IWMI WATER BRIEF 1**

Water Scarcity in the Twenty-First Century*

by

David Seckler, David Molden, and Randolph Barker

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International Water Management Institute (IWMI)**
P O Box 2075, Colombo, Sri Lanka
Tel: +94-1 867404 • Fax +94-1 866854 • E-mail: iimi@cgiar.org

WATER SCARCITY IN THE TWENTY-FIRST CENTURY

ABSTRACT:

As we approach the next century, more than a quarter of the world's population, or a third of the population in developing countries live in regions that will experience severe water scarcity. This paper reports on a study to project water supply and demand for 118 countries over the period 1990 to 2025. The nature and geographic focus of growing water scarcity are identified.

In the semi-arid regions of Asia and the Middle East, which include some of the major bread baskets of the world, the groundwater table is falling at an alarming rate. There is an urgent need to focus the attention of both professionals and policy makers on the problems of groundwater depletion and pollution is seen as a major threat to food security in the coming century.

INTRODUCTION

After thousands of years of human development in which water has been a plentiful resource in most areas, amounting virtually to a free good, the situation is now abruptly changing to the point where, particularly in the more arid regions of the world, water scarcity has become the single greatest threat to food security, human health and natural ecosystems. Based on a recent IWMI study (Seckler *et al*., 1998)**,** we estimated that nearly 1.4 billion people, amounting to a quarter of the world's population, or a third of the population in developing countries, live in regions that will experience severe water scarcity within the first quarter of the next century.

Slightly more than one billion people live in arid regions that will face *absolute* water scarcity by 2025. These regions do not have sufficient water resources to maintain 1990 levels of per capita food production from irrigated agriculture, even at high levels of irrigation efficiency, and also meet reasonable water needs for domestic, industrial and environmental purposes by 2025. People in these regions will accordingly have to reduce water use in agriculture and transfer it to other sectors, reducing domestic food production and importing more food.

About 348 million more people face *severe* economic water scarcity. They live in regions where the potential water resources are sufficient to meet reasonable water needs by 2025, but they will have to embark on massive water development projects, at enormous cost and possibly severe environmental damage, to achieve this objective.

This paper briefly reviews and interprets these estimates and examines the kinds of research and information needs necessary to manage water recourses more efficiently and productively in the twenty-first century. Since water resource programs typically require twenty years or more to bring to fruition, it is important to anticipate problems and take appropriate actions well in advance before they reach a crisis state.

The paper is divided into two parts. Part I describes the IWMI study of water scarcity. Part II shows how all of the issues of water scarcity are concentrated in what we believe to be the single greatest problem of water resources in the next century, the problem of groundwater depletion and pollution.

PART I. THE NATURE AND EXTENT OF WATER SCARCITY

The estimates

The IWMI study identifies the water demand and supply situation of 118 countries over the 1990–2025 period. The country-level data obscure geographic variation within a country and annual and seasonal variation. While the study is limited by the poor quality of the international data set on water, it is based on a methodology that we believe provides the best estimates available to date. The details on the data and methodology are included in the IWMI study.[1] Only a brief overview is given here. Map 1 and table 1 provide the basic results and information.

Table 1 is organized in terms of four basic groups of countries arranged in decreasing order of water scarcity. For reasons explained below, China and India are considered separately. Table 1 is presented for all 118 countries individually in Appendix A.

Ignoring the groups for the moment, the basic methodology can be explained very simply in terms of the columns of table 1 (with the column number shown in parenthesis where necessary). The columns 1 & 2 show the 1990 populations and percentage increase in population to the year 2025.[2]

Per capita withdrawals

The next set of columns show the 1990 per capita withdrawals of water, in cubic meters (m^3) for the domestic, industrial and irrigation sectors and projected withdrawals by these sectors in 2025. The 2025 projections for the domestic sector withdrawals are based on a standard of basic needs of 20 m^3 per capita (Gleick 1996) for countries below that level. For those above that level, estimates of withdrawals are based on projected per capita GNP both for the domestic and industrial sectors. The projections for the irrigation sector are explained below.

Per capita withdrawals for irrigation are much larger than for the other sectors; and they are projected to decrease over the 1990 to 2025 period. Finally, column 9 shows the total percentage increase of withdrawals for the domestic and industrial sectors over the period.

The irrigation sector

Irrigation consumes or depletes over 70% of the total developed water supplies of the world. Many people believe that existing irrigation systems are so inefficient that most—if indeed not all—of future needs for water by all the sectors could be met by increasing the efficiency of irrigation and transferring the water saved in irrigation to the domestic, industrial and environmental sectors. However, it is exceptionally difficult even to know what irrigation efficiency means, much less to measure it. The IWMI study made estimates of the irrigation efficiency in 1990 (column 10) and projected high but not unreasonable levels to which it could be increased in 2025 (column 11).

These two estimates of irrigation efficiency provide the basis for two scenarios of water supply and demand in 2025. In the first, "business as usual," scenario (S1, column 10) it is assumed that the 1990 level of irrigation efficiency remains constant through 2025. In the second scenario (S2, column 11), it is assumed that the higher efficiencies are attained.

Each of these scenarios is based on the assumption that the per capita amount of food production from irrigated agricultural will be constant over the 1990 to 2025 period. In addition to the fact that the potential efficiency gains may be less than the projected difference between S1 and S2 in 2025, there are two other important assumptions that may underestimate the severity of the problem.

> No allowance was made for additional irrigated area or irrigation water to meet increased per capita food demands. It is assumed that all increased per capita food consumption will be met from increased yields due to better seeds, fertilizers and management. But there are ominous signs that yields of major cereals are stagnating in many of the highest most productive areas of the world. Also, much of the existing irrigated area is being lost to urbanization, diversions of water from agriculture and increasing salinity. If these trends continue, more irrigated area and water will be required.
>
> It is assumed that the proportion of food supplied by irrigated and rainfed areas will remain constant over the period. But most of the good rainfed area in the world either is already utilized, or the financial and environmental costs of developing it are prohibitive. Growth of yield is slower on marginal rainfed land than on irrigated land. Thus irrigation may have to play a proportionately
>
> greater role in meeting future food demands in the future than it has in the past.

Given these assumptions and caveats, the growth of water requirements can be estimated under the two scenarios. Under the business as usual scenario, irrigation efficiency remains constant and, therefore, growth in irrigation withdrawals is equal to population growth, 60% for all the countries studied (column 12). However, under the second scenario, with increased irrigation efficiency, the increase in water required for irrigated agriculture is reduced to 13% (column 13). This is a substantial amount of water savings. But even with high irrigation efficiency, more water will be needed in irrigated agriculture to meet 2025 food demands. Thus, at a global level, there is no excess water to transfer out of agriculture to the other sectors, although this can be done in many individual countries.

Columns 14 and 15 show the increase in total withdrawals for all of the sectors under the two irrigation scenarios. At a global level, about 23% more water will be required under S2 (column 15), compared to 56% under S1 (column 14).

The last column (16) shows total withdrawals as a percentage of the annual water resources (AWR) of the country. Because of the inability to utilize all of the water resources—due to floods to the seas, lack of storage, the need for discharges of water into coastal areas and the like—the IWMI study assumes that when total withdrawals exceed 50% of AWR, the costs of further development are likely to be prohibitively high. Although this figure will vary among countries, the study assumes that countries with percentages greater than this are in a condition of absolute water scarcity.[3] As we turn to the next section, it can be noted that these countries are contained in the "Absolute Scarcity Group" in Table 1.

THE GROUPS

The 118 countries included in the study have been classified into two broad groups excluding China and India (shown in grey on the map), according to the nature and degree of their projected water scarcity in 2025.

Group 1 - Absolute Water Scarcity. The countries in this group representing 377 million people, are projected to be in a state of absolute water scarcity by 2025. These countries do not have sufficient annual water resources to meet reasonable per capita water needs for their rapidly expanding populations. These countries will almost certainly have to reduce the amount of water used in irrigated agriculture and transfer it to the other sectors, importing more food instead. While this is a viable option for countries with foreign exchange earnings, it will impose additional burdens on others, many of whom are already suffering large deficit accounts. Many of these countries will also have to increase their dependency on expensive and energy-consuming desalinization plants to meet domestic and industrial needs.

One of the most difficult problems encountered in the IWMI study is that the international data set used in the study (WRI 1996, FAO 1994, 1995, 1997a and 1997b) is at the country level, not at the level of regions within countries. This country-level data hides massive regional differences in water scarcity behind the average figures for many countries. This is an especially important problem for two of the largest countries, China and India. North China is very dry, while South China is very wet. East India is very wet while West and South India are very dry. Yet large numbers of people live in all these regions. Because of these regional differences the IWMI study listed China and India separately from the other countries (their nominal Group is shown in parentheses in table 1). Subsequent study of these countries led us to believe that around one-third of the population of both China and India live in regions that should be classified in the Absolute Water Scarcity Group. This amounts to 381 million people in China and 280 million people in India, i.e. a total of 661 million people. This increases the total population in the Absolute Water Scarcity Group to slightly over one billion. Other large countries, such as Mexico and Nigeria, also have pronounced regional differences in water scarcity. The grouping of these countries has not been

changed here, pending further research (but their existence does tend to make the one billion estimate conservative).[4]

Group 2 - Economic Water Scarcity. The remaining countries, categorized by economic scarcity, do have sufficient potential water resources to meet projected

2025 requirements, but many of these countries need to embark on massive water development programs to actually utilize these resources. Thus they face varying degree of economic scarcity in 2025. These countries have been placed in the three subgroups based on the S2 (column 15) withdrawal projection for 2025 as a percent of 1990 (i.e. assuming significant improvement in irrigation efficiency).

Countries in subgroup 1 have to more than double the amount of developed water supplies by 2025 to meet reasonable needs. These countries, with 348 million people, are mainly in sub-Saharan Africa. It will be extremely difficult to find the financial and other resources to achieve this rapid pace of water development. If we add the population of these countries, suffering severe economic scarcity of water, to those suffering absolute scarcities discussed above the total amounts to 1386 billion people: 26% of the 1990 population of the world, and 33% of the population of developing countries.

Countries in subgroup 2 also need to increase water development by between 25% and 100%. But, as indicated on the map, many of these countries, in Latin

America, North Africa and East Asia have more resources to achieve the objective.

Finally, there is a large number of countries in subgroup 3, comprising 28% of the population of the countries studied, that have only modest (less than 25%) requirements for additional water development and, indeed, with increased irrigation efficiency some of these countries have zero or even negative needs for water development. The average increase in water use for this group (column 12; excluding those with negative increases) is only 5%. Most of these countries are in North America and Europe.

THE REAL LIFE OF WATER SCARCITY

Behind these rather dry figures and groupings lie dramatic tragedies of water scarcity ranging from the need to carry heavy pots of water several kilometers everyday to meet household needs, through the destitution of farmers who lose their land because of lack of sufficient irrigation water to flush salts from the soil, to the loss of wetlands and estuaries because of upstream water depletion.

Water scarcity leads to declining water quality and pollution and has an especially adverse impact on poor people. Many, probably most of the poorest people in developing countries are forced to drink water that literally is unfit for human consumption. They suffer from skin and other forms of sanitary diseases because of polluted water used for bathing and due to lack of sufficient water for washing. However, experts in the field agree that the quantity of water is even more important than the quality of water in terms of its effects on public health. Poor water management also provides breeding grounds for malaria and other disease vectors that are the scourge of the poor.

Perhaps the single greatest impact of water on the poor is in the production of the kinds of food consumed by the poor. People below the poverty line in Asia spend approximately 60% of their total income on cereals (which provide over 72% of their total nutrients). It has been estimated that over 80% of the total increase in

cereal production in Asia since the 1960s has been from irrigated land. Largely as a result of this, real cereal prices have fallen to less than one-half their previous levels. The direct and indirect effects of the green revolution of irrigated land, as it should properly be called, has certainly been by far the greatest source of poverty reduction in Asia. But there are reasons to fear that water scarcity may halt or even reverse these trends, as in the case of China.

CHINA

The relationships between water scarcity and food production are epitomized by the current debate over the ability of China to feed itself without importing massive quantities of cereals. In a recent article, Lester Brown (Brown & Halweil, 1998) contended that primarily because of impending water shortages in the northern region of China, China would have to import as much as 210-370 million tons of grain per year to feed its population in 2025. This massive increase in imports could cause steeply increasing cereal prices and disruption of the world market. Many people thought that these estimates were greatly exaggerated. However, the National Security Agency of the United States thought that the problem was sufficiently serious to sponsor a special study by MEDEA (Brown & Halweil, 1998). MEDEA is a group of distinguished academicians that have special access to secret intelligence information of the USA—especially remote sensing facilities. The MEDEA study estimated China’s demand for cereal imports in 2025 at 175 million tons, close to Brown’s lower estimate.

On the other hand, the IWMI study of water in 2025 indicated that at a national level, China does not have a major water problem. There are two reasons for this conclusion:

> As noted before, it is based on national-level data: while the North of China is arid, the South has surplus water.
>
> The official statistics on water diversions to irrigation indicate very low efficiency and, hence, the opportunity for large real water savings in this sector.

Thus the question of the future of China’s cereal grain production depends on three major water issues:

> The potential for additional grain production in the water-surplus South, both in terms of increased yields and additional area and multiple cropping.

The ability to grow rice with less real water in the semi-arid North. A generic study of this possibility is the subject of a research project by IWMI and IRRI under the Inter-Center Program on Water Management (SWIM).

The economic feasibility of large inter-basin transfers of water from South to North. These transfers are technically feasible, but the economics is not clear—especially in the light of the possibility of massive increases in cereal imports and international prices in the absence of an alternative.

PART II. THE EMERGING GROUNDWATER PROBLEM

The issues discussed in the preceding part of this paper have direct relevance to what we believe is the single most serious problem in the entire field of water resources management, the problem of groundwater depletion. Many of the most populous countries of the world—China, India, Pakistan, Mexico, and nearly all of the countries of the Middle East and North Africa—have literally been having a free ride over the past two or three decades by depleting their groundwater resources. The penalty of mismanagement of this valuable resource is now coming due, and it is no exaggeration to say that the results could be catastrophic for these countries, and given their importance, for the world as a whole.

The groundwater problem has two contradictory aspects. First, there is the rapid draw-down of fresh water aquifers mainly due to the worldwide explosion in the use of wells and pumps for irrigation, domestic and industrial water supplies.

Second, there is the opposite problem of rising water tables of saline and sodic water, and the pollution of aquifers by these and other toxic elements.

The first problem, of draw-down, is a consequence of one of the most dramatic yet generally unappreciated revolutions in water resource technology, the development and explosive spread of small pumpsets throughout the world. India, for example, has more area irrigated by pumpsets than by all the other surface irrigation systems combined. Pump irrigation from aquifers is the ideal form of irrigation. The water is stored underground, with no evaporation loss, and is instantly available when it is needed. Further, it acts as a supplement to surface irrigation and as a reserve for periods of water shortage. That is why the productivity of pump irrigated systems is much higher than for other systems in India and elsewhere. And, as though this were not enough, pump irrigation provides water in the dry season, thus enabling multiple cropping of irrigated areas. We believe that a large part of the credit for the green revolution in India and other Asian countries needs to be given to irrigation generally, and especially, to pump irrigation.

But the extraction of water from aquifers in India exceeds recharge by a factor of two or more. Thus, almost everywhere in India, fresh-water aquifers are being pulled down by 1 – 3 meters per year. This increases the energy and other costs of pump irrigation and reeks havoc with supplies of fresh-water to villages. Lakes

and rivers dry up as the aquifer recedes and the problem is compounded. Eventually, the costs of pumping become so high that the pumps are shut down

and the whole house of cards collapses. It is not difficult to believe that India could lose 25% or more of its total crop production under such a scenario.

The opposite problem, of rising water tables of polluted water, is also severe in many countries. At a country-wide level, Pakistan is probably the country most severely affected by saline and sodic water tables. It is cursed with high salt content of the Indus river and of most of the soils, combined with no natural drainage from the agricultural areas of the Indus basin except the Indus river itself. Thus, as salinity and other pollutants enter the river upstream, the downstream users become progressively affected by pollution. Crop productivity decreases and water becomes undrinkable. Another insidious problem is that as polluted water tables rise, sewage that would otherwise be filtered down into the aquifer instead rises to the surface, with overflowing cisterns and other sewage flows in the middle of villages as a result.

While the problems of groundwater are clear, the solutions are not. In some cases, it is even difficult to imagine how some of these problems can be solved. In the case of draw-down of aquifers, for example, the solution of pricing or regulating pump water to reduce withdrawals to a sustainable level is too facile. Even if it

could be done, practically speaking, what country would be willing to pay the enormous price of this policy in terms of reduced food production and domestic and industrial water supplies?

A much better alternative is to increase the recharge of aquifers, but how can this be done? One of the best ways to do this, ironically enough, is to discourage irrigation efficiency, especially by encouraging more paddy irrigation in the wet season. The deep percolation "losses" of paddy irrigation recharge aquifers and replenish stream flows. The amount of temporary water storage in bunded paddy fields can be enormous. In Japan, it is larger than the total storage in the reservoirs. These bunded fields can capture precipitation that would otherwise flood to the sea for recharge of aquifers. Similarly, large areas of bunded fields could be set aside as recharge units in the wet season, or for diversion of excess water supplies in the dry season. Paddy, other water tolerant crops, and fish could be grown in these fields, with the farmers' paid a subsidy per unit of recharge. In other areas, pressurized (reverse pump) recharge could be used, but this requires clean water to avoid polluting the aquifer. In areas where rainfall is not sufficient, additional water storage and development projects would be necessary to feed water to these recharge areas, perhaps through surface irrigation systems, provided that they were not too efficient!

The opposite techniques are needed in the case of rising water tables and salinity. Here the objective is to maximize evaporation per unit of water applied, thus reducing the volume of polluted drainage, while simultaneously keeping salts below the root zone of plants - and periodically flushing them out of the system through drainage. Here, irrigation systems with high efficiency are required. And it is possible to create evaporation ponds that are periodically flushed in the wet season, with the pollutants joining the flood waters of the rivers to the sea. Also, in certain cases, bio-drainage with salt-tolerant plants can be used to lower water tables. But still, the accumulated salts in the root zones of these plants have to be periodically flushed out by applications of less polluted water for this purpose.

In sum, given the truly alarming threat of groundwater depletion in the world, it is astonishing how little attention, whether in research or action, is given to it. As we have noted before, the classification of pump irrigation, along with small tanks, as "minor irrigation" in India reflects more on the amount of attention paid to it than to its significance. But this is true in the entire field of water resource management. The fact is that most professionals in this field, whether in research, in the field, or in the donor community, are trained to manage surface water.

Groundwater is literally hidden from their view and attention. The time is long past for this dangerous situation to change.

CONCLUSIONS

This paper has reported on a study of the projections of water supply and demand for 118 countries for the period 1990 to 2025. Despite the limitations of the country-level data, it has been possible to identify the nature and geographic regions of growing water scarcity. We estimate that a quarter of the world's population or a third of the population in developing countries, live in regions that will experience severe water scarcity within the first quarter of the next century.

Of particular concern is the overlooked problem of declining water tables in the semi-arid regions of Asia and the Middle East. These regions contain some of the major bread baskets of the world such as the Punjab and the North China Plane. There is an urgent need to focus the attention of both professionals and policy makers on the problems of groundwater depletion which must be seen as the major threat to food security in the coming century.

Notes

[1]These can be obtained by email to IWMI or downloaded on http://www.cgiar.org/iimi

[2]These are the United Nations (1994) "Medium" projections. Seckler & Rock (1997) contend that the UN "Low" projections are likely to be more accurate, but this issue is not entered into here.

[3]The study by Raskin, P. et. al. assumes this level at 40% of annual water resources.

[4]In some cases, inter-basin transfers of water, for example from South to North China, can alleviate regional scarcities, but the economic, social and environmental feasibility of most of these schemes is questionable.

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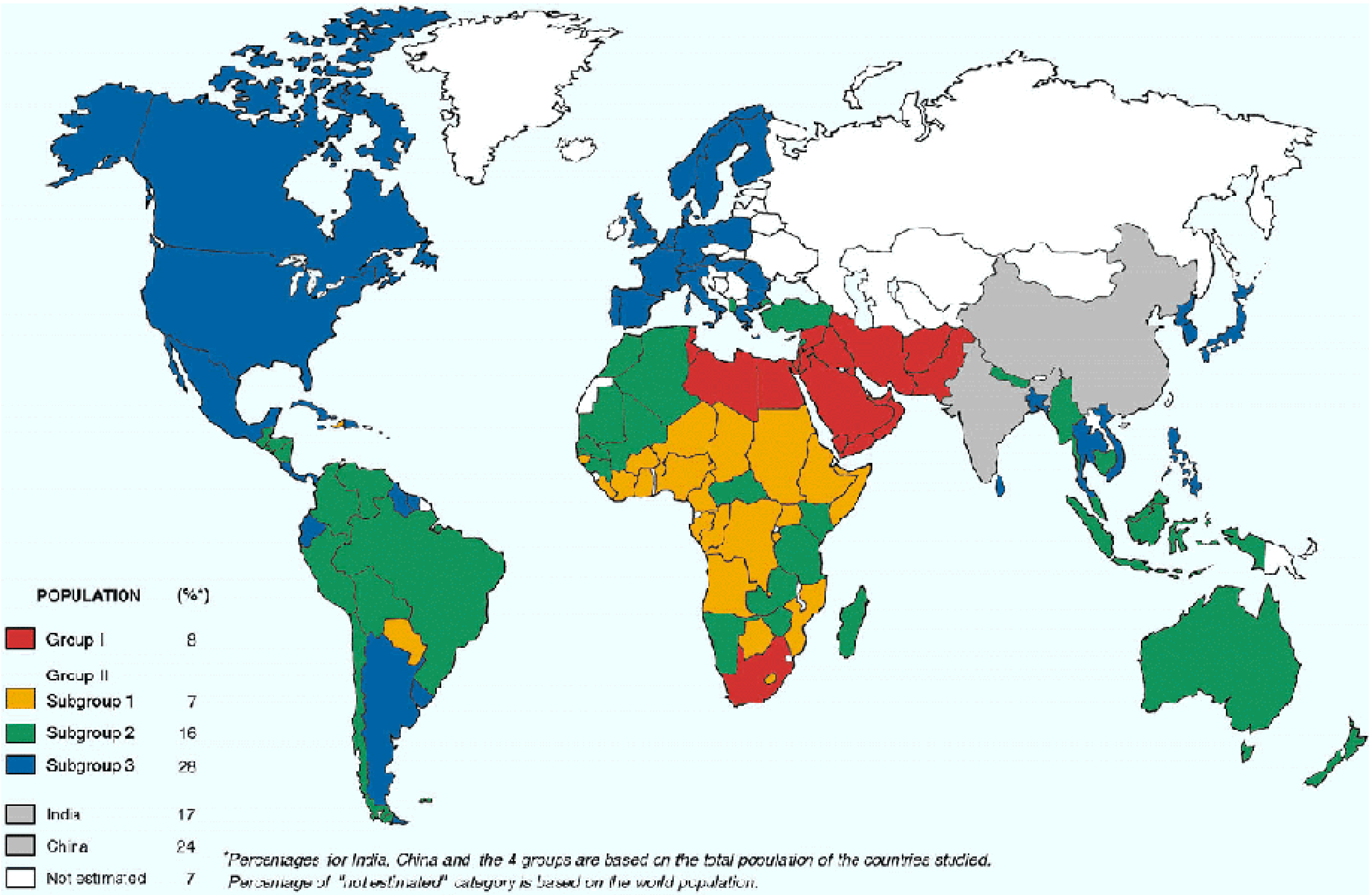
POPULATION (%*)
Group I 8
Group II
Subgroup 1 7
Subgroup 2 16
Subgroup 3 28
India 17
China 24
Not estimated 7
*Percentages for India, China and the 4 groups are based on the total population of the countries studied.
Percentage of "not estimated" category is based on the world population.

Table 1. Water supply and demand.

Country	ID	Population 1990 (UN Med) (millions)	Population 2025 - % increase from 1990 %	Per capita water withdrawals: Domestic 1990 m^3	Domestic 2025 m^3	Industrial 1990 m^3	Industrial 2025 m^3	Irrigation 1990 m^3	Irrigation 2025 (S2) m^3	Dom & Ind. 2025 total - % increase from 1990 %	Irrigation efficiency 1990 (S1) %	Irrigation efficiency 2025 (S2)[a] 70% %	Irrigation withdrawals 2025 total - % increase from 1990 (S1) %	Irrigation withdrawals 2025 total - % increase from 1990 (S2) %	Indicators: 2025 Total withdrawals (S1) % change from 1990 %	(S2) % change from 1990 %	(S2) % of AWR %
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
All countries		4,892	60%	54	58	114	97	426	302	47%	43%	60%	60%	13%	56%	23%	9%
% World		93%															
Group I		377	122%	55	56	39	41	985	836	126%	54%	66%	122%	88%	122%	91%	91%
		8%															
Group II																	
Subgroup	**1**	348	157%	10	17	4	8	67	53	350%	58%	62%	157%	105%	191%	148%	2%
% of Total		7%															
Subgroup	**2**	777	76%	59	63	33	45	192	131	107%	43%	62%	76%	20%	86%	48%	2%
% of Total		16%															
Subgroup	**3**	1,385	30%	106	108	330	312	430	284	25%	40%	53%	30%	-14%	27%	5%	9%
% of Total		28%															
China (Subgroup 3)		1,155	32%	28	46	32	38	401	261	84%	39%	60%	32%	-14%	39%	-1%	19%
% of Total		24%															
India (Subgroup 3)		851	64%	18	28	24	24	569	377	100%	40%	60%	64%	8%	66%	15%	29%
% of Total		17%															
Group I																	
Libya(1)	1	4.5	183%	96	96	19	20	765	584	186%	53%	70%	183%	116%	184%	125%	999%
Saudi Arabia(1)	2	16.0	166%	94	94	10	21	936	623	193%	47%	70%	166%	77%	169%	88%	999%
UAE(1)	3	1.7	77%	266	266	100	100	742	478	77%	45%	70%	77%	14%	77%	35%	999%
Kuwait(1)	4	2.1	31%	129	129	7	14	212	106	38%	6%	13%	31%	-35%	34%	-6%	349%
Oman(1)	5	1.8	248%	36	73	15	29	677	452	596%	47%	70%	248%	132%	272%	165%	343%
Jordan(1)	6	4.3	183%	54	54	7	15	185	145	217%	55%	70%	183%	121%	191%	145%	292%
Yemen(1)	7	11.3	198%	18	20	3	5	231	231	271%	70%	70%	198%	198%	204%	204%	210%
Israel	8	4.7	68%	65	126	20	41	322	229	227%	50%	70%	68%	19%	101%	63%	141%
Egypt(1)	9	56.3	73%	53	53	79	79	781	664	73%	60%	70%	73%	47%	73%	51%	113%
Tunisia(1)	10	8.1	64%	32	49	11	21	339	244	169%	51%	70%	64%	19%	76%	36%	106%
Iraq(1)	11	18.1	136%	71	71	118	118	2178	1663	136%	53%	70%	136%	80%	136%	85%	105%
Singapore	12	2.7	24%	41	82	43	86	0	0	148%	NS	NA	-	-	148%	148%	94%
Iran(1)	13	58.9	110%	65	65	22	36	1004	938	143%	65%	70%	110%	96%	112%	100%	93%
Syria(1)	14	12.3	171%	41	41	20	23	956	642	183%	47%	70%	171%	82%	172%	88%	90%
Pakistan(1)	15	121.9	134%	26	26	26	26	1226	993	134%	49%	60%	134%	89%	134%	91%	71%
South Africa(1)	16	37.1	91%	96	96	61	61	404	262	91%	45%	70%	91%	24%	91%	43%	60%
Group II																	
Subgroup 1																	
Congo(1)	17	2.2	154%	12	25	5	11	2	1	409%	37%	70%	154%	34%	381%	367%	0%
Zaire(1)	18	37.4	180%	5	11	1	3	2	1	459%	26%	51%	180%	40%	394%	362%	0%
Gabon(1)	19	1.1	135%	41	77	13	25	3	2	347%	47%	70%	135%	58%	334%	329%	0%
Niger(1)	20	7.7	190%	11	20	1	3	57	57	431%	70%	70%	190%	190%	233%	233%	5%
Cameroon(1)	21	11.5	153%	14	23	6	12	11	5	331%	25%	51%	153%	27%	269%	224%	0%
Cote d'Ivoire(1)	22	12.0	207%	14	28	7	14	43	25	515%	40%	70%	207%	77%	309%	221%	3%
Botswana(1)	23	1.3	134%	27	54	17	35	41	23	367%	40%	70%	134%	32%	255%	207%	2%
Lesotho(1)	24	1.8	133%	7	14	7	14	17	13	366%	52%	70%	133%	73%	235%	201%	3%
Burundi(1)	25	5.5	145%	7	14	0	1	13	9	424%	48%	70%	145%	66%	246%	195%	9%
Guinea-Bissau(1)	26	1.0	105%	10	20	1	1	6	3	301%	36%	70%	105%	7%	230%	195%	0%
Uganda(1)	27	18.0	167%	6	13	2	3	12	6	435%	11%	22%	167%	34%	274%	194%	2%
Nigeria(1)	28	96.2	148%	11	20	6	11	20	11	353%	40%	70%	148%	42%	242%	185%	4%
Ghana(1)	29	15.0	153%	12	20	5	9	18	9	338%	17%	34%	153%	26%	242%	176%	3%
Benin(1)	30	4.6	164%	6	13	3	6	19	10	429%	39%	70%	164%	46%	252%	172%	1%
Angola(1)	31	9.9	168%	8	16	6	11	43	29	437%	48%	70%	168%	82%	233%	167%	1%
Haiti	32	6.5	102%	2	3	1	1	5	5	305%	70%	70%	102%	102%	167%	167%	1%
Mozambique(1)	33	14.2	148%	6	13	3	5	30	24	395%	56%	70%	148%	98%	205%	167%	1%
Liberia(1)	34	2.6	181%	15	20	7	14	33	17	338%	3%	6%	181%	41%	244%	160%	0%
Somalia(1)	35	8.7	145%	3	6	0	1	96	96	473%	70%	70%	145%	145%	155%	155%	16%
Sudan(1)	36	24.6	137%	28	28	7	14	597	568	185%	67%	70%	137%	126%	140%	129%	23%
Paraguay	37	4.3	109%	16	33	8	15	85	62	318%	51%	70%	109%	53%	155%	112%	0%

Table 1. Water supply and demand.

															Indicators		
		Population		Per capita water withdrawals						Dom & Ind.	Irrigation efficiency		Irrigation withdrawals		2025 Total withdrawals		
Country	ID	1990	2025 -	Domestic		Industrial		Irrigation		2025 total -	1990	2025	2025 total -		(S1)	(S2)	
		(UN Med)	% increase	1990	2025	1990	2025	1990	2025	% increase	(S1)	(S2)[a]	% increase from 1990		% change	% change	% of
			from 1990						(S2)	from 1990		70%	(S1)	(S2)	from 1990	from 1990	AWR
		(millions)	%	m^3	m^3	m^3	m^3	m^3	m^3	%	%	%	%	%	%	%	%
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Ethiopia(4)	38	47.4	168%	6	11	2	3	44	25	435%	40%	70%	168%	53%	205%	106%	6%
Chad(1)	39	5.6	132%	5	11	1	1	28	18	365%	45%	70%	132%	49%	174%	106%	1%
Burkina Faso(1)	40	9.0	141%	8	16	0	1	32	17	413%	37%	70%	141%	27%	194%	102%	4%
Subgroup 2																	
Nicaragua	41	3.7	147%	92	92	77	77	198	125	147%	44%	70%	147%	55%	147%	98%	2%
Cen. African Rep.	42	2.9	117%	5	11	1	3	19	10	335%	6%	12%	117%	9%	174%	93%	0%
Tanzania(1)	43	25.6	146%	3	7	1	2	36	23	391%	44%	70%	146%	56%	172%	92%	2%
Guinea(1)	44	5.8	162%	14	21	4	8	121	71	328%	41%	70%	162%	53%	184%	89%	1%
Nepal	45	19.3	111%	6	12	2	3	143	118	323%	58%	70%	111%	75%	122%	87%	3%
Peru	46	21.6	70%	57	58	27	54	216	216	128%	70%	70%	70%	70%	86%	86%	30%
Kenya(1)	47	23.6	168%	17	20	3	7	66	33	252%	27%	54%	168%	34%	188%	85%	13%
Guatemala	48	9.2	136%	13	25	24	25	103	59	228%	40%	70%	136%	35%	160%	85%	2%
Senegal(1)	49	7.3	131%	10	20	6	12	185	119	361%	45%	70%	131%	49%	149%	74%	7%
Mali(1)	50	9.2	167%	3	6	2	3	156	93	434%	42%	70%	167%	59%	175%	71%	3%
Bolivia	51	6.6	100%	20	29	10	20	171	118	226%	48%	70%	100%	38%	119%	66%	1%
Turkey(1)	52	56.1	62%	87	87	60	86	395	380	91%	67%	70%	62%	56%	70%	66%	27%
Zimbabwe(1)	53	9.9	98%	19	23	9	19	107	69	194%	45%	70%	98%	28%	118%	63%	11%
Namibia(1)	54	1.3	126%	49	49	5	11	117	58	149%	25%	51%	126%	13%	133%	56%	1%
Colombia	55	32.3	53%	71	71	28	53	75	53	91%	49%	70%	53%	8%	75%	55%	1%
Zambia(1)	56	8.2	135%	29	29	13	20	144	72	174%	13%	27%	135%	17%	144%	53%	2%
Brazil	57	148.5	55%	54	77	47	84	145	82	147%	39%	70%	55%	-13%	93%	53%	1%
Venezuela	58	19.5	78%	164	164	42	71	176	88	104%	35%	70%	78%	-11%	92%	51%	1%
Algeria(1)	59	24.9	82%	45	45	27	27	108	75	82%	49%	70%	82%	26%	82%	49%	47%
Australia	60	16.9	46%	606	606	19	37	308	298	50%	68%	70%	46%	41%	49%	47%	7%
Cambodia	61	8.8	123%	3	6	1	1	60	35	345%	40%	70%	123%	28%	136%	47%	0%
Gambia(2)	62	0.9	128%	2	4	1	1	26	13	355%	26%	53%	128%	14%	148%	45%	0%
Madagascar(1)	63	12.6	174%	16	20	0	1	1622	811	251%	23%	47%	174%	37%	175%	39%	8%
Indonesia	64	182.8	51%	12	25	11	21	73	42	202%	34%	60%	51%	-13%	87%	38%	1%
Malaysia	65	17.9	76%	177	177	230	230	361	180	76%	8%	16%	76%	-12%	76%	35%	4%
Belize	66	0.2	104%	11	22	0	1	98	49	327%	35%	70%	104%	2%	127%	35%	0%
Albania	67	3.8	22%	6	11	17	20	71	71	69%	70%	70%	22%	22%	33%	33%	2%
Morocco(1)	68	24.3	67%	21	42	13	25	402	279	228%	49%	70%	67%	16%	80%	32%	47%
Honduras	69	4.9	118%	12	24	15	20	268	134	258%	23%	45%	118%	9%	130%	31%	3%
New Zealand(2)	70	3.4	30%	271	271	59	118	259	197	53%	53%	70%	30%	-1%	43%	29%	1%
Myanmar	71	41.8	81%	7	14	3	6	91	51	261%	39%	70%	81%	1%	99%	27%	0%
Mauritania(1)	72	2.0	122%	57	57	17	20	849	445	132%	37%	70%	122%	16%	123%	25%	20%
El Salvador	73	5.2	88%	17	34	10	20	218	109	276%	35%	70%	88%	-6%	109%	25%	8%
Lebanon(1)	74	2.6	73%	124	124	18	36	302	161	95%	37%	70%	73%	-8%	80%	25%	32%
Chile	75	13.2	50%	358	358	309	309	959	684	50%	50%	70%	50%	7%	50%	25%	6%
Subgroup 3																	
Canada(2,3)	76	27.8	38%	288	288	1121	1121	192	96	38%	26%	51%	38%	-31%	38%	29%	2%
USA(2)	77	249.9	33%	243	243	842	842	785	605	33%	54%	70%	33%	2%	33%	20%	23%
Philippines	78	60.8	72%	123	123	144	144	418	209	72%	18%	35%	72%	-14%	72%	20%	15%
Jamaica	79	2.4	40%	11	22	11	22	137	88	179%	45%	70%	40%	-10%	59%	17%	5%
Switzerland	80	6.8	14%	40	40	126	126	7	7	14%	70%	70%	14%	14%	14%	14%	3%
Sweden	81	8.6	14%	123	123	188	188	31	31	14%	70%	70%	14%	14%	14%	14%	2%
Vietnam	82	66.7	77%	54	54	37	37	323	173	77%	32%	60%	77%	-5%	77%	13%	8%
Ecuador	83	10.3	73%	41	45	17	35	523	295	138%	39%	70%	73%	-2%	80%	12%	2%
Norway(2)	84	4.2	11%	98	98	351	351	39	29	11%	52%	70%	11%	-17%	11%	9%	1%
Poland	85	38.1	9%	42	58	244	244	35	18	15%	15%	30%	9%	-46%	14%	8%	24%
Mexico	86	84.5	62%	54	58	72	72	773	467	67%	42%	70%	62%	-2%	62%	7%	23%
France(2)	87	56.7	8%	106	106	459	459	100	82	8%	58%	70%	8%	-11%	8%	5%	20%
Argentina	88	32.5	42%	94	109	188	188	761	462	49%	43%	70%	42%	-14%	44%	3%	4%
Greece(2)	89	10.2	-4%	42	84	152	180	329	294	31%	62%	70%	-4%	-14%	9%	3%	9%
Austria(2)	90	7.7	7%	100	100	176	176	27	14	7%	2%	4%	7%	-46%	7%	2%	3%
Bangladesh	91	108.1	81%	7	13	2	4	211	106	263%	30%	60%	81%	-9%	89%	2%	1%
Belgium(2,3)	92	10.0	5%	101	101	779	779	37	0	5%	NS	NA	-	-	0%	0%	73%
Costa Rica	93	3.3	70%	31	57	55	55	694	347	121%	15%	31%	70%	-15%	75%	0%	3%
Dominican Rep.	94	7.1	57%	22	45	27	40	397	198	172%	32%	64%	57%	-21%	70%	0%	16%
South Korea	95	42.9	27%	120	126	221	221	291	145	29%	16%	33%	27%	-37%	28%	-1%	41%
Denmark(2)	96	5.1	-1%	70	70	63	63	100	100	-1%	70%	70%	-1%	-1%	-1%	-1%	9%

Table 1. Water supply and demand.

Country	ID	Population		Per capita water withdrawals						Dom & Ind.	Irrigation efficiency		Irrigation withdrawals		Indicators: 2025 Total withdrawals		
		1990	2025 -	Domestic		Industrial		Irrigation		2025 total -	1990	2025	2025 total -		(S1)	(S2)	
		(UN Med)	% increase	1990	2025	1990	2025	1990	2025	% increase	(S1)	(S2)[a]	% increase from 1990		% change	% change	% of
			from 1990						(S2)	from 1990		70%	(S1)	(S2)	from 1990	from 1990	AWR
		(millions)	%	m^3	m^3	m^3	m^3	m^3	m^3	%	%	%	%	%	%	%	%
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
UK(2)	97	57.4	7%	4	8	158	158	43	22	10%	9%	17%	7%	-46%	9%	-2%	16%
North Korea	98	21.8	53%	76	76	110	110	502	251	53%	15%	31%	53%	-23%	53%	-3%	22%
Panama	99	2.4	57%	90	90	83	83	581	290	57%	7%	14%	57%	-21%	57%	-3%	1%
Sri Lanka	100	17.2	45%	10	20	10	20	483	292	191%	36%	60%	45%	-12%	51%	-4%	19%
Romania(2)	101	23.2	-6%	91	91	374	374	669	669	-6%	70%	70%	-6%	-6%	-6%	-6%	12%
Netherlands(2)	102	15.0	9%	26	26	316	316	176	96	9%	38%	70%	9%	-41%	9%	-8%	8%
Thailand	103	55.6	32%	24	48	36	72	542	284	165%	31%	60%	32%	-31%	46%	-11%	17%
Spain	104	39.3	-4%	94	126	203	203	484	396	6%	57%	70%	-4%	-22%	0%	-11%	29%
Cuba	105	10.6	19%	78	78	17	26	774	534	31%	48%	70%	19%	-18%	21%	-12%	23%
Germany	106	79.4	-4%	64	64	405	405	110	55	-4%	11%	21%	-4%	-52%	-4%	-13%	23%
Bulgaria	107	9.0	-14%	46	46	1173	1173	324	324	-14%	70%	70%	-14%	-14%	-14%	-14%	6%
Finland(2)	108	5.0	8%	53	53	198	198	189	95	8%	11%	21%	8%	-46%	8%	-15%	2%
Surinam	109	0.4	50%	71	71	59	59	1058	529	50%	23%	45%	50%	-25%	50%	-17%	0%
Portugal(2)	110	9.9	-2%	111	126	273	273	355	217	2%	43%	70%	-2%	-40%	0%	-18%	9%
Uruguay	111	3.1	19%	14	29	7	14	219	121	139%	39%	70%	19%	-34%	30%	-19%	0%
Hungary	112	10.4	-9%	59	80	364	364	238	119	-5%	26%	53%	-9%	-55%	-7%	-23%	4%
Japan	113	123.5	-2%	125	125	243	243	368	184	-2%	4%	7%	-2%	-51%	-2%	-26%	12%
Guyana	114	0.8	43%	18	33	0	1	1794	897	171%	14%	27%	43%	-28%	45%	-26%	0%
Italy	115	57.0	-8%	138	138	266	266	582	357	-8%	43%	70%	-8%	-44%	-8%	-29%	24%

a - 2025 Irrigation efficiency is assumed to be twice the1990 level or 70 percent, which ever is lower.
For major rice irrigating countries such as China, India, Indonesia, Vietnam, Bangladesh, Sri Lanka, and Thailand, 2025 irrigation efficiency is assumed to be 60%.