typical situation in small-holder farming in the semiarid zone in Subsaharan Africa (Rockström&Falkenmark 2000). In this case rainfall amounts to 90 percent of the crop water requirement. The red square shows a crop yield of only about 1 ton/ha in spite of the fact that 60 percent of the crop water requirement has in fact been taken up by the soil. First there were infiltration problems so that part of the rain formed flash floods and ran off as blue water losses (as seen from the perspective of the farmer). Then there was a poor water holding capacity in the soil, so that the infiltrated water did not stay in the root zone but percolates and forms groundwater. But, moreover, the plants were not able to take up more than a very limited amount of the water in the soil due to dryspell damage to the roots. Much infiltrated water instead evaporated, forming a green water loss.

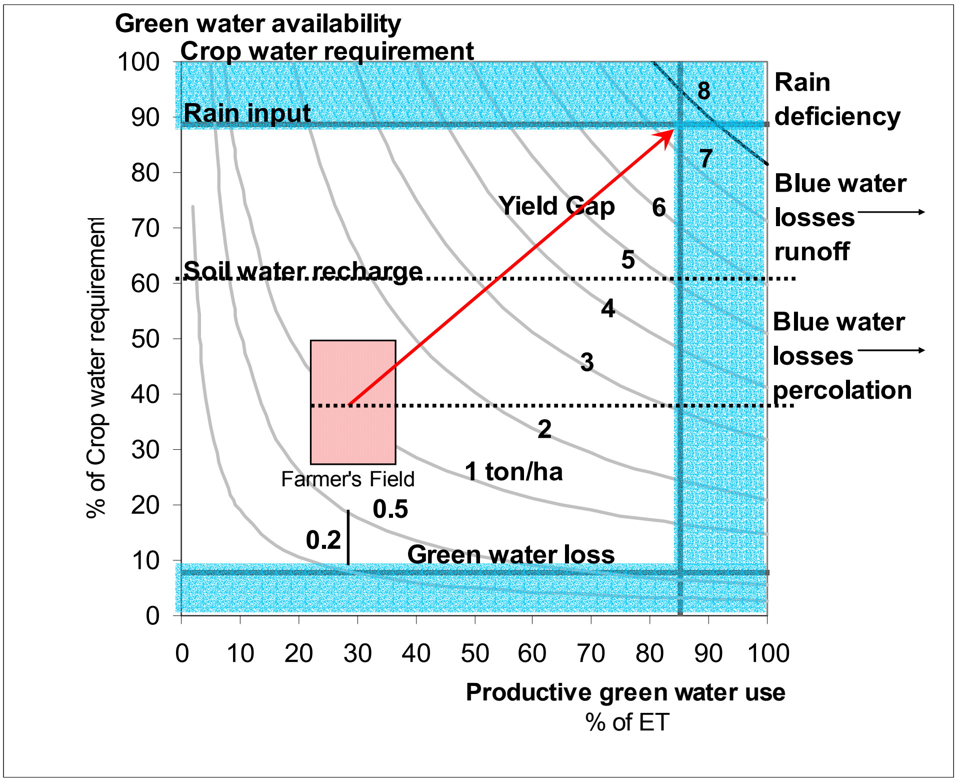


Fig 7 Water deficiency and losses for a typical smallholder farmer in semiarid Africa. The arrow indicated the gap between current yields (the small square) and potential yield without water losses. From Rockström, Lannerstad&Falkenmark 2007

This means that in this case, most of the green water scarcity was in fact apparent only.This is important and a key aspect in a green water strategy. It could be met by soil conservation measures to improve infiltrability and water holding capacity, and protection from dryspell-related root damage by protective irrigation, based on locally harvested and stored rainwater. If root uptake can be protected, yields might increase from 1 ton/ha to 3 ton/ha. If all blue water losses could be avoided (might cause conflicts with blue water users downstream though), yields might increase even to 7 ton/ha if there is no nutrient deficiency. The true water scarcity, linked to the rainwater deficiency, is however real and linked to the hydroclimate.

Meeting exploding water requirements for food and biofuels

Food. As the human population increases, more food will have to be produced. Both rainfed and irrigated agriculture will have to contribute. Where blue water is already overused, rainfed agriculture will have to be further developed by reducing the huge water losses just discussed, typical for smallholder crop production in the semiarid zone.

A recent assessment (Rockström et al 2007) has been made of crop water requirements to alleviate hunger in 92 developing countries, assuming that by 2030 a per capita food supply of 3000 kcal/p d should be achieved – this is the food demand level projected by FAO for the developing world by 2030 (FA 2003), see **Fig 8 a.** Even if this overestimates the per capita food requirements, it represents the average food supply level at which the country's proportion of undernourished is approaching zero (SEI 2005.

Since blue water has been overused in many of the countries, irrigated agriculture will contribute to only a limited degree in meeting these water requirements, especially if a minimum streamflow would have to be left to protect/support aquatic ecosystems. In the study, it was estimated that only some 15 percent of the water required could be met by blue water, while most of the production would have to be met by rainfed agriculture, **Fig 8 b**.

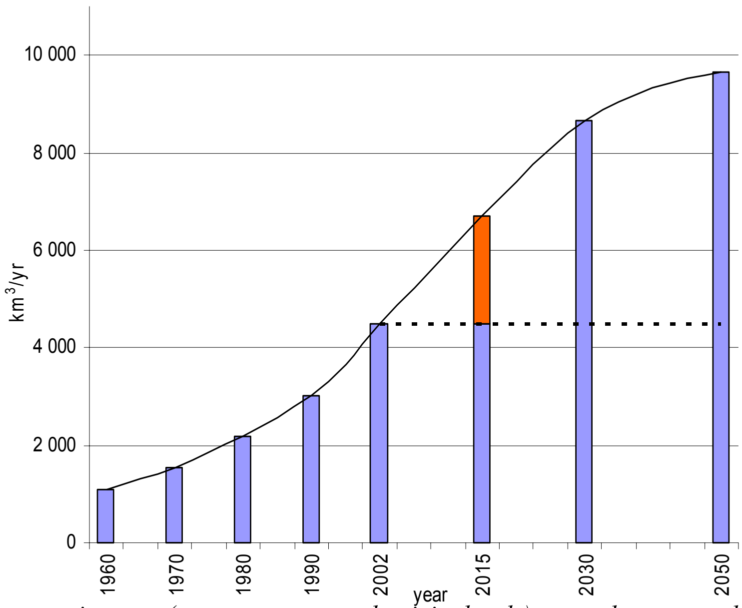
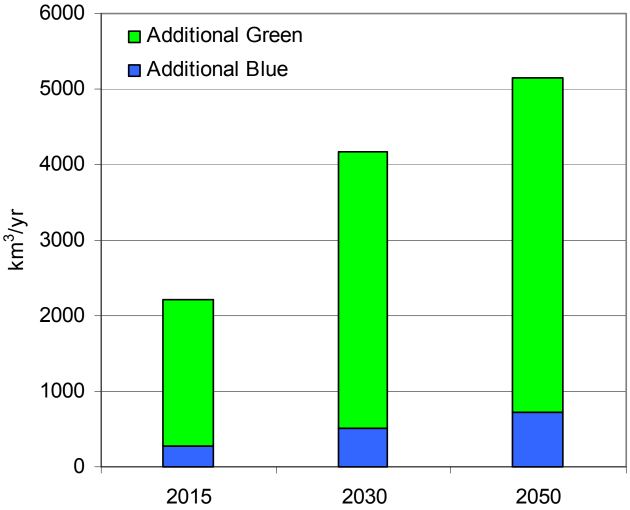


Fig 8 a.Water requirement (present water productivity levels) to produce a standard supply of 3000 kcal/p d (20 % animal protein) in 92 developing countries to first achieve the 2015 MDG target, and then eliminate undernutrition. From SEI 2005.



8 b.Blue and green water contributions to hunger alleviation.

After consideration of plausible possibilities in terms of water productivity increase through loss reduction, the study concluded that, if developing countries were to be food self-sufficient, production on this food supply level will not be possible without a 50 percent expansion up till 2050 of today's cropland area. The alternatives will be food trade from better water endowed regions, better food distribution in society, reduced post harvest losses, and/or altered diet expectations.

The potential for partial *decoupling* of increasing water requirements for food by water productivity increase has been confirmed by a later study by the Swedish Environmental Advisory Council (MVB 2007). That study showed that by adding a 50% reduction of losses in the post harvest food chain, the additional food water requirements might in fact be altogether compensated.

Biofuels. Besides the rapid growth of water requirements for food crop production, also a huge growth may be expected in *biomass use for energy* (Berndes in MVB 2007). The production of that biomass will add to the future water requirements. There is however no way to narrowly determine the potential contributions of biomass in the future primary energy supply, since it depends on many factors that can develop in different directions. After subtraction of the contribution from food crop residues as a source, Berndes has estimated that the water required for biofuel production may amount to somewhere between 3900 and 12 000 km3/yr for respectively 25 and 75 Mg/GJ feedstock. If 15 % were to be contributed by irrigation, the blue water demand would rise by 1200-3500 km3/yr.

The contribution from food crop residues has to be carefully pondered over, however, in view of the fundamental role of adding organic matter to the vulnerable tropical soils due to the high the high rate of turnover of soil carbon,. With growing demand for residues for biofuels, there is a risk that fields will literally be vacuum cleaned: all post harvest biomass may go to produce fuel. There will be little left for soil amelioration.

POLICY RESPONSES FOR COPING WITH GROWING WATER SCARCITY

The world is fast approaching a period of wide scale water problems: world population continues to grow with another 40 percent until 2050; water requirements continue to increase to improve quality of life, to secure poverty alleviation and to alleviate hunger, especially in poor and hungry regions in the water scarce semiarid tropics. Water pollution continues to intensify. Emerging near future problems is climate change, altering precipitation with dry regions getting drier, wet regions wetter, and rising needs for bioenergy production in response to the need to replace fossil fuels on a grand scale. Furthering the scarcity situation is the lack of functioning governance structures in place in countries and regions.

At the same time as water scarcity is evidently an increasing problem, history, as already stressed, has witnessed the potential of human ingenuity and social adaptive capacity as demonstrated by past generations. Communities have managed to reduce the risks of scarcity and irregular rainfall through water storage, exploitation of aquifers and elaborate water conveyance systems. Many countries have benefited from the alleviation of their strategic water shortage by food import from the North temperate regions. Moreover, business and industry, with its knowledge, skill and experience, can evidently contribute in solving technical problems caused by water scarcity (WWW06). It shall be noted that many solutions to the water scarcity have also been found outside of the water sector itself through means of diversification of a national economy which has enabled a move from a situation where the bulk of the water is allocated to agriculture to a situation where water is to a larger extent allocated to areas with a larger economic return thus making it possible to increasingly rely on 'virtual water' (predominantly in the form of imported food).

Water scarcity categories differ in terms of typical policy response

While in Section 3, the causes of the main forms of water scarcity were identified, this Section will identify some main policy approaches by which the situation can be mastered. First of all, we have distinguished between *blue* water scarcity, relevant for conventional water use (domestic water supply, industry, irrigation and waste water dilution), and *green* water scarcity, relevant for plant production and therefore for the production of food and forestry.

It is relevant here to describe blue water scarcity as being either *demand driven water scarcity* (use-to-availability) or *population driven water scarcity* (water crowding).

The *demand driven water scarcity* refers to situations with large water losses or involves highly wasteful water use of both blue and green water, and *population driven water scarcity* is either natural because of low resource for climatic reasons (most rain evaporates), or human caused because of consumptive water use (often non effective irrigation) that has depleted the river, or because of high population pressure (per capita related water shortage). In addition there are situations of *temporary* scarcity, refering to climate variability in the sense that there are practically no years with "normal" rainfall and streamflow, or alternatively to situations of ongoing river basin closure, where dry season flow has vanished in response to depletive water use (mainly irrigation).

Basically, demand driven water scarcity – whether referring to blue or green water - refers to situations which can be addressed stimulating measures that bring down water demand, such as increased use of economic incentives (or disincentives) for example by lowering subsidies of water for irrigation, which would enable a more productive water use. When water scarcity is population driven and where demand management is in place, society has to adapt by reallocation, avoiding unnecessary water demands, or ultimately seeking alternative ways to meet water dependent societal sectors. This means for example import of bulk water, desalination, import of food, rainwater harvesting etc. When water scarcity is temporary only and linked to seasonality and to climate variability between good years and bad, the natural solution is water and food storage, insurances etc.

In outlining possible policy responses it is important to also acknowledge that policy makers are not in a situation where they can easily choose whatever method they think is the most rational. Policy makers are bound by the context in which they are operating which largely determines what is politically feasible. The picture below seeks to illustrate different governance options and also points out to which degree they are easily (or not so easily) implemented. It shall be noted that the figure represents an example of a situation in a country. Rather than being a general description of a situation it can be seen as an analytical tool with which a country can develop an approach for improved water management based on the main complexities, opportunities and constraints for a certain policy option to be adopted or not. From this analysis the easiest and most efficient measure that does not compromise economy and ecology should be selected as priority.

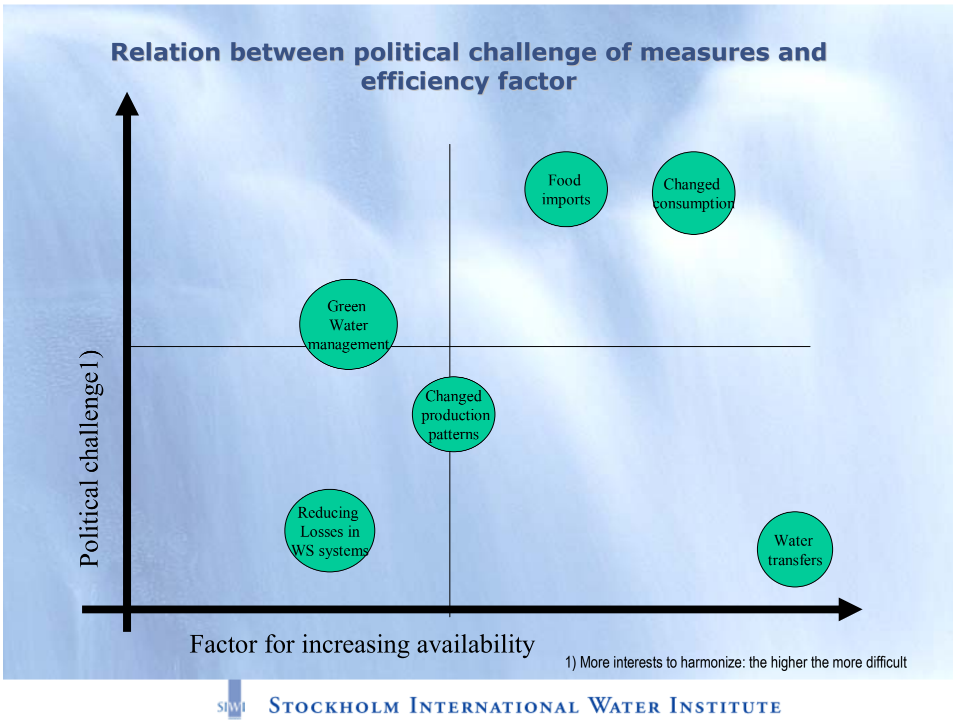


Fig 9

Policy responses are not only options for policy-makers to choose from and implement but the context in which they are supposed to be implemented in is one crucial factor both for understanding why policy makers choose certain policies as well as why they might shy away from others. In other words the policy-makers ‘degree of freedom’ is effectively circumscribed.

Meeting blue water scarcity by demand management, reallocation, even water import
The way to meet demand driven blue water scarcity is by reducing wasteful water use, unnecessary leakages in water supply systems, losses in irrigation systems, exaggerated household water use, and by pollution abatement, etc.

Population driven blue water scarcity is typically met by reallocation, by raw water transfers from other basins, by desalination of sea water, by groundwater carriers in terms of pipelines, or by bulk water import.

The way to conventionally meet temporary blue water scarcity is by water storage, by terracing in irrigated agriculture, by resource allocation and by rainwater harvesting.

It is argued here (and exemplified further below) that there needs to be a stepwise approach in the adoption of the different policy measures to meet the blue water scarcity. *First*, focus should be put on *managing demand*. Direct policy measures to this end would include decreased use of subsidies to agriculture and more of relevant water pricing measures, reallocation of water to sectors with higher economic return per water unit used, increased support for more efficient agricultural techniques such as drip-irrigation and green houses for local food production (minimising evaporation losses), increased reliance on virtual water import etc. *Second* and after strict demand management measures being implemented policies to *increase supply* should be adopted, including desalination and bulk water import.

Meeting green water scarcity by water productivity increase, land care, even food import
In situations where green water scarcity is apparent only in the sense that there is enough rain, but the problems are linked to soil problems related to infiltrability difficulties due to land degradation ("desertification"), crusting etc, and poor content of organic matter, soil conservation is an evident measure (conservation tillage etc together with mulching to improve water holding capacity of the soil). Terracing and 'diguettes' (stone mounds) along contour lines will facilitate infiltration of overland water along the slope. In semiarid regions where intermittent dryspells damaging the roots are characteristic of the climate, protective irrigation based on local water harvesting and farm scale water tanks can help bring up yields considerably, especially when supported by adequate fertilising. In regions with small holder farming, extension services will be fundamental to encourage farmers.

Where green water scarcity is real and linked to aridity and rain deficiency, irrigation will be necessary to allow crop and vegetable production. Policy measures include promotion of efficient agriculture production practices, measures aimed at a change of consumption patterns to less water consuming food and less waste of food. Agricultural measures are needed to avoid drying out of the soil (covering with mulch, weed etc).

Governance components to improve green water productivity may include extension services, land rights questions, and a landcare system stimulating a general societal effort to protect land productivity conditions.

The future increasing bio-energy demands, which are oil-peak driven as well as a result of the fact that policy makers are seeking more climate friendly energy sources, needs to be addressed by adequate policies. Potentially a large water consumer (of possibly both green and blue water, as elaborated above), it is imperative that bio-energy production is incorporated into socio-economic national planning. From a policy perspective, measures to curb energy consumption such as caps on emissions or improved energy efficiency form an important part of addressing not only climate issues but also green water scarcity.

Overarching governance components
Most often water scarcity is referred to as the relation between demand and supply. Basing assumptions of future demand on current use will inevitably lead to approaches focusing only on increasing supply. Such a development would not be advisable. We believe that there is a need of a step-wise approach to the water scarcity situation. Most of the steps that should be taken by countries are still related to improved water management and governance, in particular in relation to demand management.

In order to address the water scarcity problems outlined above, a range of different governance options is needed. The role of governance measures is essentially to facilitate best possible use of the basic water resource (including both blue and green water management, increased re-use etc.) in a water scarce region. In addition the policy responses needs to include measures to reduce water losses in irrigation, industry etc., re-thinking of water allocation based on economic principles ('more money per drop') weighted against social and environmental considerations, increased utilisation and management of green water, changing consumption and productions patterns and in certain instances also the use of large-scale water infrastructure and desalination to ameliorate the physical scarcity.

Studies of the impacts of anticipated climate change, at the regional level, indicate that present tropical semi-arid and Mediterranean climate zones may be severely affected by decreased rainfall, increased temperatures or both (IIASA, 2002). Thus, on regional scale, climate change may be a key driver for change in biomass production for food and energy, both affecting and being affected by available water and land resources.[1] As noted above future water requirements will radically increase also in response to the increased demand for energy and the reduced importance of fossil fuels after the "oil peak". Additional water requirements to meet the needs for bio-energy production are estimated to be of a similar order of magnitude as the agricultural sector requirements (Berndes, 2002).

Essential will be to incorporate foreseeable water scarcity implications into the socio-economic national planning system, paying due attention to comparative advantages of different sectors. Such planning should incorporate long term allocation of water between rural needs for food production, bioenergy production, and employment/income generating activities on the one hand, and urban needs related to urban health and urban income raising activities, especially domestic water provision, water for industry and water reuse on the other hand.

It will also be essential to secure adequate allocation between upstream and downstream water users, and to pay adequate attention to the need to safgeguard a certain minimum streamflow and water quality for aquatic ecosystems. In many areas the blue water sources (including groundwater) are shared between two or more countries. In particular in the MENA region and soon in Southern Africa the water scarcity issues are high on the agenda and they form an intricate part of the larger political context. (Turton&Ashton, 2007). It is envisaged that in such circumstances the challenges faced are even greater, in particular since the scarcity situation might worsen due to climatic changes and increased water demands from the bio-energy sector. In many circumstances in the MENA region as well as in other regions the

[1] A comprehensive review of recent scientific material on consequences on water resources and food production of regional climate change was recently presented by Stern (2006).

transboundary water relations are part of a complex web of relations, by Schulz termed Hydropolitical Security Complex (Schulz, 1997?). In order to address the political as well as water scarcity challenges in highly 'securitised' basins there is a need for sustained support and engagement from the international community. In particular institutional development, a 'levelling of the playing field' thus enabling less powerful riparians to better negotiate their equitable share. Riparians in a river basin should strive to share the potential benefits that could be derived from a rational use of the water available in a basin. It is however recognised that in certain basins in which the political actors are pre-occupied with security considerations the prospects for effective benefit sharing are slim. (Phillips et al 2006). The need to balance land use, water and ecosystems should be facilitated by broad use of Integrated Water Resources Management (IWRM), incorporating also land use, turning IWRM into Integrated Land and Water Resources Management (ILWRM). From a policy perspective international actors should engage in transboundary processes for the long haul – not viewing their engagement as a project intervention but as a support to a *process* (Jägerskog, 2003 and Nicol, 2000).

Concrete policy steps

When outlining possible policy responses and recommendations on how to address the new water scarcity we argue that it is necessary also to prioritise between the different recommendations. Indeed a stepwise approach of the measures is needed. The figure below outline an example of how an "order of priority" could be identified. It is important to note however that this is merely an example of what it might look like.

Prioritisation of measures to react to water scarcity as a staircase: concentrate first on demand measures and don't jump to the highest stair from the ground!

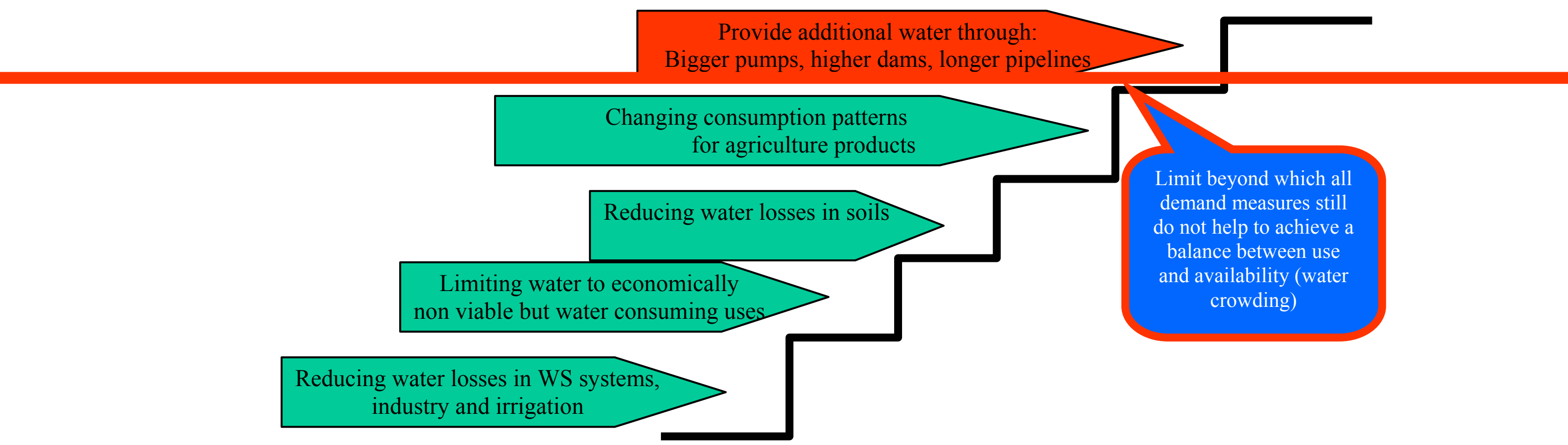


Fig 10.

Some key concrete steps to address the water scarcity problems are succinctly summarised in the above figure while acknowledging that the political circumstances might not be enabling for certain measures we still believe that it is worthwhile proposing a sensible strategy to address the current as well as future water scarcity situation. All in all the focus shall *first* be on managing demand and *second* on increasing supply.

The key recommendations that should be translated in clear and culturally applicable legal and administrative framework by policy makers are:

- ❖ Decrease losses and change water use patterns (increasing productivity) through:
  - improving water governance approaches through stricter demand management, effectively reduce losses in agricultural, industry and domestic uses
  - improving green water management through for example increased rainwater harvesting
  - increase pollution abatement measures and water reuse
  - increased use of modern agricultural techniques such as drip-irrigation and increased use of green houses (minimising evaporation losses)

- ❖ Incorporate water into socio-economic national planning through:
  - re-allocating water to an increasing extent to the sectors with a higher economic returns
  - establish clear land and water rights systems
  - decrease subsidies to irrigated agriculture, thus enabling a more sound water use.
  - taking into account into planning the import of water demanding goods, especially food import (the -virtual water factor)-
  - consider adopting measures aiming at changing food consumption patterns to less water demanding uses.
  - incorporate into planning future bio-energy generated water demands
  - improve energy efficiency as a means to curb not only climate change but to decrease use of green water (for production of bio-fuel).
  - adopt measures aimed at improving transboundary water relations as a means to seek to share the benefits that could be reaped from a rational use of the resource.

- ❖ When these options have been considered and when the upper limit of water accessibility is reached it is necessary to produce *additional water* which could be done through:
  - building of desalination plants
  - use of pipe-lines that transports water

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**Complete list of references to be included in final version.*

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