THE FAO IRRIGATED AREA FORECAST FOR 2030

Jean-Marc Faurès[a], Jippe Hoogeveen[a] and Jelle Bruinsma[b]

a) Land and Water Development Division, FAO, 00100 Rome, Italy
email: JeanMarc.Faures@fao.org *(Corresponding author) and* Jippe.Hoogeveen@fao.org
b) Global Perspective Studies Unit, FAO, 00100 Rome, Italy
email: Jelle.Bruinsma@fao.org

Introduction

One of the major questions on the future of irrigation is whether there will be sufficient freshwater to satisfy the growing needs of agricultural and non-agricultural users. Agriculture already accounts for about 70 percent of the freshwater withdrawals in the world and is usually seen as the main factor behind the increasing global scarcity of freshwater.

In the framework of its study "World Agriculture: Towards 2015/2030" (AT2030), FAO recently reviewed the current status and role of irrigation in 93 developing countries, and assessed the likely situation of irrigation in 2015 and 2030. The method used in this assessment and the main results of the study, in terms of agricultural production, land under irrigation and agricultural water use are presented in this paper.

The study shows that fears of a looming crunch between population growth and land availability are unwarranted. In the recent past, world demand for agricultural products has slowed, driven mostly by a decreasing rate of population growth and the fairly high levels of food consumption reached in many countries. Future demand growth will slow further. If, at the global level, the production potential exists to cope with increasing demand, developing countries will be more dependent on agricultural imports, and production in poor areas must increase if food security is to improve. The same applies to land and water resources. Globally, there is still untapped potential for use of land and water resources for agriculture. The globally positive situation should not hide the fact that in large areas of the developing world, agriculture is facing its limits, either by lack of water or lack of land.

Method used to assess current and future irrigated areas

Figure 1 summarises the method used by FAO to assess current and future contributions of irrigation to food production. The study covered 93 developing countries. It was part of a much larger effort carried out at regular intervals by FAO to assess the state of the world's agriculture, forestries and fisheries, and their possible long-term development. Three main sources of data and information were used in this assessment: FAOSTAT[1], the main FAO statistical database, AQUASTAT[2], FAO's information system on water use in agriculture, which focuses on irrigation in developing countries, and the study "World Agriculture - Towards 2015/2030" (AT2030). The AT2030 study is first shortly described in the next section, after which details are provided about irrigation forecasting and the computation of agricultural water use.

The study "Agriculture - Towards 2015/30"

AT2030 is the latest FAO assessment of possible long-term developments in world food, nutrition and agriculture, including the forestry and fisheries sectors (FAO, forthcoming). It is the product of an

[1] Accessible on the Web at: http://apps.fao.org/

[2] Accessible on the Web at: http://www.fao.org/ag/agl/aglw/aquastat/main/index.htm

inter-disciplinary exercise, involving most of FAO's technical units and disciplines. Similar previous assessments can be found in Alexandratos (1995), Alexandratos (1988), FAO (1981) and FAO (1970).

The projections covered about 140 individual countries and 32 crop and livestock commodities. For nearly all developing countries of this report, the main contributors to agricultural production growth were identified and separately analyzed. Sources of productivity growth like higher yields and carcass weights were distinguished from other growth resources like harvested land and herd sizes. Special attention was given to land which was broken down into five land classes for rainfed agriculture and a separate land class for irrigated land. The great deal of detail proved both necessary and advantageous in the process of identifying the main issues that are likely to emerge for world agriculture over the next 30 years. Specifically, it helped spotting local production and resource constraints, gauging country-specific food import requirements, and assessing progress and failure in the fight against hunger and under-nourishment. The high degree of detail was also necessary to integrate the expertise of FAO specialists from various disciplines, as the analysis draws heavily on 'expert-judgement' making maximum use of FAO's in-house expertise. The results are mainly presented at the aggregate regional and sectoral levels.

An important feature of this outlook is that its approach is 'positive' rather than 'normative'. This means that all assumptions and projections reflect the most likely future but not necessarily the most desirable one. For example, the report finds that agricultural land use will continue to expand into wetlands and rainforests. Similarly, the report finds that irrigation will continue to expand in environmentally vulnerable regions where pressure on water resources is already high, even though these are undoubtedly highly undesirable outcomes. In general, the prospective developments presented in this report are therefore not goals of an FAO strategy, but they can provide a basis for action to cope with the problems likely to persist and new ones that may emerge.

The main focus of the study has been placed on how the world will be able to feed itself in the future and what the need to produce more food means for its natural resource base. The base year for this study is the three-year average 1997/99 and projections are made for the years 2015 and 2030. The time horizon to 2030 offers a sufficiently long period to analyze issues that revolve around the sustainability of the world's agricultural resource base, its capability to cope with longer-term pressures arising from a further degradation of agricultural land, desertification, water requirements and use, as well as increasing demographic pressure.

The population projections used in this study reflect the latest assessment (2000 Assessment, Medium Variant) available from the UN (UN, 2001). The prospective income developments are largely based on the latest GDP projections from the World Bank. Most of the agricultural data are from FAO's database (FAOSTAT) as available in July 2001.

Assessing and mapping area under irrigation for the base year 1997/99

FAOSTAT, the main FAO statistics database, maintains country time series of area of land under irrigation since 1961. This dataset forms the basis of any analysis on the importance and role of irrigated agriculture in the world. Data obtained from countries are regularly checked and improved through comparison with the regular AQUASTAT country surveys. The AQUASTAT programme compiles information by country on water use in agriculture, with emphasis on irrigation and drainage in developing countries. It develops GIS based datasets with the aim to monitor the agricultural component of the water balance. These datasets include a global map of irrigated areas, and the climatological information necessary to assess agricultural water use and water balance.

The preparation of a reliable global map of irrigated agriculture is the first necessary step towards assessing the extent, location, and role of irrigated agriculture, both in terms of agricultural production and in terms of water balance.

The Centre for Environmental Systems Research (CESR) of the University of Kassel, Germany, has recently developed a methodology for mapping irrigated areas at continental level and produced the first global digital map of irrigation with a resolution of 0.5 degrees (about 50 km at the equator) on the basis of cartographic information and FAO statistics. FAO and CESR have further improved the methodology and accuracy of the map by integrating more detailed information obtained, in parts, from the AQUASTAT surveys.

The "Global map of irrigation" consists of a spatial database in a GIS environment for each continent (North America, South America, Europe, Africa, Asia, Oceania) with different data layers containing raw data on the locations of irrigated areas, and tools to convert these raw data into one raster data layer representing the amount of irrigated area per grid-cell. The data in the spatial database are organised in such a way that new data can be easily incorporated allowing quick updates of the global map.

The methodology used to generate the map is explained in detail in Döll and Siebert (1999). Further developments and improvements are described in Siebert and Döll (2001). The generation of the digital map includes a variety of steps depending on the type of data for the respective country. First, the location of irrigated areas within each country is determined, mainly by digitising existing irrigation maps and extracting all possible information from country databases and reports about location of main irrigation areas. Additional information like interpreted satellite images provides indication on agricultural areas and help identifying possible location of irrigated land. Once all the information on irrigation location is captured in GIS, irrigation density is modelled on a 5' raster based on information on the total irrigated area within a spatial unit (e.g. a country). The final product is a raster map indicating the percentage of land in the cell that is under irrigation.

In the first version of the map, the irrigation density was calculated on a working resolution of 5' (0.0833°). For Latin America, Europe and Africa, which were updated after 2000, the working resolution was increased to a 0.01° raster. The final map shows the amount of irrigation as a percentage of the total area, aggregated on a 5' raster grid.

Irrigation potential

Irrigation potential is an important indicator to help assessing future irrigation development. It is expressed in units of area and indicates how close the countries are from maximum extension of irrigated land. In AQUASTAT, the value of irrigation potential is systematically compiled from national surveys. It refers to the extent of land suitable for irrigation and for which sufficient water is available. Methods to compute irrigation potential vary, however, from one country to another, and it is difficult to obtain a homogenous assessment of this indicator across countries. In particular, in countries with abundant water resources, the concept of irrigation potential also includes some consideration of economic feasibility of irrigated land, therefore reducing the total amount of land with irrigation potential. In arid lands, however, the AQUASTAT country surveys have shown that countries had a fair and relatively detailed estimate of their irrigation potential.

The irrigation potential was taken into account in projecting irrigation and the projections to 2030 assume that agricultural water demand will not exceed available water resources. However, the concept of irrigation potential is not static. It varies over time, in relation to the country's economic situation or as a result of increased competition for water for domestic and industrial use. In addition, estimates of irrigation potential also are based on renewable water resources, i.e. the resources replenished annually through the hydrological cycle. In those arid countries where mining of fossil groundwater represents an important part of water withdrawal, or where groundwater resources are over-exploited through depletion of the aquifers, the area under irrigation can be larger than the irrigation potential.

Assessing area under irrigation in 2015 and 2030

Assessment of area under irrigation in 2015 and 2030 was done on a country basis, through an iterative process, on the basis of the AT2030 estimates of food production demand. The AQUASTAT information base provided estimates of base year (1997/99) values of land under irrigation, cropping patterns and cropping intensities in irrigation, and national projections for irrigation development in the forthcoming years. The AT2030 study provided estimates of food demand in 2015 and 2030, and of crop yield in irrigation for the base year, 2015 and 2030. Although they are not food crops, cotton and fodder were included in the computation of land under irrigation in view of their relative importance in irrigation in some countries.

Results

Sources of crop production growth

There are three main sources of growth in crop production: expanding the land area, increasing the frequency with which it is cropped (often through irrigation), and boosting yields. It has been suggested that we may be approaching ceilings in all three factors. This study does not support this view at the global level, though in some countries and even whole regions serious problems exist and could deepen.

In the future, 80 percent of increased crop production in developing countries will come from intensification: higher yields, increased multiple cropping and shorter fallow periods (Table 1). The remaining 20% will come from expansion of agricultural land, mainly in countries showing important potential.

Table 1: Sources of growth in crop production (percent)

	Arable land expansion (1)		Increases in cropping intensity (2)		Harvested land expansion (1+2)		Yield increases	
	1961 -1999	1997/99 -2030	1961 -1999	1997/99 -2030	1961- 1999	1997/99 -2030	1961 -1999	1997/99 -2030
All developing countries	23	21	6	12	29	33	71	67
excl. China	23	24	13	13	36	37	64	63
excl. China and India	29	28	16	16	45	44	55	56
Sub-Saharan Africa	35	27	31	12	66	39	34	61
Near East/North Africa	14	13	14	19	28	32	72	68
Latin America and Car.	46	33	-1	21	45	54	55	46
South Asia	6	6	14	13	20	19	80	81
East Asia	26	5	-5	14	21	19	79	81
World	15		7		22		78	
All developing countries								
crop production – rainfed		25		11		36		64
crop production – irrigated		28		15		43		57

Cropland

The projections suggest that the arable area in developing countries will see a net increase of 120 million hectares over the years 1997/99 to 2030, or almost 13 percent. This would take up less than 7 percent of the unused land that is suitable for rainfed crop production. A slowdown in expansion is expected in all regions, as a result of the slower growth in demand for crops. More than 80 percent of the projected land expansion is expected to take place in sub-Saharan Africa and Latin America. By contrast, in South Asia and Near East/North Africa, where almost all the suitable land is already in use, there will be next to no expansion in area. By 2030 the Near East/North Africa region is projected to be using 94 percent of its suitable cropland, with a surplus of only 6 million hectares. In South Asia the situation will be even tighter, with 98 percent already in cultivation. In South and East Asia, more than 80 percent of production growth will be based on yield increases and only 5-6 percent on expansion of the arable area.

Crop production

The growth rate of world demand for cereals has been in decline, from 2.5 percent a year in the 1970s and 1.9 percent a year in the 1980s to only 1.0 percent a year in the 1990s, as a result of slower population growth and shifts in diets and animal feeds. Cereal consumption growth is expected to rise again to 1.4 percent a year to 2015, slowing to 1.2 percent per year thereafter. In developing countries overall, cereal production is not expected to keep full pace with demand. There, the net cereal deficits of 103 million tons in 1997/99 - 9 percent of developing country consumption - could rise to 265 million tons in 2030, when it will be 14 percent of consumption. This gap will be bridged by increased production from traditional grain exporters, and by the expected shift of transition countries from net importers to net exporters of cereals.

Cropping intensities and yield improvement

Cropping intensities will rise in all developing regions, from 93 percent to 99 percent. This will occur by way of a shortening of fallow periods, and an increase in multiple cropping, made possible partly by growth in the irrigated area.

In the last four decades yield improvements accounted for almost 80 percent of the increase in global crop production. Yield growth will continue to be the dominant factor in future. In developing countries yield increases will account for more than two thirds of crop production growth to 2030, and they will not need to be as rapid as in the past.

Irrigation

Cropping intensities and yields are systematically higher in irrigated than in rainfed areas. In 1997/99, irrigated land made up only about one fifth of the total arable area but produced two fifths of all crops and close to three fifths of cereal production. This importance is expected to increase further. The developing countries as a whole are expected to expand their irrigated area from 202 million hectares in 1997/99 to 242 million hectares by 2030. Most of this expansion will occur in land scarce areas of southern and Eastern Asia where irrigation is already crucial.

The net increase in irrigation is less than 40 percent of that achieved since the early 1960s. There appears to be enough unused irrigable land to meet future needs. This study estimates a total irrigation potential of some 402 million hectares in developing countries, of which half is currently in use. However, water resources will be scarce in South Asia (and in particular in India and Pakistan) which will be using 41 percent of its renewable freshwater resources by 2030, and even more so in the Near East/North Africa, which will be using 58 percent of the total amount of fresh water produced annually. Pressed by increased competition from other sectors, these areas will need to free additional water resources by achieving greater efficiency in irrigation water use.

Assessment of the water balance in developing countries

Previous data collection processes through AQUASTAT country surveys have shown that country figures for agricultural water use are not always available. When they exist, they are rarely reliable, and in most cases they are rough estimates based on water use per unit area of irrigated land. In this study, a water balance approach was used to estimate current and future water use in agriculture for the 93 developing countries, based on the global map of irrigation and available climatic datasets.

Method used to compute the water balance

Precipitation provides part of the water crops need to satisfy their transpiration requirements. The soil, acting as a buffer, stores part of the precipitation water and returns it to the crops in times of deficit. In humid climates, this mechanism is sufficient to ensure satisfactory growth in rainfed agriculture. In arid climates or during extended dry seasons, irrigation is necessary to compensate for the evaporation deficit due to insufficient or erratic precipitation. Net irrigation water requirements in irrigation are therefore defined as the volume of water needed to compensate for the deficit between potential evapotranspiration and effective precipitation over the growing period of the crop. It varies considerably with climatic conditions, seasons, crops and soil types. For a given month, the crop water balance can be expressed as follows:

$$IWR = Kc.ETo - P - \Delta S$$

where: IWR is the net irrigation water requirement needed to satisfy crop water demand

Kc is a coefficient varying with crop type and growth stage

Eto is the reference potential evapotranspiration, depending on climatic factors

P is the precipitation

ΔS is the change in soil moisture from previous month

In the specific case of paddy rice irrigation, additional water is needed for flooding to facilitate land preparation and for plant protection. In that case, irrigation water requirements are the sum of rainfall deficit and the water needed to flood paddy fields. In this study, irrigation water requirement has been computed for each country on the basis of the irrigated and harvested areas by crop for the reference period 1997/99. The methodology is described in details below.

Water balance under natural conditions

The estimation of the water balance for an average year is based on three digital geo-referenced data sets for precipitation (Leemans and Cramer, 1991), reference evapotranspiration (Fischer et al., 2000) and soil moisture storage properties (FAO, 1995b). The computation of water balance is carried out by a model with a 10 km spatial resolution of grid-cells and in monthly time steps. The results consist of annual values by grid-cell for actual evapotranspiration, runoff and water stored as soil moisture.

For each grid cell, actual evapotranspiration (Eta) is assumed to be equal to the reference evapotranspiration (Eto), calculated for each cell with the Penman-Monteith method (FAO, 1998; New et al., 1999) in those periods of the year when precipitation exceeds reference evapotranspiration or when there is enough water stored in the soil to allow maximum evapotranspiration. In drier periods of the year, lack of water reduces actual evapotranspiration to an extent depending on the available soil moisture. Evapotranspiration in open water areas and wetlands is considered to be equal to reference evapotranspiration throughout the whole calculation period.

For each grid cell, runoff is calculated as the part of the precipitation that does not evaporate and cannot be stored in the soil. Runoff is always positive except for areas identified as open water or wetland, where actual evapotranspiration can exceed precipitation.

The method is calibrated by comparing calculated values for water resources per country (i.e. the difference between precipitation and actual evapotranspiration) with data on water resources for each country obtained from AQUASTAT country surveys (FAO, 1995a; 1997a; 1997b; 1999). In addition, the discharges of major rivers given in the literature have been compared with the calculated runoff for the drainage basin of these rivers. Where the calculated runoff values did not match the values available in the literature, correction factors have been applied to one or more of the basic input data on precipitation, reference evapotranspiration, soil moisture storage and open water.

Irrigation water requirements

The calibrated water balance under natural conditions, the global irrigation map and the irrigated crops database produced in the framework of AT2030 have been used as inputs for the computation of the amount of water withdrawn for crop production. Like the computation of the water balance under natural conditions, the calculation of consumptive water use in irrigation (or net irrigation water requirements) is carried out by grid cells of 10 by 10 km in monthly time steps.

Evapotranspiration requirements of crops in irrigated agriculture are calculated by converting data of irrigated area by crop (at the national level) into a cropping calendar with monthly occupation rates of the land equipped for irrigation. Cropping calendars have been developed for each of the countries of the study (except for China, India and Indonesia that were divided in several zones of homogenous cropping pattern). Table 2 presents irrigation cropping calendar for Morocco for the base year 1997/99.

Table 2: Cropping calendar in irrigation for Morocco for the base year 1997/99

Crop under irrigation	**Irrigated area (1000 ha)**	**Crop area as share (percent) of the total area equipped for irrigation by month**											
		J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Wheat	592	47	47	47	47						47	47	47
Maize	156			12	12	12	12	12					
Potatoes	62					5	5	5	5	5			
Beet	34				3	3	3	3	3	3			
Cane	15	1	1	1	1	1	1	1	1	1	1	1	1
Vegetables	156					12	12	12	12	12			
Citrus	79	6	6	6	6	6	6	6	6	6	6	6	6
Fruits	88	7	7	7	7	7	7	7	7	7	7	7	7
Groundnut	10					1	1	1	1	1			
Fodder	100	8	8							8	8	8	8
Sum over all crops	1305	70	69	74	77	49	49	49	36	44	70	70	70
Equipped for irrigation	1258												
Total cropping intensity	104 %												

The rate of evapotranspiration coming from the irrigated area per month and per grid cell is calculated by multiplying the area equipped for irrigation with cropping intensity and crop evapotranspiration for each crop.

$$ET = IA.\sum_{c} CI_{c}.kc.ETo$$

where ET is the evapotranspiration of the irrigated are for a given month and a given grid cell

IA is the irrigated area in percentage of cell area for the given grid cell

CI is the cropping intensity for a given crop c

kc is the crop coefficient, varying for each crop and each growth stage

Eto is the reference evapotranspiration.

The difference between the calculated evapotranspiration of the irrigated area and actual evapotranspiration under non-irrigated conditions is equal to the consumptive use of water in irrigated agriculture in the grid cell, i.e the net irrigation water requirement. In the case of paddy rice, an additional amount of water is needed for flooding. In this study it was computed by by multiplying the area under irrigated rice by a water layer of 25 centimetre.

Irrigation water use

Assessing the impact of irrigation on water resources requires an estimate of the water effectively withdrawal for irrigation, i.e. the volume of water extracted from rivers, lakes and aquifers for irrigation purposes. Irrigation water withdrawal normally far exceeds the consumptive use of irrigation because of water lost in its distribution from its source to the crops. The ratio between the estimated irrigation water requirements and the actual irrigation water withdrawal is usually referred to as "irrigation efficiency".

Data on country water withdrawal for irrigation have been collected through the AQUASTAT country surveys. (FAO, 1995b, 1997a, 1997b and 1999c). Data on irrigation efficiencies are generally not easily available at field, irrigation scheme or river basin levels and very scattered and unreliable information is available at country level. In order to estimate national figures on irrigation efficiencies, the AQUASTAT figures on water withdrawal have been compared with the figures on irrigation water requirements calculated above. In view of the fact that large uncertainties exist on the value of the country figures, a regional rather than national approach was used to assess irrigation efficiency:

$$WUE_r = \frac{IWR_r}{AWW_r}$$

where r is the region

WUE is the water use efficiency for the region

IWR is the total irrigation water requirement for the countries of the region

AWW is the total agricultural water use for the region, obtained from the country surveys.

Individual estimates of irrigation efficiencies by country have then been obtained on the basis of these regional ratios and adapted on the basis of expert judgement when felt necessary. Dividing the irrigation water requirements from the water balance model by the irrigation efficiency results in revised estimations of water withdrawal for irrigated agriculture per country. The results are summarised for five regions in Table 3.

On average, for the 93 developing countries, it is estimated that irrigation efficiency was around 38 percent in the reference period 1997/99, varying from 25 percent in areas of abundant water resources (Latin America) to 40 percent in Near East/North Africa and 44 percent in South Asia where water scarcity calls for higher efficiencies.

Irrigation water withdrawal was estimated to account for only 7 percent of total renewable water resources for the 93 countries. However, there are wide variations between regions, with the Near East / North Africa region using 53 percent of its water resources in irrigation while Latin America barely uses 1 percent. At the country level, variations are even higher: 10 countries used more than 40 percent of their water resources for irrigation in the reference year, a situation which can be considered critical. An additional nine countries used more than 20 percent of their water resources, a threshold that could be used to indicate impending water scarcity.

For several countries, relatively low national figures may give an overly optimistic impression of the level of water stress: China, for instance, is facing severe water shortage in the north while the south still has abundant water resources. Already by 1997/99, two countries (Libya, Saudi Arabia) used volumes of water for irrigation larger than their annual water resources. Groundwater mining also occurs at the local level in several other countries of the Near East, South and East Asia, Central America and in the Caribbean, even if at the national level the water balance may still be positive.

Projections for irrigation water withdrawal in 2030

To estimate irrigation water withdrawal in 2030, an assumption had to be made about possible developments in the irrigation efficiency in each country. Two factors have an impact on the evolution of irrigation efficiency: the estimated levels of irrigation efficiency in 1997/99 and the level of water scarcity. An empirical function was designed to capture the influence of these two parameters, bearing in mind that improving irrigation efficiency is a very slow and difficult process. The overall result is that efficiency will increase by 4 percentage points, from 38 percent to 42 percent over the 30 years period. Such an increase in efficiency will be more pronounced in water scarce regions (e.g. a 13 percentage point increase in the Near East / North Africa region) than in regions with abundant water resources (between 0 and 4 percentage points in Latin America East Asia and sub-Saharan Africa). Indeed, it is expected that, under pressure from limited water resources and competition with other users, demand management will play a more important role in improving irrigation efficiency in water scarce regions. In contrast, in humid areas the issue of irrigation efficiency is much less relevant and is likely to receive little attention.

Table 3: Water balance and irrigation water withdrawal in 1997/99 and 2030

	unit	sub-Saharan Africa	Latin America	Near East /North Africa	South Asia	East Asia	All developing countries
Precipitation	mm	880	1534	181	1093	1252	1043
Water balance							
Renewable water resources	km^3	3450	13409	541	2469	8609	28477
Irrigation water withdrawal							
Irrigation efficiency 1997/99	%	33	25	40	44	33	38
Irrigation water withdrawal 1997/99	km^3	80	182	287	895	684	2128
idem as percent of RWR	%	2	1	53	36	8	7
Irrigation efficiency 2030	%	37	25	53	49	34	42
Irrigation water withdrawal 2030	km^3	115	241	315	1021	728	2420
idem as percent of RWR	%	3	2	58	41	8	8

Note: The RWR for all developing countries excludes the regional incoming flows to avoid double counting.

For the 93 countries, irrigation water withdrawal is expected to grow by about 14 percent, from the current 2128 km^3/yr to 2420 km^3/yr in 2030. This increase is low compared to the 34 percent increase projected in harvested irrigated area, from 254 million ha in 1997/99 to 340 million ha in 2030. Most of this difference is explained by the expected improvement in irrigation efficiency, leading to a reduction in irrigation water withdrawal per irrigated hectare. A small part of this reduction is also due to changes in cropping patterns for some countries such as China, where a substantial shift from rice to wheat production is expected: irrigation water requirements for rice production are usually twice those for wheat.

In conclusion, irrigation currently represents a relatively small part of the total water resources of the 93 developing countries, and there remains a significant potential for further irrigation development. With a relatively small increase in irrigation water withdrawal expected between 1997/99 and 2030, this situation will not change much at the aggregate level. At the local level, however, there are already very severe water shortages, in particular in the Near East / North Africa region, and the number of regions facing water scarcity will increase with growing competition from agriculture, cities and industries.

Conclusions

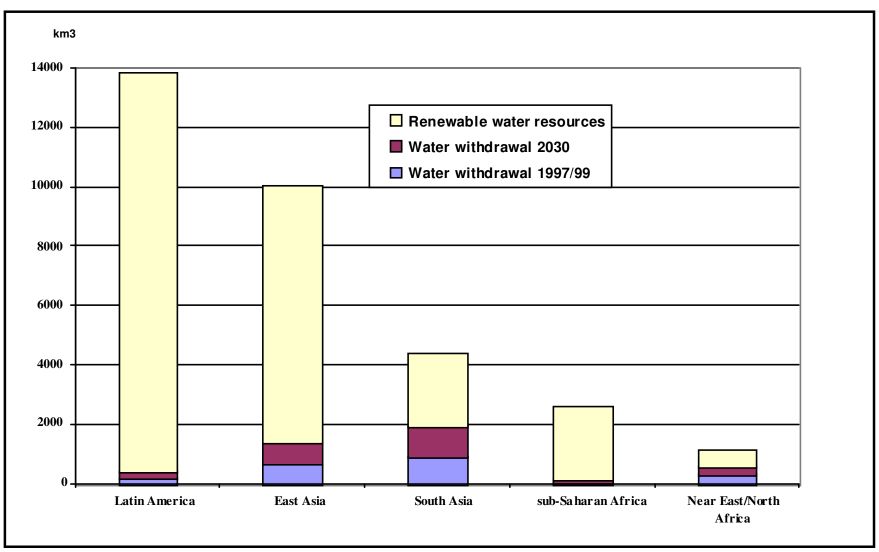
In recent years the growth rates of world agricultural production and crop yields have been on a slowing trend. The slowdown occurred not because of shortages of land or water, but because demand for agricultural products was slowing. World population growth rates have been declining since the late 1960s, and fairly high levels of food consumption per person are being reached in many countries, beyond which further rises are limited. These trends will continue. As a result, the growth in world demand for agricultural products is expected to fall from an average 2.2 percent a year over the past 30 years to 1.5 percent a year for the next 30. World agricultural production can grow in line with demand, and global shortages are unlikely, but at national and local level serious problems already exist in many places, and may worsen unless focussed efforts are made.

Irrigation prospects and water resources

In most regions there will be no shortage of land or water for irrigation, but serious problems will persist in some countries and regions. In 1997/99, irrigated land made up only about one fifth of the total arable area in developing countries. However, because of higher yields and higher cropping intensity, it accounted for two fifths of all crop production. This importance is expected to increase further in the next three decades.

The developing countries as a whole are expected to expand their irrigated area from 202 million hectares in 1997/99 to 242 million hectares by 2030. Most of this expansion will occur in land scarce areas where irrigation is already crucial – South Asia and East Asia will add 14 million hectares each. The Near East/North Africa will also see a significant expansion in the area where there are still untapped water resources. In the land abundant areas of sub-Saharan Africa and Latin America, where both the need and the potential for irrigation are lower, the increase is expected to be much more modest – 2 million and 4 million hectares respectively. Such an expansion is much lower than the one observed during the last 30 years. The expected annual growth rate of 0.6 percent of irrigated land is less than a third of the rate achieved in the past 30 years.

Chart 1: Irrigation and water resources, 1997/99-2030



Globally, about 7 percent of renewable water resources were withdrawn for irrigation in 1997/99. But because of differences in efficiency and in water availability, some regions were using a very much higher proportion of their renewable water resources for irrigation than others. In sub-Saharan Africa, where irrigation is less widespread, only 2 percent were used, and in water-rich Latin America a mere 1 percent. But in South Asia irrigation used 36 percent of renewable water resources, and in Near East/North Africa no less than 53 percent. AT2030 projections for developing countries imply a 14 percent increase in water withdrawals for irrigation by 2030. By then still only 8 percent of their renewable water resources will be used for irrigation. The shares in Sub-Saharan Africa and Latin America will remain very small.

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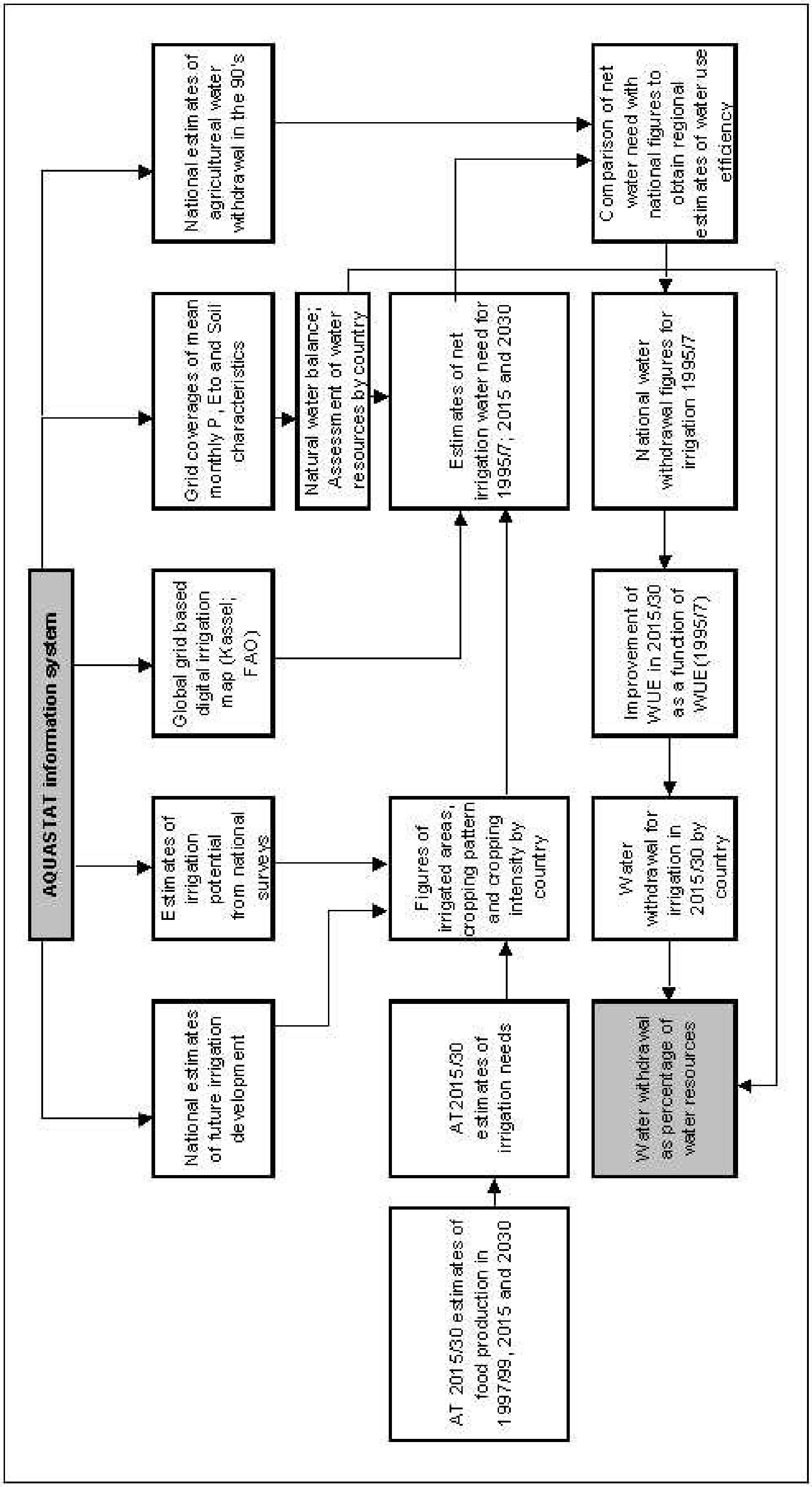

Figure 1: Methodology used to assess water withdrawal for irrigation in 2030 in 93 developing countries

World Agriculture: Towards 2015/30: Selected data and projections

Population (millions)	1979/81	1997/99	2015	2030	2050
World	4430	5900	7207	8270	9322
Developing countries	3259	4595	5858	6910	7987
Industrial countries	789	892	951	979	986
Transition countries	382	413	398	381	349
Population (% p.a.)	**1979-99**	**1989-99**	**1979/99-2015**	**2015-2030**	**2030-2050**
World	1.6	1.5	1.2	0.9	0.6
Developing countries	1.9	1.7	1.4	1.1	0.7
Industrial countries	0.7	0.7	0.4	0.2	0.0
Transition countries	0.5	0.1	- 0.2	- 0.3	- 0.4
Total demand for agricultural products (% p.a.)					
	1969-99	**1979-99**	**1989-99**	**1979/99-2015**	**2015-2030**
World	2.2	2.1	2.0	1.6	1.4
Developing countries	3.7	3.7	4.0	2.2	1.7
Industrial countries	1.1	1.0	1.0	0.7	0.6
Transition countries	- 0.2	- 1.7	- 4.4	0.5	0.4
Total agricultural production (% p.a.)					
	1969-99	**1979-99**	**1989-99**	**1979/99-2015**	**2015-2030**
World	2.2	2.1	2.0	1.6	1.3
Developing countries	3.5	3.7	3.9	2.0	1.7
Industrial countries	1.3	1.0	1.4	0.8	0.6
Transition countries	- 0.4	- 1.7	- 4.7	0.6	0.6

Arable land (million ha)		1997/99	2015	2030	1979/81	1997/99	2015	2030
		total			irrigated			
World		1608			210	271		
Developing countries		956	1017	1076	151	202	221	242
Industrial countries		387			37	42		
Transition countries		265			22	25		
Crop land and yields in developing countries								
	1979/81	1997/99	2015	2030	1979/81	1997/99	2015	2030
	harvested land (million ha)				yield (tonnes/ha)			
Wheat	96	111	113	118	1.6	2.5	3.1	3.5
Rice (paddy)	138	157	162	164	2.7	3.6	4.2	4.7
Maize	76	97	118	136	2.0	2.8	3.4	4.0
All cereals	408	465	497	528	1.9	2.6	3.2	3.6
as percent of total	60	55	53	51				

World Agriculture: Towards 2015/30: Summary table for land use

	Arable land			Harvested land			Cropping intensity		
	Total	Rainfed	Irrigated	Total	Rainfed	Irrigated	Total	Rainfed	Irrigated
	million ha			million ha			%		
Developing countries									
1997/99	956	754	202	885	628	257	93	83	127
2015	1017	796	221	977	671	306	96	84	138
2030	1076	834	242	1063	722	341	99	87	141
sub-Saharan Africa									
1997/99	228	223	5.3	154	150	4.5	68	67	86
2015	262	256	6.0	185	179	5.7	71	70	95
2030	288	281	6.8	217	210	7.0	76	75	102
Near East/North Africa									
1997/99	86	60	26	70	43	27	81	72	102
2015	89	60	29	77	45	32	86	75	110
2030	93	60	33	84	46	37	90	78	112
Latin America and Car.									
1997/99	203	185	18	127	112	16	63	60	86
2015	223	203	20	150	131	19	67	64	95
2030	244	222	22	172	150	22	71	68	100
South Asia									
1997/99	207	126	81	230	131	100	111	103	124
2015	210	123	87	248	131	117	118	106	134
2030	216	121	95	262	131	131	121	109	137
East Asia									
1997/99	232	161	71	303	193	110	130	120	154
2015	233	155	78	317	186	131	136	120	168
2030	237	151	85	328	184	144	139	122	169