SOLAW TR01

Anticipated trends in the use of global land and water resources

SOLAW Background Thematic Report – TR01

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Introduction

Concerns have been expressed that, in the not too distant future, agriculture may be unable to produce the food needed to feed a still growing world population. The continuing decline of arable land per person is often cited as an indicator of impending problems in this respect[1]. The underlying cause of these problems is perceived to be an ever increasing demand for agricultural products from a finite pool of natural resources such as land, water and genetic potential. Scarcity of these resources would be compounded by competing demands from urbanization, industrial uses and their use in biofuel production. At the same time, forces are at work that could change their availability such as climate change and the need to preserve resources for future generations.

Table 1 shows the drastic slowdown in expected production growth as compared with the past. This mirrors the projected deceleration in demand for agricultural products, which in turn reflects decelerating population growth and the fact that an ever increasing share of population gradually attains mid- to high-levels of food consumption thereby reducing the need for further increases in demand (FAO, 2006).

TABLE 1: ANNUAL CROP PRODUCTION GROWTH (PERCENT PER ANNUM)

	1961-07	1987-07	1997-07	2005/07-30	2030-50	2005/07-50
Developing countries	**3.0**	**3.0**	**2.9**	**1.5**	**0.9**	**1.2**
idem, excluding China and India	2.7	2.8	3.1	1.8	1.3	1.6
sub-Saharan Africa	2.5	3.2	2.9	2.5	1.7	2.1
Near East / North Africa	2.6	2.3	2.1	1.7	1.0	1.4
Latin America and Caribbean	2.6	2.9	3.6	2.1	1.3	1.8
South Asia	2.6	2.2	2.0	1.6	0.9	1.3
East Asia	3.5	3.4	3.3	1.0	0.5	0.8
Developed countries	**0.9**	**0.2**	**0.7**	**0.9**	**0.4**	**0.7**
World	**2.2**	**2.1**	**2.2**	**1.3**	**0.8**	**1.1**

Source: Bruinsma, 2009

Although the annual growth of world agricultural production is projected to fall from 2.2 percent over the last decade to 1.5 percent over the period to 2030 and 0.9 percent for the period 2030 to 2050 (Table 1), it should be noted that the incremental quantities involved are considerable. An additional billion tonnes of cereals and another 200 million tonnes of meat would need to be produced annually until 2050 to meet effective demand as expressed by market projections. These increments do not account for additional production required as feedstock for biofuel production.

Bruinsma (2009) estimated that about 80 percent of the projected growth in crop production in developing countries would come from intensification in the form of yield increases (71 percent) and higher cropping

[1] Note that declining land per person, combined with increasing average food consumption, could be interpreted as a sign of ever increasing agricultural productivity

intensities (8 percent). The share, as a result of intensification, rises to 95 percent in the land-scarce region of South Asia and to over 100 percent in the Near East/North Africa where increases in yield would need to compensate for the foreseen decline in the arable land area. Arable land expansion will remain an important factor in crop production growth in many countries of sub-Saharan Africa and Latin America; although less so than in the past.

These results mask a wide variation between countries. The combination of factors used for crop production (e.g. land, labour and capital) in different countries will be determined by their relative prices. As a result, intensification (higher yields and more intensive use of land) is seen to contribute over the projection period more than 90 percent to growth in crop production at the world level.

In developing countries, the bulk of wheat and rice is produced in the land-scarce regions of Asia and the Near East/North Africa, while maize is the major cereal crop in sub-Saharan Africa and Latin America, which are regions with room for area expansion. Expansion of harvested land, therefore, will continue to be a major contributor to the production growth of maize.

It is estimated that currently irrigated agriculture in developing countries covers about one-fifth of all arable land, and accounts for 47 percent of all crop production and almost 60 percent of cereal production (Table 2). It should be emphasized that, except for some major crops in some countries, there is only limited data on irrigated land and production by crops and the results presented in Table 2 are partly based on expert-judgment. Nevertheless, these data clearly demonstrate the continuing importance of irrigated agriculture.

TABLE 2: SHARES OF IRRIGATED LAND AND PRODUCTION IN TOTAL

	All crops			Cereals	
Shares (in percent)	arable land	harvested land	production	harvested land	production
World					
share in 2005/2007	15	23	42	29	42
share in 2050	16	24	43	30	43
Developing countries					
share in 2005/2007	19	29	47	39	59
share in 2050	20	30	47	41	60

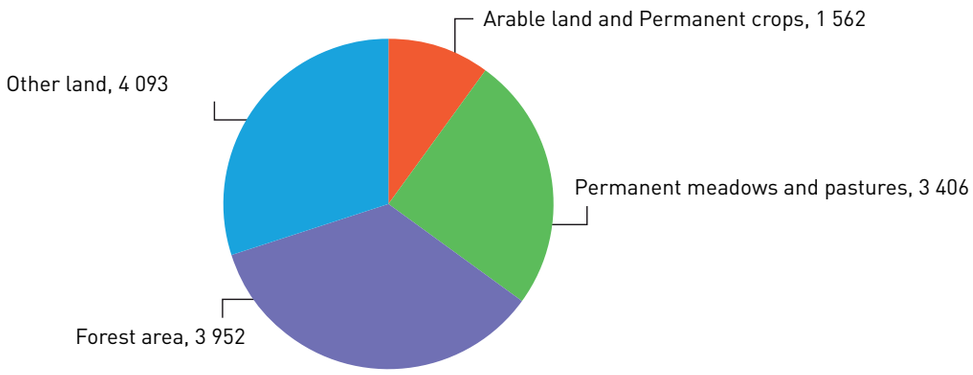
Land balance

Currently, some 12 percent (over 1.6 billion ha Figure 1) of global land surface (13.4 billion ha) is used for crop production (arable land and land under permanent crops).

The Global Agro-Ecological Zone (GAEZ) study (Fischer *et al.*, 2002), which combines soil; terrain and climate characteristics with crop production requirements; estimates; resource suitability (in terms of extent of land and attainable yield levels) for crop production at three technology levels (low, intermediate and high). Taking the sum of all crops and technology levels considered, it is estimated that about 30 percent of the

world's land surface, or 4.2 billion ha[2] is suitable to some extent for rainfed agriculture (Table 3). Of this area, some 1.6 billion ha are already under cultivation. Developing countries have around 2.8 billion ha of land of varying quality that could potentially be used to grow rainfed crops at yields above an 'acceptable' minimum level, of which nearly 970 million ha are already under cultivation. The gross land balance of 2.6 billion ha (4.2 – 1.6 billion; 1.8 billion ha for developing countries) would therefore seem to provide significant scope for further agricultural expansion.

FIGURE 1: **WORLD LAND USE AND LAND COVER AREA (MILLION HA IN 2005)**



Source: FAOSTAT (April 2009)

TABLE 3: **LAND WITH POTENTIAL FOR RAINFED CROP PRODUCTION (MILLION HA)**

	Total land surface	Share of land suitable (Percentage)	Total land suitable	Very suitable (VS)*	Suitable (S)	Moderately suitable (MS)	Marginally suitable (mS)	Not suitable (NS)
Developing countries	**7 302**	**38**	**2 782**	**1 109**	**1 001**	**400**	**273**	**4 520**
Sub-Saharan Africa	2 287	45	1 031	421	352	156	103	1 256
Near East/North Africa	1 158	9	99	4	22	41	32	1 059
Latin America	2 035	52	1 066	421	431	133	80	969
South Asia	421	52	220	116	77	17	10	202
East Asia	1 401	26	366	146	119	53	48	1 035
Industrial countries	3 248	27	874	155	313	232	174	2 374
Transition countries	2 305	22	497	67	182	159	88	1 808
World**	**13 400**	**31**	**4 188**	**1 348**	**1 509**	**794**	**537**	**9 211**

* VS = yield attainable is 80 to 100% of the maximum constraint-free yield; S = 60-80%; MS = 40-60%; mS = 20-40%; NS = ←20%.
** "World" includes a few countries not included in the other country groups shown.

[2] Fischer (2002) reports a lower 3.56 billion ha (Table 5.15) for the gross extent of land with potential for rainfed crops, which is based on a different version of the GAEZ 2002 as used in Bruinsma (2003). Likewise, OECD/FAO (2009), also based on the GAEZ 2002, reports a total of 4.3 billion ha for the gross extent of land with rainfed crop production potential.

However, this favourable impression should be qualified by a number of considerations and constraints that should be taken into account.

First, the estimate concerns all land suitable for growing crops. Thus, forest cover, protected areas and land used for human settlements and economic infrastructure are not excluded from the potential. An estimate by George and Nachtergaele (2009) shows that at the world level urban areas take up some 60 million ha of the gross land balance, protected areas 200 million ha and forests 800 million ha, so that (if one postulates that forests should not be converted into arable land for environmental reasons) the net land balance would 'only' be 1.5 billion ha.

Second, the estimation of the suitability classes considers the most favourable specific crop/input level for that piece of land. Therefore land that is considered very suitable for olives is classified the same way as land that is very suitable for three successive crops of paddy rice in a year. Obviously there is a difference in calorie or economic value between the two, which is masked by simply classifying it as Very Suitable land.

Third, the land balance (land with crop production potential not being used for agricultural) is unevenly distributed between regions and countries. Half the total balance is concentrated in seven countries: Brazil, Democratic Republic of the Congo, Angola, Sudan, Argentina, Colombia and Bolivia. At the other extreme, no spare land is available for rainfed agricultural expansion in South Asia and the Near East/North Africa.

Fourth, much of the currently unused land also suffers from constraints such as ecological fragility, low fertility, toxicity, high incidence of disease or lack of infrastructure. These constraints reduce its productivity, require high input use and management skills to permit its sustainable use, or require prohibitively high investments for the land to be rendered accessible or disease-free. Fischer (2002) shows that over 70 percent of land having potential for rainfed crop production in sub-Saharan Africa and Latin America suffers from one or more soil and terrain constraint. Natural causes, as well as human intervention, can lead to deterioration of the productive potential of the resource, for example through soil erosion or salinization of irrigated areas.

Hence, the evaluation of suitability contains elements of overestimation and much of the land balance cannot be considered a ready-to-use resource for food production on demand.

In reality, expansion of land for agricultural use continues to take place (Figure 2, Table 4). It does so mainly in countries that combine growing needs for food and employment with limited access to technology packages that could increase intensification of cultivation on land that is already being used for agricultural. The data show that expansion of arable land continues to be an important source of agricultural growth in sub-Saharan Africa, Latin America and East Asia. This includes countries having ample land resources with potential for crops facing fast demand growth, particularly for exports and for non-food uses, e.g. soybeans in South America and the oil palm in Southeast Asia. Indeed, oil crops have been responsible for a good part of the increases in total cultivated land in developing countries and worldwide (FAO, 2006), albeit often at the expense of deforestation.

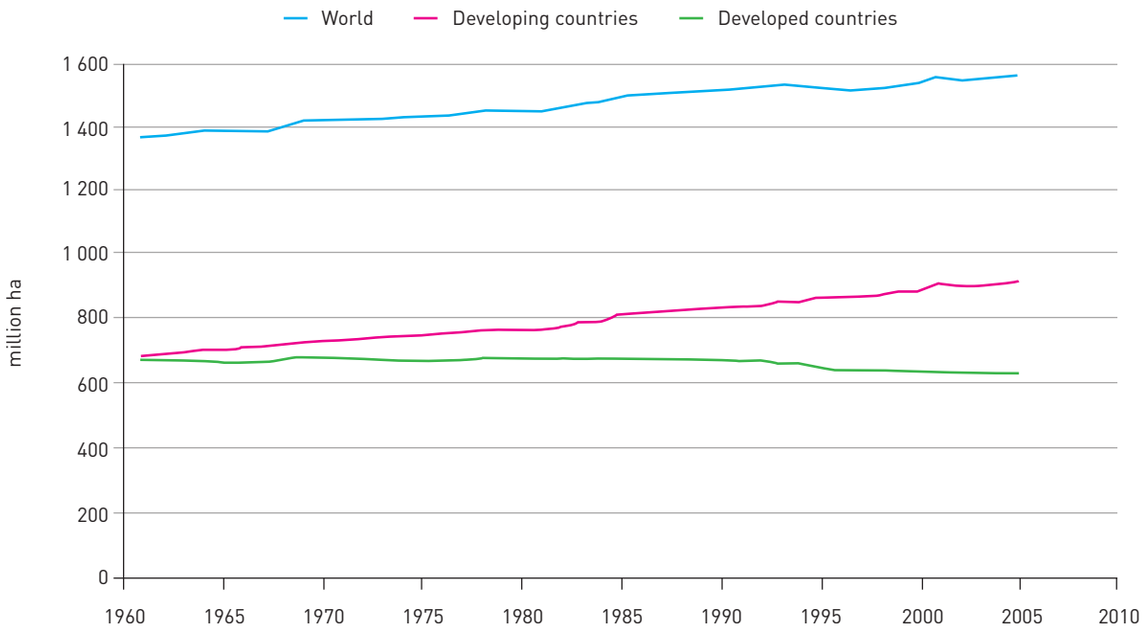
Bruinsma (2009) estimates that the arable area in developing countries could expand by 120 million ha, from 966 in the base year to 1 086 in 2050, an increase of 12.4 percent (see Table 4). Not surprisingly, the bulk of this projected expansion is expected to take place in sub-Saharan Africa (64 million) and Latin America (52 million), with almost no land expansion in East and South Asia, and even a small decline in the Near East/North Africa. The slowdown in the expansion of arable land is mainly the result of the projected slowdown in the growth of crop production and is common to all regions.

TABLE 4: TOTAL ARABLE LAND: DATA AND PROJECTIONS

	Arable land in use						Annual growth			Balance	
	1961 /63	1989 /91	2005	2005 adj.	2030	2050	1961-2005	1990-2005	2005-2050	2005	2050
	(million ha)						(percent p.a.)			(million ha)	
sub-Saharan Africa	133	161	193	236	275	300	0.80	1.07	0.55	786	723
Latin America	105	150	164	203	234	255	101	64	52	861	809
Near East/ North Africa	86	96	99	86	84	82	34	-2	-11	13	16
South Asia	191	204	205	206	211	212	15	7	7	14	7
East Asia	178	225	259	235	236	237	99	112	2	131	129
Developing countries	**693**	**837**	**920**	**966**	**1040**	**1086**	**67**	**65**	**27**	**1805**	**1684**
Industrial countries	388	401	388	388	375	364	-2	-21	-15	486	510
Transition countries	291	277	247	247	234	223	-32	-90	-23	250	274
World	**1 375**	**1 521**	**1 562**	**1 602**	**1 648**	**1 673**	**30**	**17**	**10**	**2 576**	**2 503**

Source: FAOSTAT (April 2009)
Source for historical data: FAOSTAT, January 2009. 'World' includes a few countries not included in the other country groups shown.

TABLE 2: MITIGATION POTENTIAL IN AGRICULTURE AND FORESTRY IN 2030



Although arable area in developing countries is projected to expand by 120 million ha over the projection period, the harvested area would increase by 160 million ha or 17 percent, owing to increases in cropping intensities (Table 5). The overall cropping intensity for developing countries could rise by about 4 percentage points over the projection period (from 95 to 99 percent). Cropping intensities continue to rise owing to shorter fallow periods and more multiple cropping. An increasing share of irrigated land in total agricultural land also contributes to increased multiple cropping. Almost one-third of the arable land in South and East Asia is irrigated, a share that is projected to rise to over 36 percent in 2050. This high share of irrigation of total arable land is one of the reasons why the average cropping intensities in these regions are considerably higher than in others. Average cropping intensities in developing countries are, and will continue to be much lower, (except for India and China which account for half of the irrigated area in developing countries).

TABLE 5: **ARABLE LAND IN USE, CROPPING INTENSITIES AND HARVESTED LAND**

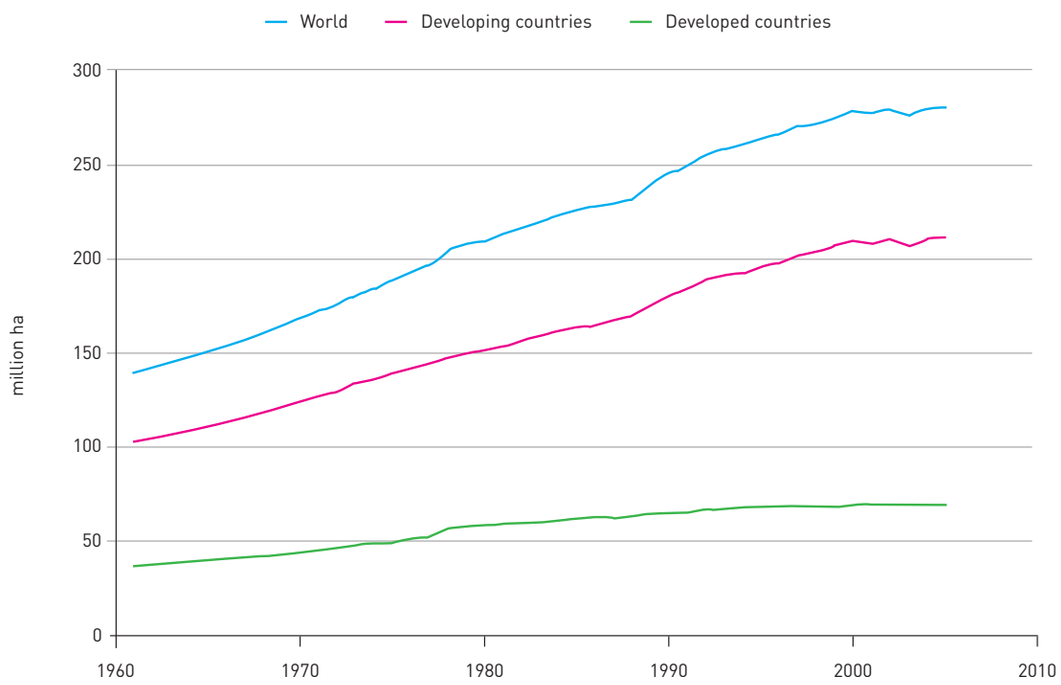
		Total land in use			Rainfed use			Irrigated use*		
		A#	CI	H	A	CI	H	A	CI	H
Developing countries	**2005/07**	**966**	**95**	**919**	**777**	**83**	**649**	**189**	**143**	**270**
	2050	**1 086**	**99**	**1 078**	**864**	**87**	**753**	**222**	**147**	**325**
excluding China and India	2005/07	666	82	547	582	76	442	84	124	105
	2050	785	89	697	680	83	562	106	129	136
Developed countries	**2005/07**	**635**	**74**	**473**	**584**	**72**	**422**	**51**	**100**	**51**
	2050	**587**	**81**	**478**	**536**	**80**	**426**	**51**	**100**	**51**
World	**2005/07**	**1 602**	**87**	**1 392**	**1 361**	**79**	**1 070**	**240**	**134**	**321**
	2050	**1 673**	**93**	**1 556**	**1 400**	**84**	**1 179**	**273**	**138**	**377**

A = arable land (million ha); CI = cropping intensity in percent; H = harvested land (million ha).
* Irrigated area actually in use as distinguished from 'area equipped for irrigation' (Table 6).

Trends in irrigated land use

The area equipped for irrigation has been continuously expanding (mainly in developing countries and only slowly in developed countries); although more recently this expansion has considerably slowed (Figure 3). The projections for irrigation that are presented in (Table 5) reflect scattered information for plans to expand existing irrigation in different countries, potential for expansion (including water availability) and the need to increase crop production. The projections include expansion for both formal and informal irrigation, the latter being important particularly in sub-Saharan Africa.

FIGURE 3: **AREA EQUIPPED FOR IRRIGATION**



The aggregate result shows that the area equipped for irrigation could expand by 32 million ha (11 percent) by 2050 all of it in developing countries. This means that some 16 percent of the land with irrigation potential in this group of countries that are not currently equipped could be brought under irrigation, and that by 2050 some 60 percent of all land with irrigation potential (417 million ha) would be in use (Table 6).

TABLE 6: **AREA EQUIPPED FOR IRRIGATION**

	1961/ 1963	1989/ 1991	2005/ 2007	2030	2050	1961 -2005	1990- 2005	1996- 2005	2005- 2050
	Million ha					Annual growth (percent per annum)			
Developing countries	**103**	**178**	**219**	**242**	**251**	**1.76**	**1.05**	**0.63**	**0.31**
idem, excluding China and India	47	84	97	111	117	1.91	1.06	0.89	0.42
sub-Saharan Africa	2.5	4.5	5.6	6.7	7.9	2.07	1.49	0.98	0.67
Latin America and Caribbean	8	17	18	22	24	2.05	0.62	0.27	0.72
Near East / North Africa	15	25	29	34	36	1.86	1.21	1.30	0.47
South Asia	37	67	81	84	86	1.98	1.10	0.28	0.14
East Asia	40	64	85	95	97	1.42	1.00	0.80	0.30
Developed countries	**38**	**66**	**68**	**68**	**68**	**1.57**	**0.38**	**0.20**	**0.00**
World	**141**	**244**	**287**	**310**	**318**	**1.71**	**0.87**	**0.52**	**0.24**

The expansion of irrigation would be strongest (in absolute terms) in the land-scarce regions that are hard-pressed to raise crop production by intensive cultivation practices, such as East Asia (+ 12 million ha), South Asia (+ 8 million ha), and the Near East/North Africa (+ 6 million ha); although in the latter region further expansion will become increasingly difficult as water scarcity increases and competition for water from households and industry continues to reduce the share available to agriculture. China and India alone account for more than half (56 percent) of the irrigated area in developing countries. Although the overall arable area in China is expected to decrease further, the irrigated area would continue to expand through conversion of rainfed land.

Most of the expansion of irrigated land is achieved by converting land in use in rainfed agriculture into irrigated land. Part of irrigation, however, takes place on arid and hyper-arid (desert) land, which is unsuitable for rainfed agriculture. It is estimated that of the 219 million ha that is currently irrigated in developing countries, some 40 million ha are on arid and hyper-arid land, which could increase to 43 million ha in 2050. In some regions and countries, irrigated arid and hyper-arid land forms an important part of the total irrigated land in use: 19 out of 28 million ha in the Near East/North Africa, and 15 out of 70 million ha in South Asia.

At the global level irrigation water withdrawal is expected to increase by about 11 percent, from the current 2 620 km^3/yr to 2 906 km^3/yr in 2050 (Table 6), increasing in developing countries by 14 percent (or 298 km^3), offset by a decline of over 2 percent (or 12 km^3) in developed countries. The 11 percent increase in irrigation water withdrawal should be seen against the projected 17 percent increase in the harvested irrigated area (from 321 million ha in 2005/2007 to 377 million ha in 2050; Table 7). This difference is partly explained by the expected improvement in water-use efficiency (consumptive use of water in irrigation as a percent of water withdrawal for irrigation), leading to a reduction in irrigation water withdrawal per irrigated hectare.

This reduction is partly the result of changes in cropping patterns for some countries such as China, where a substantial shift in the irrigated area from rice to maize production is expected: irrigation water requirements for rice production are usually twice those for maize.

TABLE 7: ANNUAL RENEWABLE WATER RESOURCES AND IRRIGATION WATER WITHDRAWAL

	Precipi-tation	Renewable water resources*	Water use efficiency ratio		Irrigation water withdrawal		Pressure on water resources due to irrigation**	
			2005/ 2007	2050	2005/ 2007	2050	2005/ 2007	2050
	mm per annum	km³	Percent		km³		Percent	
Developing countries	**990**	**28 000**	**44**	**47**	**2 115**	**2 413**	**8**	**9**
sub-Saharan Africa	850	3 500	22	25	55	87	2	2
Latin America /Caribbean	1530	13 500	35	35	181	253	1	2
Near East / North Africa	160	600	51	61	347	374	58	62
South Asia	1 050	2 300	54	57	819	906	36	39
East Asia	1 140	8 600	33	35	714	793	8	9
Developed countries	**540**	**14 000**	**42**	**43**	**505**	**493**	**4**	**4**
World	**800**	**42 000**	**44**	**46**	**2 620**	**2 906**	**6**	**7**

* At the regional level includes 'incoming flows'
** Water withdrawal for irrigation as a percentage of total annual renewable water resources

Source: Bruinsma, 2009

Nevertheless, 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 in 2005/2007, four countries (Libya, Saudi Arabia, Yemen and Egypt) used larger volumes of water for irrigation than their annual renewable water resources. Groundwater mining also occurs in certain parts of some countries of the Near East, South and East Asia, Central America and the Caribbean; even if at the national level the water balance may still be positive.

In concluding this section on irrigation, for developing countries as a whole, water use in irrigation currently represents a relatively small part of their total water resources and there is significant potential for further irrigation development. With the relatively small increase in irrigation water withdrawal expected between 2005/2007 and 2050, this situation will not change much at the aggregate level. Locally and in some countries, however, there are already very severe water shortages, particularly in the Near East/North Africa region.

Inland waters and fisheries

Globally, lakes, reservoirs and wetlands, that are important for inland fisheries cover about 7.8 million km² (Table 8). A relatively high proportion of land is covered with surface waters in Southeast Asia, North America, East and Central West Africa, the northern part of Asia, Europe and South America (Figure 4).

FIGURE 4: INLAND FISHERIES PROPORTION OF TOTAL GLOBAL PRODUCTION BY CONTINENT

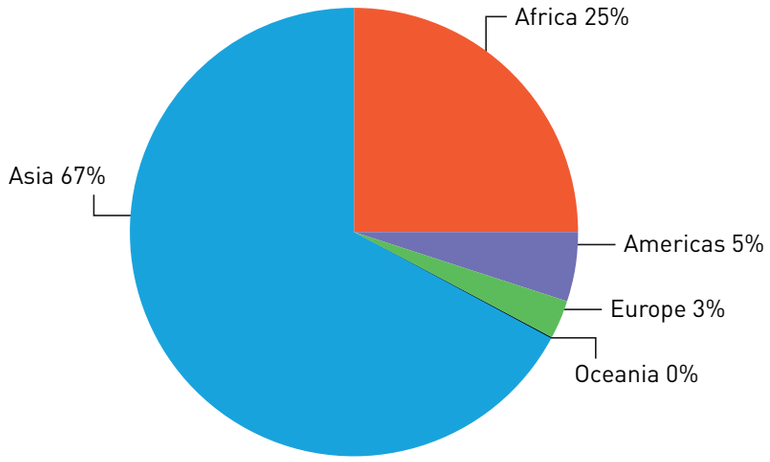


TABLE 8: DISTRIBUTION BY CONTINENT OF MAJOR SURFACE FRESHWATER RESOURCES

Continent	Surface area in km²							TOTAL	Percentage of global total
	Lakes	Reservoirs	Rivers	Floodplain	Flooded forest	Peat land	Intermittent wetland		
Asia	897 909	80 474	141 346	1 292 040	56 957	491 289	357 333	3 317 348	42.37
North America	861 284	68 970	58 424	17 913	56 679	205 624	26 029	1 294 923	16.54
Africa	223 325	34 247	44 656	693 549	179 013		187 072	1 361 862	17.40
Europe	100 756	13 780	5 131	52 783		12 975	288	185 713	2.37
South America	90 396	46 786	108 581	422 310	860 547		2 778	1 531 398	19.56
Australia	8 026	4 163	521				111 609	124 319	1.59
Oceania	4 992	1 000	1 161	5 844			89	13 086	0.17
TOTAL	**2 186 688**	**249 420**	**359 820**	**2 484 439**	**1 153 196**	**709 888**	**685 198**	**7 828 649**	

Note 1. Lakes and reservoirs ↗ 10 ha, Global Lakes and Wetlands Database GLWD, http://www.worldwildlife.org/science/data/item1877.html): Lehner and Döll, 2004: Development and validation of a global database of lakes, reservoirs and wetlands. Journal of Hydrology 296/1-4: 1-22.

The ecosystem services provided by inland waters, for example, include food and water supply, water purification, biodiversity habitat, fibre and raw materials for handicrafts and construction work, climate regulation, flood protection and recreational opportunities. Many aquatic plants and animals are important components of ecosystems and are essential for sustaining fisheries and other uses of aquatic ecosystems. Where ecosystem processes are largely undisturbed, biodiversity conserves the adaptive capacity of the ecosystem giving it the ability to buffer or absorb perturbations including exploitation by fisheries. Modified habitats, such as reservoirs and rice fields, that are managed for maintenance of ecosystem services and biodiversity are also productive inland water bodies.

Inland fisheries involve the extraction of living aquatic organisms from surface waters existing inland of the coastline. These include lakes, ponds, streams, rivers, wetlands, artificial watercourses and reservoirs, and

coastal lagoons and artificial water bodies. Since 1950, inland fisheries have been growing by ~3 percent per year reaching 10.2 million tonnes in 2008 (FAO FishStat+, 2010). Asia and Africa account for respectively 67 and 25 percent of the reported landings; the Americas, Europe and Oceania contribute 5, 3 and 0.2 percent of the catches (Figure 4).

The tonnage of fish produced by inland fisheries globally does not adequately reflect the importance of inland fisheries. In the rural areas of many developing countries, and especially in land-locked countries, inland fisheries are more important to food security and income generation than marine fisheries. A recent study concluded that at least 61 million people in developing countries are employed in inland fisheries of which over 50 percent are women. Approximately 1 million people are employed in the larger-scale commercial inland fisheries and 60 million in small-scale inland fisheries and the majority (41 million) live in Asia (Table 9).

TABLE 9: EMPLOYMENT IN INLAND FISHERIES IN DEVELOPING COUNTRIES

	Inland small scale		Inland commercial		Total
	Fishers	Other employment	Fishers	Other employment	
Africa	5 634 000	11 832 000	213 000	85 000	17 764 000
Americas	519 000	1 091 000	34 000	14 000	1 658 000
Asia	13 146 000	27 607 000	534 000	216 000	41 503 000
Oceania	9 000	19 000	500	500	29 000
Total by category	**19 308 000**	**40 549 000**	**781 500**	**315 500**	**60 954 000**
Total employment by sub sector	**59 857 000**		**1 097 000**		**60 954 000**
Total women employment by sub sector	**32 921 000**		**342 000**		**33 263 000**

Although most rural people consider themselves 'farmers', or work as labourers most of the year, many rural households live close to inland waters and engage in fishing on a part time or seasonal basis. This is an essential component in a mixed livelihood strategy bringing cash income, and food and nutrition at times of the year when no other options are available. Thus inland waters and their fisheries provide a 'safety net' to rural communities. The bulk of the production is consumed locally, providing high quality and cheap animal protein, crucial to the diets of the rural poor.

Inland capture fisheries is in direct and severe competition with other water-using sectors. Environmental degradation and increasingly scarce land and water in most regions of the world are threatening inland fish production. With world population increasing to 9 billion in 2050, water resources and thus inland fisheries will come under increasing pressure from development, land reclamation, damming for power generation and water supply, pollution, eutrophication and climate change. The major issue is how to maintain the integrity of the ecosystem and mitigate the impacts on aquatic regimes.

The increased interest in transferring water between separate basins is also worrying as it will unpredictably affect aquatic biodiversity. Farming and fishing are not mutually exclusive activities, e.g. 134 million ha of rice fields are grown under conditions that make them a habitat for a wide range of aquatic organisms that comprise an integral part of the harvest from these fields. While usually considered a by-product, the value of the living aquatic resources in some cases is considerably higher than the value of the crop.

Technological advances may save water and reduce pollution from agriculture and industries. New methods such as fish pass technologies, ecological engineering, and reconnection of rivers and floodplains can, to a certain extent, mitigate some of the impacts caused by water-consuming sectors. Although these technologies may initially be available in developed countries they will increasingly be adopted by other countries.

While climate change almost certainly will significantly influence water availability and inland fisheries, both directly, for example as a result of changes in rainfall patterns and rising sea levels, and indirectly through shifts in demand and trade of commodities, the exact nature of these changes cannot be easily established and in any event predictions will likely be highly variable.

References

Bruinsma, J. 2003. World agriculture: towards 2015/2030. An FAO perspective. London and Rome, Earthscan/FAO. (Available at: ftp://ftp.fao.org/docrep/fao/005/y4252e/y4252e.pdf).

Bruinsma, J. 2009. The resource outlook to 2050: By how much do land, water use and crop yields need to increase by 2050? 33 pp. Expert Meeting on How to Feed the World in 2050. Rome, FAO and ESDD. (Available at: ftp://ftp.fao.org/docrep/fao/012/ak542e/ak542e06.pdf).

FAO. 2006. World agriculture: towards 2030/2050. Interim report. Prospects for food, nutrition, agriculture and major commodity groups. Rome. 78 pp. (Available at: HYPERLINK "http://www.fao.org/fileadmin/user_upload/esag/docs/Interim_report_AT2050web.pdf" http://www.fao.org/fileadmin/user_upload/esag/docs/Interim_report_AT2050web.pdf).

FAOFISHSTAT+. 2010. (Web site: http://www.fao.org/fishery/statistics/software/fishstat/en).

FAOSTAT. 2009. FAOSTAT database. (Web site: HYPERLINK "http://faostat.fao.org" http://faostat.fao.org/).

Fischer, G., Van Velthuizen, H., Shah, M. & Nachtergaele, F.O. 2002. Global agro-ecological assessment for agriculture in the twenty-first century: methodology and results. (Available at: HYPERLINK "http://www.iiasa.ac.at/Admin/PUB/Documents/RR-02-002.pdf" http://www.iiasa.ac.at/Admin/PUB/Documents/RR-02-002.pdf).

Fischer, G., Hizsnyik. E., Prieler, S. & Wiberg, D. 2010. Scarcity and abundance of land resources: competing uses and the shrinking land resource base. SOLAW Background Thematic Report - TR02. Rome, FAO. (Available at: HYPERLINK "http://www.fao.org/nr/solaw/" http://www.fao.org/nr/solaw/).

GLWD. 2010. Global Lakes and Wetlands Database. (Web site: HYPERLINK "http://www.worldwildlife.org/science/data/item1877.html" http://www.worldwildlife.org/science/data/item1877.html).

George, H. & Nachtergaele, F. 2006. Preparation of a report on the State of land and water resources, Rome, Land and Water Division, FAO. (Unpublished report)

Lehner, B. & Döll, P. 2004. Development and validation of a global database of lakes, reservoirs and wetlands. Journal of Hydrology 296/1-4: 1-22.

OECD/FAO. 2009. Agricultural outlook 2009-2018. Paris and Rome.