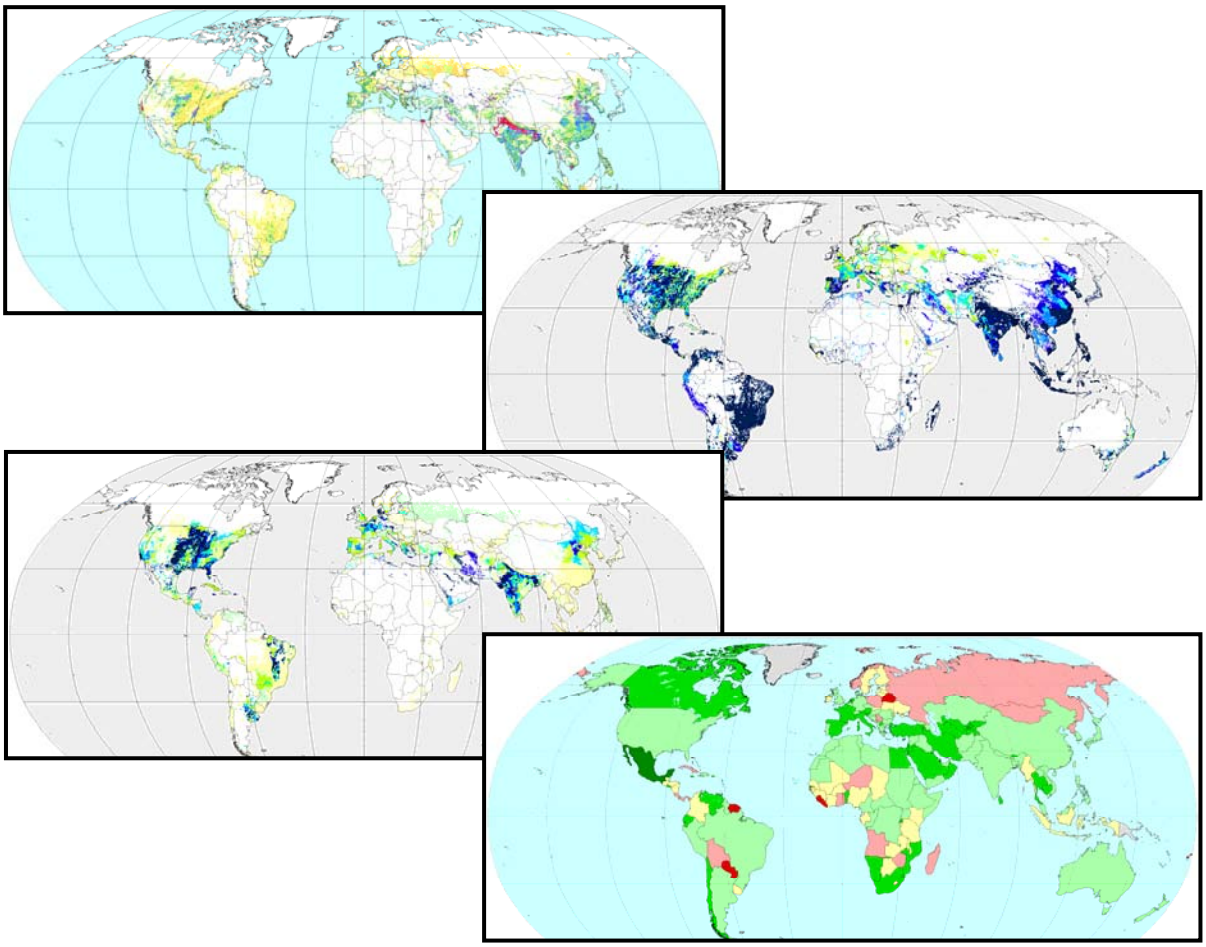
Update of the Digital Global Map of Irrigation Areas to Version 5



DOCUMENTATION

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Update of the Digital Global Map of Irrigation Areas (GMIA) to Version 5

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Contents

1 Summary

The Land and Water Division of the Food and Agriculture Organization of the United Nations and the Rheinische Friedrich-Wilhelms-Universität Bonn, Germany, are cooperating in the development of a global irrigation-mapping facility. This report describes the update of the Digital Global Map of Irrigation Areas to version 5. For this update, the inventory of subnational irrigation statistics was updated with new information derived from national census surveys or irrigation sector studies. For the first time, the global map of irrigation areas also contains data layers on the percentage of area equipped for irrigation that is actually used for irrigation and on the source of irrigation water (groundwater, surface water, water from non-conventional sources). The number of subnational units in the global inventory increased to 36 090 for area equipped for irrigation, 10 316 for area actually irrigated and 14 483 for the statistics on the water source for irrigation. The reference years for the statistics differ between countries and variables but in most cases the data refer to period 2000 - 2008. Total area equipped for irrigation at the global scale in version 5 of this data set is 307.6 million ha of which 255.2 million ha (83 percent) were actually irrigated. 116.2 million ha (38 percent of the total area equipped for irrigation) were equipped for irrigation with groundwater, 191.2 million ha (62 percent) for irrigation with surface water and 0.3 million ha (0.1 percent) for irrigation with non-conventional water sources. In order to distribute the statistics on area equipped for irrigation per subnational unit, digital spatial data layers and printed maps were used. Irrigation maps were derived from project reports, irrigation subsector studies, and books related to irrigation and drainage. These maps were digitized and compared with satellite images of many regions. In areas without spatial information on irrigated areas, additional information was used to locate areas where irrigation is likely, such as land-cover and land-use maps that indicate agricultural areas or areas with crops that are usually grown under irrigation. In contrast, percentage of area actually irrigated and of area equipped for irrigation with groundwater, surface water or with water from non-conventional sources was kept constant in most cases for all grid cells belonging to the same subnational statistical unit because the information on the spatial distribution of these areas was very limited. Consequently, map quality differs a lot between the data layers. In the data layer on area equipped for irrigation, 93 percent of the total irrigated area was assigned to regions with excellent, very good or good map quality; the corresponding shares were 43 percent for area actually irrigated and 42 percent for the data layer on the water source of irrigation.

2 Project history

Brief history of the Digital Global Map of Irrigation Areas

1999	Version 1	Digital Global Map of Irrigated Areas Version 1 published (resolution: 0.5 ° × 0.5 °). **Döll, P. & Siebert, S.** 1999. *A digital global map of irrigated areas*. Center for Environmental Systems Research, University of Kassel, Germany; **Döll, P. & Siebert, S.** 2000. *A digital global map of irrigated areas*. ICID journal 49, 55-66.
2001	Version 2	Cooperation was established between the project team of the Global Map of Irrigated Areas and the FAO Aquastat programme. As a result of this cooperation, the map-generation methodology was improved and an update of the continents of Latin America and Europe was made. The global grid resolution was increased to a grid of 5 arc-minutes and the map was made available to the general public as Version 2. **Siebert, S. & Döll, P.** 2001. *A digital global map of irrigated areas - an update for Latin America and Europe*. Center for Environmental Systems Research, University of Kassel, Germany.
2002	Version 2.1	Update of Africa and Oceania using the improved map-generation methodology described in Siebert & Döll (2001). **Siebert, S., Döll, P. & Hoogeveen, J.** 2002. *A digital global map of irrigated areas - an update for Africa and Oceania.* Center for Environmental Systems Research, University of Kassel, Germany and FAO, Rome, Italy.
2005	Version 2.2	Update of the continent of Asia using the map-generation methodology described in Siebert & Döll (2001). **Siebert, S., Feick, S. & Hoogeveen, J.** 2005. *A digital global map of irrigated areas - an update for Asia.* Johann Wolfgang Goethe University, Frankfurt am Main, Germany and FAO, Rome, Italy.
2005	Version 3	Update of the map for North America, assessment of the map quality of map version 3 based on two indicators of map quality. **Siebert, S., Döll, P., Hoogeveen, J., Faurès, J-M., Frenken, K. & Feick, S.** 2005. *Development and validation of the global map of irrigation areas*. Hydrology and Earth System Sciences 9, 535-547. DOI:10.5194/hess-9-535-2005
2006	Version 4	Update of the map for the continents of Africa and Europe and for parts of Latin America using the methodology described in Siebert et al. (2005). **Siebert, S., Hoogeveen, J. & Frenken, K.** 2006. *Irrigation in Africa, Europe and Latin America - Update of the Digital Global Map of Irrigation Areas to Version 4.* Johann Wolfgang Goethe University, Frankfurt am Main, Germany and FAO, Rome, Italy.
2010		Development of an inventory on area actually irrigated and water sources used for irrigation. **Siebert, S., Burke, J., Faurès, J-M., Frenken, K., Hoogeveen, J., Döll, P. & Portmann, F.T.** 2010. *Groundwater use for irrigation – a global inventory*. Hydrology and Earth System Sciences 14, 1863-1880. DOI:10.5194/hess-14-1863-2010
2013	Version 5	Development of map version 5 containing layers for area equipped for irrigation, area actually irrigated and water sources used for irrigation. **Siebert, S., Henrich, V., Frenken, K. & Burke, J.** 2013. *Update of the digital global map of irrigation areas to version 5.* Rheinische Friedrich-Wilhelms-Universität, Bonn, Germany and FAO, Rome, Italy, (this document).
The complete documentation of the Digital Global Map of Irrigation Areas is always available at: http://www.fao.org/nr/water/aquastat/irrigationmap/index.stm. From this address, the map can also be downloaded.		

3 Introduction

Agriculture is by far the largest water-use sector, accounting for about 70 percent of all water withdrawn worldwide from rivers and aquifers for agricultural, domestic and industrial purposes. In several developing countries, irrigation represents up to 95 percent of all water withdrawn, and it plays a major role in food production and food security. The agriculture development strategies of most of these countries depend on the possibility of maintaining, improving and expanding irrigated agriculture. However, as the pressure on water resources increases, irrigation is facing growing competition from other water-use sectors and becoming a threat to the environment in an increasing number of regions.

In the last decade, the international community has made major efforts to assess the different elements of the water balance and to predict current and future water needs for the different use sectors. However, considerable uncertainty remains concerning the extent and distribution of irrigated land in the world and on agricultural water use, therefore, making it difficult to monitor the irrigation sector adequately. Coverage of irrigated areas in the world, available in a geographical information system (GIS), is the single most important item of information needed to improve future global studies on water and food.

The first version of the Digital Global Map of Irrigated Areas was published in 1999. It consisted of a raster map with a resolution of 0.5 ° by 0.5 ° containing the percentage of the area that was equipped for irrigation around 1995, the so-called irrigation density. To further develop and improve the global GIS coverage of areas equipped for irrigation and to make it available to users in the international community, cooperation was established between the Johann Wolfgang Goethe University in Frankfurt am Main, Germany; the Rheinische Friedrich-Wilhelms-Universität Bonn, Germany, and the Land and Water Division of the Food and Agriculture Organization of the United Nations (FAO).

Through this cooperation, the mapping project has been linked closely to the FAO global information system on water and agriculture, Aquastat. The Aquastat programme collects and disseminates data and information by country and by region. Its aim is to provide users interested in global, regional and national analysis (e.g. policy-makers, decision-makers and researchers) with the most accurate, reliable, consistent and up-to-date information available on water resources and agricultural water management. In order to make thorough analyses, the Aquastat programme collects data from many different sources including national water resources and irrigation master plans, statistics and yearbooks, FAO technical reports, and national and international surveys and reports made available by national and international research centres.

The data collected through the Aquastat programme have served as the main source for improving the overall quality and resolution of the Digital Global Map of Irrigated Areas. In addition, the methodology for producing the map has been improved substantially. This has made it possible to increase the spatial resolution of the map to 5 minutes, thus justifying the publication of an improved second version of the Digital Global Map of Irrigated Areas. For Version 2, updated maps of Latin America, Europe, Africa and Oceania have been published. The next step in improving the dataset was the inclusion of updates for the continent of Asia, and for North America. With this update to version 3, the map for the whole globe was generated by using the same methodology. By the update to version 4 improvements for the continents of Africa and Europe and for parts of Latin America were incorporated. Here we present version 5 of the data set which contains, for the first time, data layers on the percentage of area equipped for irrigation that is actually used for irrigation and on the source of irrigation water. In addition, the data layer on area equipped for irrigation was updated by using the most recent subnational data collected by Aquastat. The reference years for the statistics differ between countries and variables but in most cases the data refer to period 2000 - 2008.

4 Data and methods

4.1 Mapping of area equipped for irrigation

The data layer on area equipped for irrigation was developed by combining sub-national irrigation statistics with geospatial information on the position and extent of irrigation schemes to compute the fraction of 5 arc minute cells that was equipped for irrigation, which is called irrigation density (Figure 1). In the following, we provide a concise description of the mapping methodology. A detailed description is given in Siebert et al. (2005).

Irrigation statistics for sub-national units (e.g. districts, counties, provinces, governorates, river basins), from national census surveys and from reports available at FAO, World Bank and other international organizations, are being collected on a continuous basis. Statistics for the year closest to 2005 were used if statistics for more than one year were available. For countries, where the irrigation statistics reported by the AQUASTAT database were assumed to be more representative, the collected subnational statistics were scaled so that the sum of the irrigated area equals the area equipped for irrigation as given by AQUASTAT at the country level. For most of the countries, irrigation statistics refer to the area equipped for irrigation. Due to several reasons (e.g. crop rotation, water shortages, and damage of infrastructure) the area actually irrigated maybe significantly lower than the area equipped for irrigation. However, some countries only report the area that was actually irrigated in the year of the census. In these cases area equipped for irrigation was estimated by using time series of area actually irrigated (e.g. for five years) and selecting the maximum of the area actually irrigated reported at the highest available resolution (e.g. counties in the United States of America).

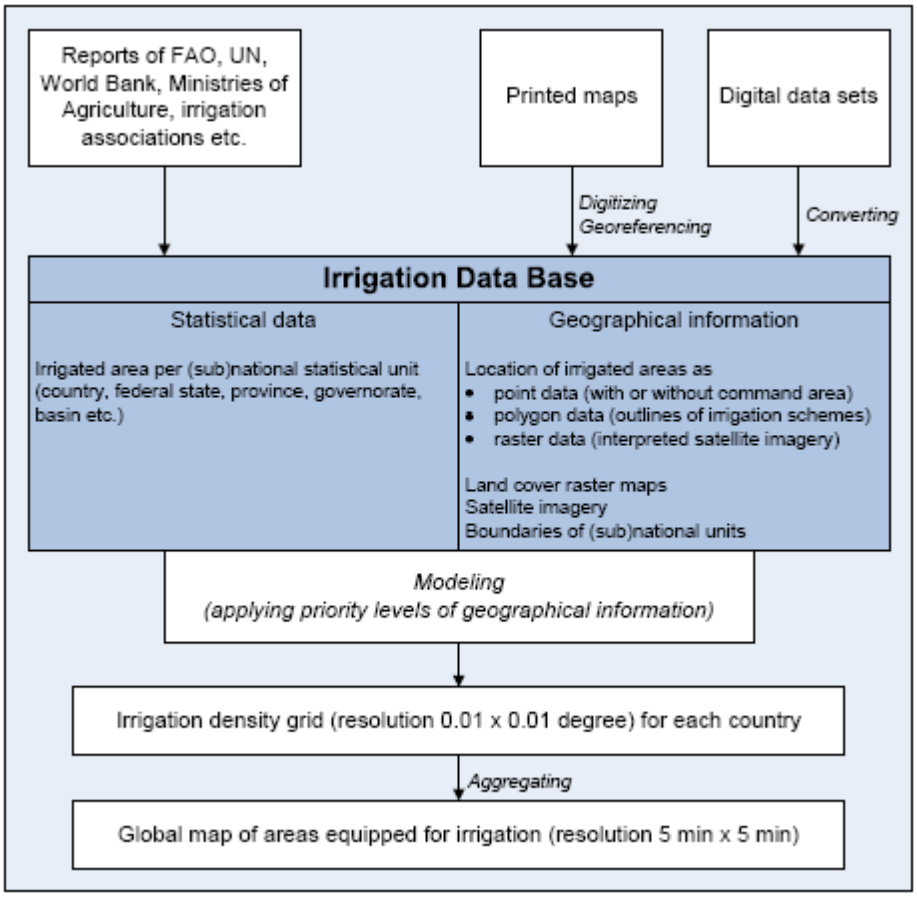

FIGURE 1
Scheme of mapping methodology used to develop the Global Map of Irrigation Areas.

In order to distribute irrigated area within the sub-national units, geospatial information on position and extent of irrigated areas was derived by digitizing hundreds of irrigation maps available in reports of FAO, World Bank, irrigation associations or national ministries of agriculture. Additionally, information from several atlases or inventories based on remote sensing available in digital format was utilized. For most of the countries, more than one data source was used. As the relevance and reliability of the maps varies, it was necessary to decide which geospatial record should be used in a specific sub-national unit. This was realized by applying a priority level to each record. Only if the extent of all digitized irrigated areas with the highest priority level was smaller than the total irrigated area reported for the specific sub-national unit, also records with the second highest priority were considered. This distribution process was repeated down to the next lower priority level until the sum of irrigated area in the map was equal to the irrigated area in the sub-national statistics. Several different criteria have been used to assign priorities to geospatial information, for example:

- the scale and publishing date of the maps;
- the type of map (simple sketch or drawing to scale);
- how the background information for the maps was collected (by ground based mapping, survey or via remote sensing);
- if only the position or also the extent of the irrigation schemes was provided.

In many sub-national units, lack of geospatial information on irrigation made it necessary to use indirect information to infer areas within the sub-national unit where irrigation is probable. Such information includes areas where the main irrigated crops are grown, or cultivated areas in very arid regions. For arid regions, remote sensing data were additionally used to verify the available maps. If no direct or indirect information about the spatial distribution of irrigation within a sub-national unit was available, irrigated area was distributed according to one of two global landcover datasets (USGC-GLCC-2.0 and JRC-GLC2000).

4.2 Mapping of area actually irrigated and of areas equipped for irrigation with groundwater, surface water or water from non-conventional sources

Statistics on area equipped for irrigation with groundwater, with surface water or with water derived from non-conventional sources and on area actually irrigated were collected from national census reports or online data bases and complemented with country information available from the FAO-AQUASTAT library, data collected by other international organizations or statistical services (e.g. Eurostat) or data taken from the literature. In many countries different ministries are responsible to collect, process, and provide data on area equipped for irrigation, area actually irrigated or on the water source for irrigation resulting in different reference years and different resolution of the statistics (Figure 2). We used the following rules for the selection of statistics used for this data set and to fill data gaps:

- Statistics provided at high resolution, for the reference year closest to 2005 and using similar definitions were preferred unless proved wrong.
- If statistics on the source of irrigation water were available for area actually irrigated only, then the fraction of area equipped for irrigation with water from the different sources was assumed to be similar to the fraction of area actually irrigated with water from the different sources.
- If the extent of area equipped for irrigation with water from the different sources was unknown but irrigation water use from different sources was reported, then the water use statistics were used to downscale the irrigated area statistics (e.g. if 20 percent of irrigation water use was from groundwater, then it was assumed that also 20 percent of area equipped for irrigation was irrigated with groundwater).
- If for specific countries the source of irrigation water was unknown and water use statistics were not available as well, the percentage of AEI irrigated with groundwater, surface water or non-conventional sources was estimated based on other information, e.g. qualitative estimates in the literature, based on borehole inventories or based on the availability of water resources.

- Areas with conjunctive use of groundwater and surface water were assigned with 50 percent to area equipped for irrigation with groundwater and 50 percent to area equipped for irrigation with surface water if not otherwise noted.
- If statistics on area actually irrigated or on the source of irrigation water were available for more than one year, then mean values for periods of up to five years around year 2005 were computed to reduce the impact of specific conditions in specific years.

Data sources and assumptions made in case of missing data are described for each country in Appendix A. For most of the countries the data reported at the level of subnational administrative units were not further disaggregated (except of a few countries for which borehole inventories were used). This results in equal values of the percentage of area actually irrigated or the percentage of the different water sources for all pixels belonging to the same subnational administrative unit.

4.3 Assessment of map quality

A common method to assess the quality of a course scale data-set is to compare it with independent information at selected locations on a more detailed scale in order to draw conclusions with respect to the map quality at these locations and extrapolate it to the general map quality. Here, however, all available data on irrigated areas at appropriate scales were used to compile the map itself and therefore could not be used for a quality assessment. Apart from this, it is very difficult to compare the quantitative information as presented on the map (expressed e.g. as area equipped for irrigation in a 5-minute cell in ha) with point information collected for specific positions by ground-truthing (irrigated or rainfed).

To assess the quality of the Global Map of Irrigation Areas, two indicators were developed that take into account the geospatial information density of the base data:

- Indicator A (*IND_A*) represents the density of the used subnational irrigation statistics;
- Indicator B (*IND_B*) represents the density of the available geospatial records on position and extent of irrigated areas.

The combination of *IND_A* and *IND_B* is used to describe the overall map quality per country for the data layer of area equipped for irrigation. In contrast, map quality of the data layers on area actually irrigated or on the water sources used for irrigation was assessed based on *IND_A* only, because data

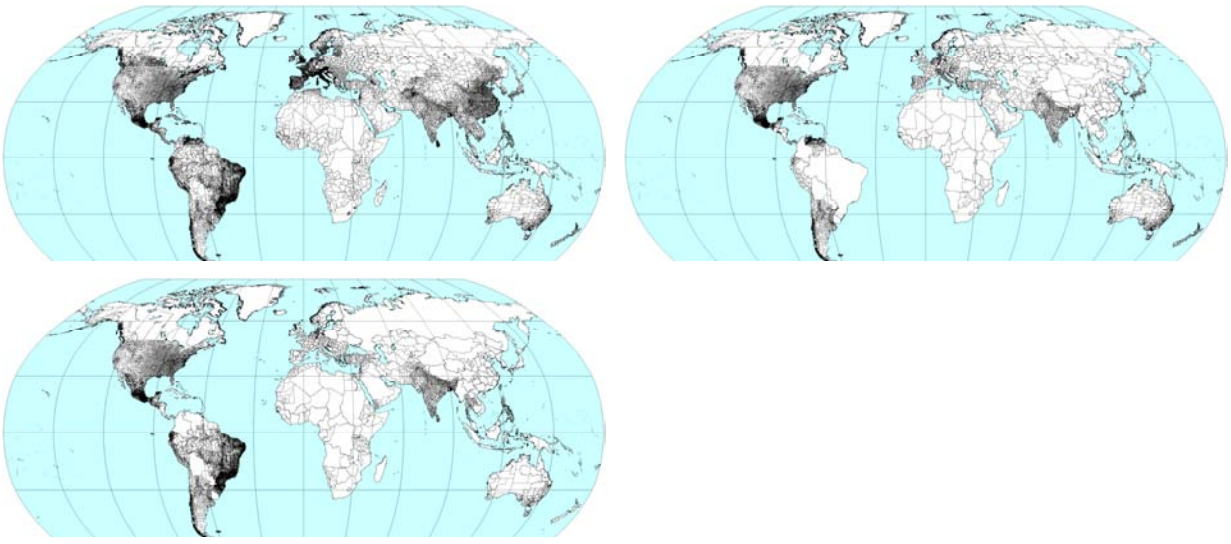

FIGURE 2
Location and extent of the 36 090 sub-national units with information on area equipped for irrigation (upper left), 10 316 sub-national units with information on area actually irrigated (upper right), and 14 483 sub-national units with information on the water sources for irrigation (buttom left) used to develop version 5 the Global Map of Irrigation Areas.

were not disaggregated below the level of the subnational statistical units (except for a few countries for which well inventories were available) and therefore *IND_B* could not be computed.

The density of subnational irrigation statistics can be obtained by calculating the arithmetic mean of the size of the subnational units. However, there are some countries where irrigation is concentrated in some small subnational units while in other very large subnational units of the same country there is no or very little irrigation. To avoid that large subnational units without significant irrigation have a negative impact on indicator A, the size of each subnational statistical unit is weighted by the irrigation density in the subnational unit relative to the irrigation density in the entire country:

$$IND\_A_{country} = \frac{area_{country}}{\sum_{adm=1}^{n} (irridens_{adm} / irridens_{country})} \quad (1)$$

with

$$irridens_{adm} = \frac{irarea_{adm}}{area_{adm}} \quad (2)$$

where $IND\_A_{country}$ is the average weighted size of the sub-national units in the country (ha), $area_{country}$ is the surface area of the country (ha), $irridens_{adm}$ is the irrigation density in sub-national unit *adm* (-), $irridens_{country}$ is the irrigation density in the country (-), *n* is the number of sub-national units in the country, $irarea_{adm}$ is the irrigated area in sub-national unit *adm* (ha) and $area_{adm}$ is the surface area in sub-national unit *adm* (ha).

IND_A equals the average size of all subnational units in a country if the irrigation density is the same all over the country. If all irrigated area is concentrated in only one subnational unit, *IND_A* is equal to the size of this subnational unit. *IND_A* is lower than the average size of the subnational units if the irrigation density is higher in small subnational units than in the larger subnational units. Lower values of *IND_A* indicate a better map quality. *IND_A* was computed for the three data layers (area equipped for irrigation, area actually irrigated, water source on area equipped for irrigation) separately to account for the different resolution of statistical data.

The second indicator (*IND_B*) was developed to give an estimate on the density of geospatial information used to assign area equipped for irrigation to specific cells within the sub-national units. *IND_B* was computed as the fraction of irrigated area that could be assigned to specific grid cells by using geospatial records on the position and extent of known irrigation schemes. Higher values of *IND_B* indicate a better map quality. Both indicators were assigned a country mark according to the classification presented in Table 1.

For area equipped for irrigation, a mark for the overall quality was given assuming that the types of information that are reflected by the two indicators can replace each other. The mark for the overall map quality was set to the better of the two marks given according to *IND_A* and *IND_B*. If, for example, the location and extent of almost all irrigation projects in a country is known then subnational statistics are not required in addition to prepare a reliable map. On the other hand, if the size of the subnational statistical units is very small (in an extreme case smaller than the map resolution of 5 arc minutes), the overall quality of the map should also be fine even if there are no geospatial records on the position of irrigation schemes within the sub-national units available. However, in version 5 of the global map of irrigation areas the overall map quality mark “excellent” was only assigned when the better mark according to *IND_A* and *IND_B* was “excellent” and the other mark “very good” or “excellent” as well.

TABLE 1

Values for map quality indicators *IND_A* and *IND_B* and corresponding marks of map quality assigned to specific countries.

Mark	Indicator *IND_A* (ha)	Indicator *IND_B* (%)
Excellent	< 100 000	90 - 100
Very good	100 000 - 250 000	70 - 90
Good	250 000 - 500 000	50 - 70
Fair	500 000 - 1 000 000	25 - 50
Poor	1 000 000 - 3 000 000	10 - 25
Very poor	> 3 000 000	< 10

5 Results

Total area equipped for irrigation at the global scale in version 5 of the Global Map of Irrigation Areas is 307.6 million ha of which 255.2 million ha (83 percent) were actually irrigated around year 2005. 116.2 million ha (38 percent of the total area equipped for irrigation) were equipped for irrigation with groundwater, 191.2 million ha (62 percent) for irrigation with surface water and 0.3 million ha (0.1 percent) for irrigation with non-conventional water sources. About 69 percent of the total area equipped for irrigation is located in Asia, 17 percent in America, 8 percent in Europe, 4 percent in Africa and 2 percent in Oceania (Table 2). The largest values of area equipped for irrigation on the country level are those for China (62.4 million ha), India (61.9 million ha) and the United States of America (28.4 million ha) (Appendix A). The largest extent of area actually irrigated was found for Asia as well with 186.7 million ha (73 percent of total area actually irrigated).

The largest contiguous areas of high irrigation density are found in North India and Pakistan along the rivers Ganges and Indus, in the Hai He, Huang He and Yangtze basins in China, along the Nile river in Egypt and Sudan, in the Mississippi-Missouri river basin and in parts of California. Other areas of high irrigation density with regional importance are located along the Snake and Columbia rivers in the northwestern United States, along the western coasts of Mexico and Peru, in central Chile, in the rice growing areas along the border between Brazil and Uruguay, along the Danube and Po rivers in Europe, in the Euphrates-Tigris basin in Iraq and Turkey, the Aral sea basin, the Amu Darya and Syr Darya river basins, the Brahmaputra basin in China and Bangladesh, the Mekong delta in Vietnam, the plain around Bangkok in Thailand, the island of Java (Indonesia) and the Murray-Darling basin in Australia. Smaller irrigation areas are spread across almost all populated parts of the world (Figure 3).

Areas predominantly irrigated with groundwater are found in a stripe stretching through the whole central part of Northern America , in a stripe of about 500 km width and 2500 km length in Brazil, in the north-eastern part of Argentina, in the northern and western part of India, the north-eastern part of China and in large parts of Northern Africa, Western Europe, the whole Arabian Peninsula, the eastern and central part of the Islamic Republic of Iran and the provinces of Punjab and Baluchistan in Pakistan. In contrast, the irrigation sector in Eastern Europe, in the states of the former Soviet Union, in Southeast Asia, the southern part of China, in Sub-Saharan Africa, in the north-western part of the United States of America, Oceania and in most regions of Southern America mainly uses surface water. The percentage of the area equipped for irrigation that is actually irrigated is in particular low in Eastern Europe, Russia, Northern Europe and the eastern part of the United States of America where often less than 30 percent of the available irrigation infrastructure is actually being used (Figure 4).

TABLE 2
Area equipped for irrigation (total, with groundwater, with surface water, with water from non-conventional sources) and area actually irrigated in regions and continents.

Region	Area equipped for irrigation (ha)				Area actually irrigated (ha)
	total	with groundwater	with surface water	with water from non-conventional sources	
Northern Africa	6 400 826	2 113 437	4 273 626	13 763	6 044 489
Sub-Saharan Africa	7 148 268	399 210	6 747 858	1 200	5 484 099
AFRICA TOTAL	***13 549 094***	***2 512 647***	***11 021 483***	***14 963***	***11 528 588***
Central America and Caribbean	1 865 268	651 185	1 214 083	0	1 051 700
Northern America	36 411 337	21 355 866	15 055 471	0	29 061 283
Southern America	13 055 707	2 235 854	10 819 854	0	11 222 607
AMERICA TOTAL	***51 332 312***	***24 242 905***	***27 089 407***	***0***	***41 335 590***

Region	Area equipped for irrigation (ha)				Area actually irrigated (ha)
	total	with groundwater	with surface water	with water from non-conventional sources	
Central Asia	13 657 552	1 085 033	12 572 518	0	11 259 730
Middle East	24 083 108	10 747 301	13 130 305	205 502	17 625 241
Southern and Eastern Asia	175 983 556	68 929 063	107 054 494	0	157 804 809
ASIA TOTAL	***213 724 215***	***80 761 397***	***132 757 317***	***205 502***	***186 689 780***
Eastern Europe	5 198 729	494 759	4 703 970	0	1 718 420
Western and Central Europe	19 138 579	7 004 714	12 133 292	573	10 842 264
EUROPE TOTAL	***24 337 308***	***7 499 473***	***16 837 262***	***573***	***12 560 684***
Australia and New Zealand	4 688 259	1 135 787	3 478 479	73 993	3 067 151
Other Pacific Islands	4 471	759	3 712	0	4 367
OCEANIA TOTAL	***4 692 730***	***1 136 546***	***3 482 191***	***73 993***	***3 071 518***
WORLD	**307 635 659**	**116 152 968**	**191 187 660**	**295 031**	**255 186 161**

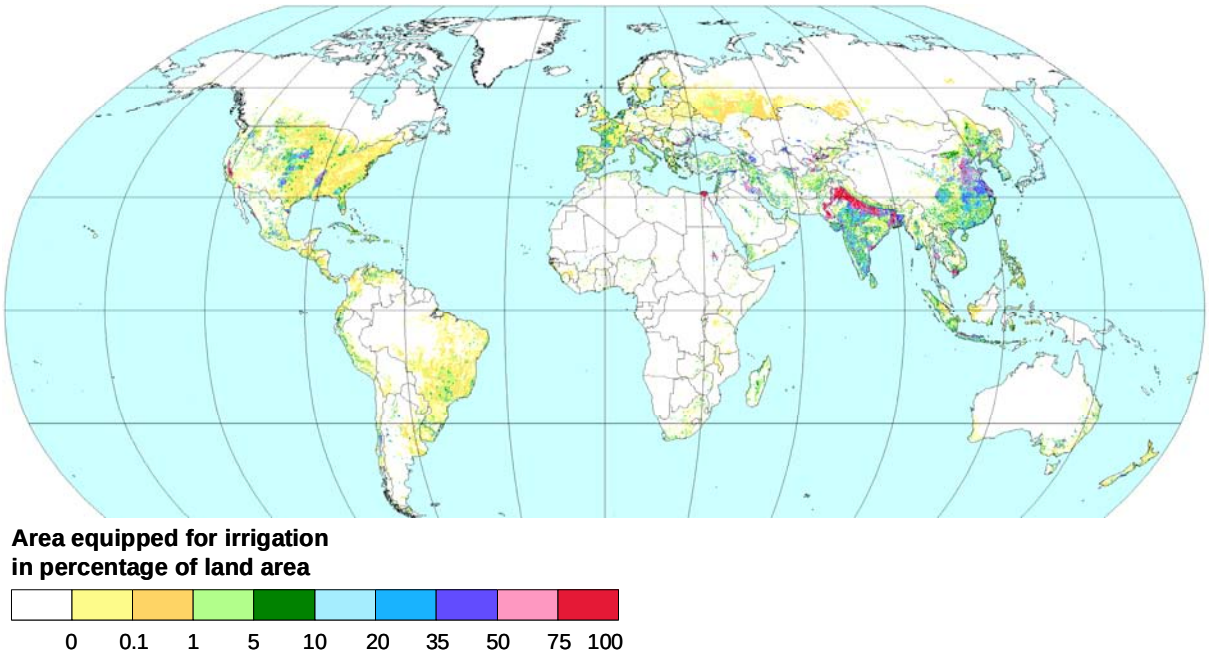

FIGURE 3
Area equipped for irrigation as percentage of total grid cell area in version 5 of the Global Map of Irrigation Areas.

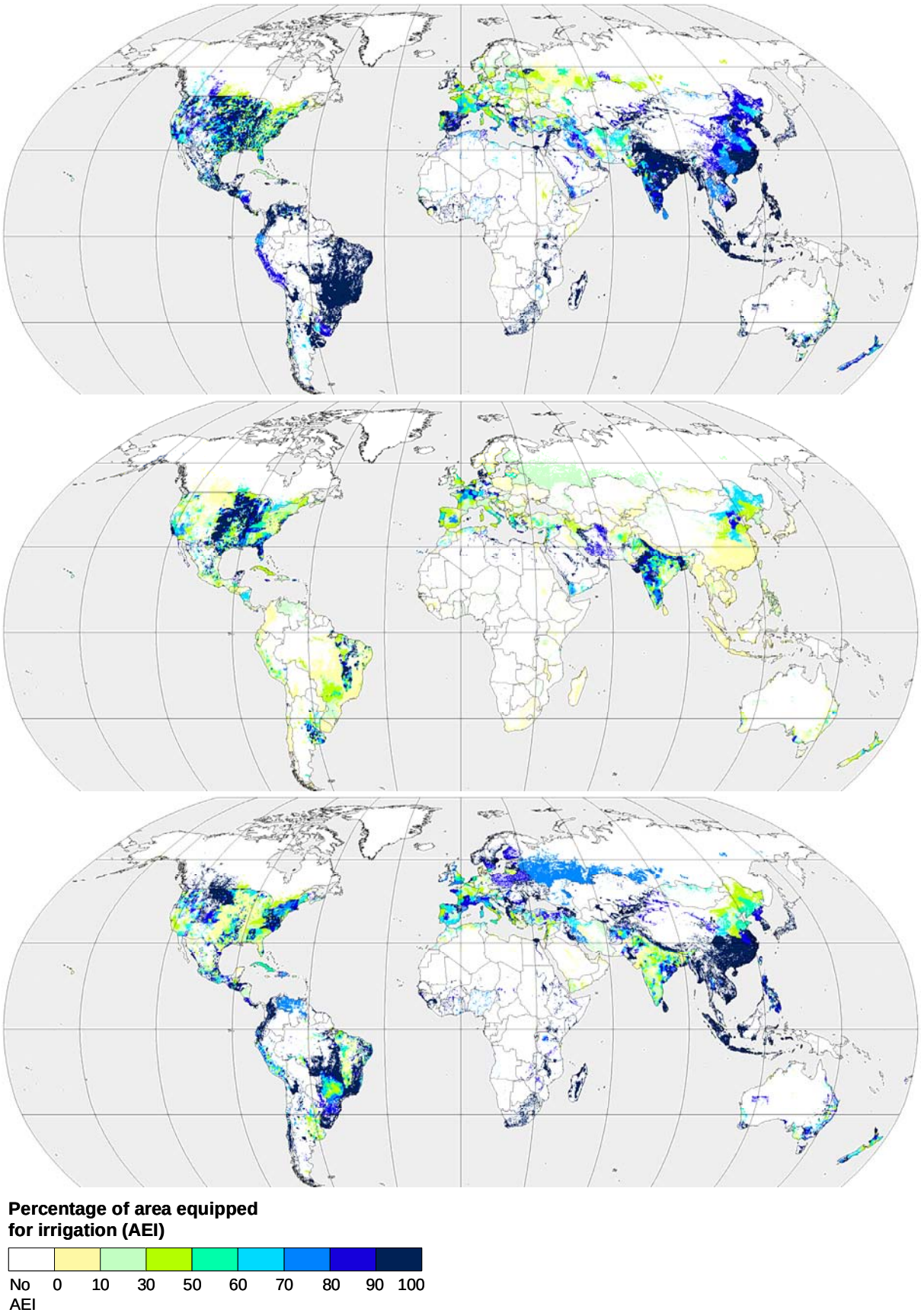

FIGURE 4
Percentage of area equipped for irrigation that was actually irrigated (top), irrigated with groundwater (center) or irrigated with surface water (buttom).

6 Discussion

6.1 Consistency of irrigation statistics

A major objective in the development of the Global Map of Irrigation Areas has always been to ensure consistency between the area equipped for irrigation in the global map and irrigation statistics provided by the FAO AQUASTAT main country database and the FAOSTAT database. It is not possible to maintain a complete consistency between these data bases because the data bases are updated with different frequency. Furthermore, FAOSTAT focuses on annual time series and contains therefore estimates for years without data while AQUASTAT provides mainly data for years when national irrigation surveys were undertaken. Furthermore, the Global Map of Irrigation Areas relies a lot on the availability of subnational data at high resolution. For most of the countries these data become available only for years in which an agricultural census was undertaken and thus less frequent than data at aggregated, national level.

A comparison of the data on area equipped for irrigation in version 5 of the Global Map of Irrigation Areas to the most recent statistics in AQUASTAT and the mean of area equipped for irrigation in FAOSTAT computed for period 2000-2008 shows in general a very good agreement between the data bases (Table B1). The total area equipped for irrigation is 307.6 million ha in version 5 of the Global Map of Irrigation Areas, 310.5 million ha in the AQUASTAT main country data base and 303.4 million ha in FAOSTAT. Differences for most of the countries are small. Larger differences in area equipped for irrigation in countries like Brazil, Argentina, France, Portugal or Paraguay can be explained by different reference years of the statistics. In addition, there are larger differences for countries like the United States of America, India, Pakistan, Australia and Canada where area equipped for irrigation is not reported by the national census statistics. Here different methods have been used in the three inventories to estimate area equipped for irrigation based on variables that are reported by the national statistics, e.g. area actually irrigated in the year of the census survey. A third group of countries with major differences in area equipped for irrigation contains many countries in Eastern Europe like Romania, Bulgaria, Hungary or the Russian Federation. In all these countries a large part of the former irrigation infrastructure has not being used anymore for a long period and differences in estimates of area equipped for irrigation are mainly caused by uncertainties on the previous condition of this infrastructure. Some inventories still account for this infrastructure while other do not account for it anymore.

6.2 Reference year of the irrigation statistics

For most of the countries subnational irrigation statistics for more than one year have been available and the statistics with a reference year closest to year 2005 were selected for version 5 of the Global Map of Irrigation Areas. The calculation of the sum of irrigated area in the three different map layers (area equipped for irrigation, area actually irrigated, water source for irrigation) according to the reference year of the used subnational statistics shows that around 90 percent of the irrigated area in all three map layers was assigned according to irrigation statistics from the years 2000-2008 (Table 3). The percentage of irrigated area derived from statistics with a reference year older than 1996 was highest for the statistics on the water source of irrigation (9.0 percent) and lowest for area actually irrigated (1.7 percent).

6.3 Map quality

The assessment of the map quality showed that the quality of the layer on area equipped for irrigation is better than the quality of the other two data layers (Figure 5). This was expected because geospatial data on the extent and location of irrigation schemes were used in addition to subnational irrigation statistics for the distribution of area equipped for irrigation to specific grid cells. Furthermore, the resolution of the subnational irrigation statistics was highest for area equipped for irrigation (Figure 2). We need to acknowledge however, that the assessment of map quality for the layers on area actually irrigated and on the water source for irrigation may be biased by the fact that area actually irrigated was 100 percent of AEI or 0 percent of AEI in some countries. Similar to this, area equipped for

irrigation with groundwater was 100 percent in some countries and 0 percent in other countries. In these countries we did not use any subnational data because the percentages would be the same for each subnational unit (100 percent or 0 percent). Consequently the map quality was often assessed as poor or very poor because it was determined based on the resolution of the subnational statistics. Therefore the map quality for these countries may be better than indicated in Figure 5.

In general good marks for the map quality were computed for many countries in Asia, for Northern America and Southern and Western Europe. In contrast, poor marks for the map quality were found for most countries in Sub-Saharan Africa, in Eastern Europe and the Russian Federation (Figure 5).

TABLE 3

Global sum of irrigated area derived from subnational irrigation statistics for different reference years. AEI means statistics on area equipped for irrigation, AAI statistics on area actually irrigated and SRC statistics on the water source for irrigation.

Year	AEI (ha)	AEI (%)	AAI (ha)	AAI (%)	SRC (ha)	SRC (%)
before 1990	2 403 315	0.8	7 704	0.0	3 970 201	1.3
1990	3 525 150	1.1	20 000	0.0	5 299 300	1.7
1991	251 336	0.1	286 629	0.1	251 336	0.1
1992	29 360	0.0	1 567 725	0.6	87 189	0.0
1993	3 304 960	1.1	39 390	0.0	2 972 646	1.0
1994	2 209 518	0.7	558 659	0.2	10 036 898	3.3
1995	2 644 599	0.9	1 858 677	0.7	4 977 842	1.6
1996	29 858	0.0	132 836	0.1	829 033	0.3
1997	2 977 609	1.0	2 264 377	0.9	3 037 983	1.0
1998	1 031 330	0.3	1 028 080	0.4	1 283 560	0.4
1999	5 220 454	1.7	4 961 633	1.9	2 193 819	0.7
2000	16 604 742	5.4	9 860 070	3.9	9 545 716	3.1
2001	67 880 248	22.1	58 753 289	23.0	62 728 233	20.4
2002	8 082 504	2.6	8 514 537	3.3	16 137 485	5.2
2003	3 181 777	1.0	1 879 362	0.7	19 848 531	6.5
2004	6 423 168	2.1	5 525 227	2.2	9 525 690	3.1
2005	85 364 207	27.7	75 175 165	29.5	80 610 414	26.2
2006	30 350 602	9.9	30 507 321	12.0	35 874 785	11.7
2007	49 880 658	16.2	47 397 042	18.6	37 682 947	12.2
2008	1 501 575	0.5	1 390 707	0.5	0	0.0
2009	2 148 744	0.7	0	0.0	742 051	0.2
2010	12 589 947	4.1	3 457 731	1.4	0	0.0
Total	307 635 659	100.0	255 186 161	100.0	307 635 659	100.0

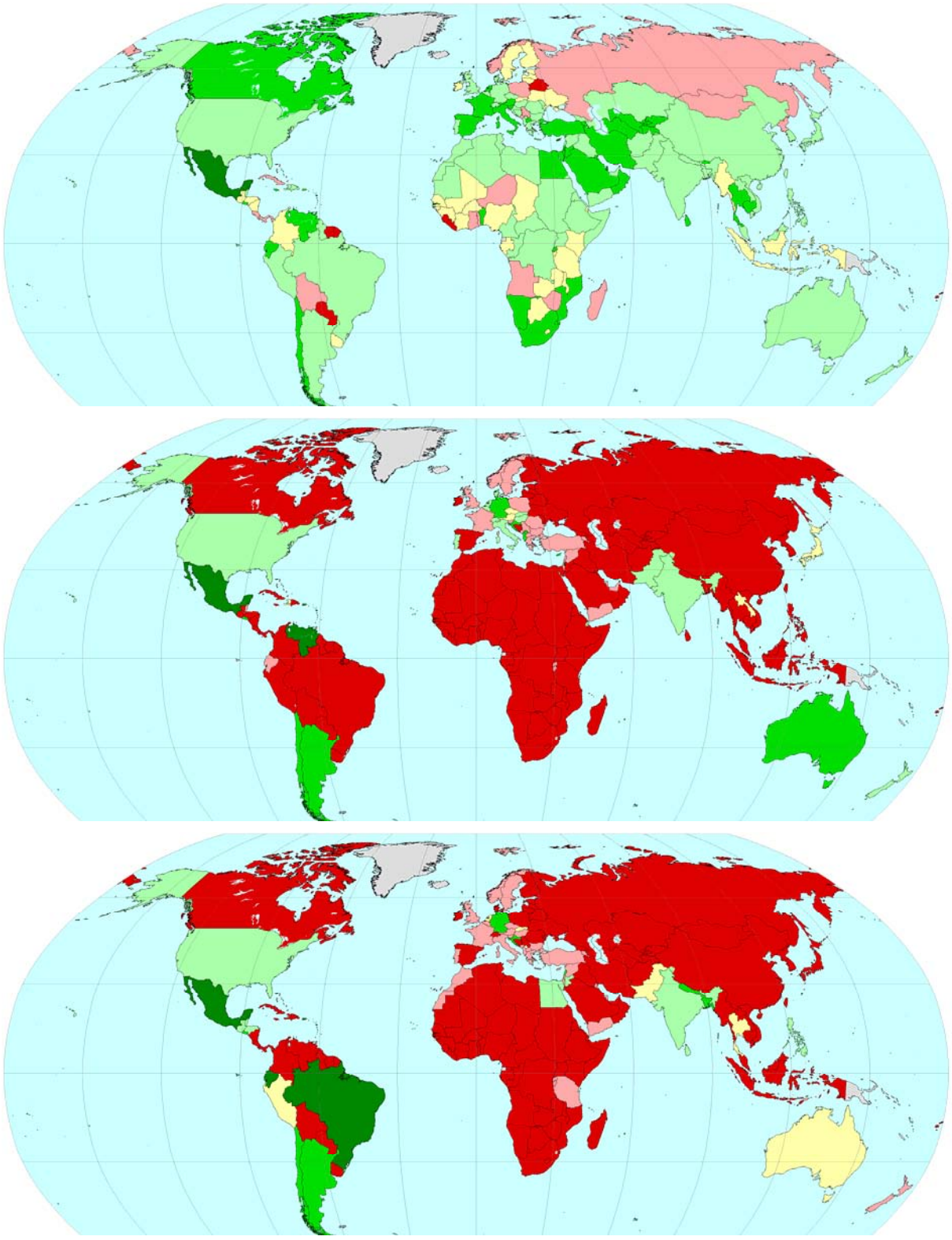

FIGURE 5
Map quality of the layers on area equipped for irrigation (top), area actually irrigated (center) and the water source for irrigation (buttom).

Appendix A

Detailed description of data sources, assumptions and results per continent and country

AFRICA

The update of the irrigation map to version 5 was the third update for Africa. In addition to the separation of area equipped for irrigation according to the source of water, the following countries have been updated due to new available spatial information: Angola, Eritrea, Ethiopia, Ghana, Kenya, Mauritius, Mozambique, Namibia, Reunion, Senegal, Tunisia and United Republic of Tanzania. Total area equipped for irrigation in Africa slightly changed due to this update from 13 457 939 ha in map version 4 to 13 549 094 ha in version 5 (Table A1).

TABLE A1
Area equipped for irrigation (AEI) and area actually irrigated (AAI) in Africa in the new version 5 of the Global Map of Irrigation Areas compared to area AEI in the previous version 4.

Country	AEI in GMIA4 (ha)	AEI in GMIA5, total (ha)	AEI in GMIA5, groundwater (ha)	AEI in GMIA5, surface water (ha)	AEI in GMIA5, non-conventional sources (ha)	AAI in GMIA5 (ha)
Algeria	569,418	569,418	368,489	200,929	0	453,300
Angola	80,000	80,000	16,000	64,000	0	35,000
Benin	12,258	12,258	2,190	10,068	0	7,131
Botswana	1,439	1,439	665	773	0	620
Burkina Faso	25,000	25,000	3,000	22,000	0	25,000
Burundi	21,430	21,430	0	21,430	0	21,430
Cameroon	25,654	25,654	100	25,554	0	25,654
Cape Verde	2,780	2,780	391	2,389	0	1,821
Central African Republic	135	135	0	135	0	69
Chad	30,273	30,273	6,000	24,273	0	26,200
Comoros	130	130	5	125	0	85
Congo	2,000	2,000	0	2,000	0	2,000
Cote d'Ivoire	72,750	72,750	0	72,750	0	66,930
Democratic Republic of the Congo	10,500	10,500	0	10,500	0	6,800
Djibouti	1,012	1,012	1,012	0	0	388
Egypt	3,422,178	3,422,178	331,927	3,090,251	0	3,422,178
Equatorial Guinea	0	0	0	0	0	0
Eritrea	21,590	21,590	3,961	17,629	0	13,490
Ethiopia	289,530	290,729	2,611	288,118	0	290,729
Gabon	4,450	4,450	0	4,450	0	4,450
Gambia	2,149	2,149	15	2,134	0	1,400
Ghana	30,900	59,000	12,000	45,800	1,200	56,000
Guinea	94,914	94,914	460	94,454	0	94,914
Guinea Bissau	22,558	22,558	4,195	18,363	0	22,558
Kenya	103,203	103,203	1,032	102,171	0	97,011
Lesotho	2,638	2,638	50	2,588	0	67
Liberia	2,100	2,100	11	2,090	0	2,100
Libya	470,000	470,000	464,000	3,000	3,000	316,000
Madagascar	1,086,291	1,086,291	0	1,086,291	0	1,080,691
Malawi	56,390	56,390	30	56,360	0	54,134
Mali	235,791	235,791	1,000	234,791	0	176,843
Mauritania	45,012	45,012	4,751	40,261	0	22,840
Mauritius	21,222	21,543	5,386	16,157	0	21,115
Morocco	1,484,160	1,484,160	677,201	804,221	2,738	1,448,011
Mozambique	118,120	118,120	639	117,481	0	40,063
Namibia	7,573	7,573	1,632	5,941	0	7,573
Niger	73,663	73,663	1,371	72,292	0	65,615
Nigeria	293,117	293,117	66,800	226,317	0	218,840
Reunion (France)	13,000	8,811	1,762	7,049	0	8,276

Country	AEI in GMIA4 (ha)	AEI in GMIA5, total (ha)	AEI in GMIA5, groundwater (ha)	AEI in GMIA5, surface water (ha)	AEI in GMIA5, non-conventional sources (ha)	AAI in GMIA5 (ha)
Rwanda	8,500	8,500	85	8,415	0	8,500
Sao Tome and Principe	9,700	9,700	0	9,700	0	9,700
Senegal	119,680	119,680	10,218	109,462	0	69,000
Seychelles	260	260	0	260	0	200
Sierra Leone	29,360	29,360	20	29,340	0	10,000
Somalia	200,000	200,000	10,000	190,000	0	65,000
South Africa	1,498,000	1,498,000	127,330	1,370,670	0	1,498,000
Sudan and South Sudan	1,863,000	1,863,000	69,239	1,793,761	0	800,000
Swaziland	49,843	49,843	1,000	48,843	0	44,859
Togo	7,300	7,300	46	7,254	0	6,278
Tunisia	394,063	455,070	271,820	175,225	8,025	405,000
Uganda	9,150	9,150	92	9,059	0	5,900
United Republic of Tanzania	184,330	189,047	17,465	171,582	0	189,047
Zambia	155,912	155,912	6,646	149,266	0	155,912
Zimbabwe	173,513	173,513	20,000	153,513	0	123,866
AFRICA TOTAL	**13,457,939**	**13,549,094**	**2,512,647**	**11,021,483**	**14,963**	**11,528,588**

Algeria

Area equipped for irrigation is 569 418 ha [DZ01]. The figure refers to year 2001. Area equipped for irrigation by province was computed by summing up irrigated areas in large schemes, irrigated area in small schemes and spate irrigation areas. The position and extent of the large irrigation schemes was derived from two maps [DZ02], while the command area of these schemes in year 1999 stems from another report [DZ03]. The total irrigated area assigned that way to the provinces summed up to 171 550 ha. 56 050 ha of spate irrigation area [DZ01] were assigned to the provinces covering the Saharan Atlas mountains. About 33 000 ha of irrigated areas, of which about 11 000 ha are center pivot systems were digitized from satellite imagery and assigned to the xeric provinces of Adrar, GhardaSa and Tamanrasset. The remaining 308 818 ha of irrigated area were assumed to represent small scale irrigation schemes and assigned to the other provinces relative to statistics stored in the AQUASTAT database. These statistics per province refer to the situation in 1987 and summing up to 221 635 ha.

The shape of the boundaries of the 20 large irrigation schemes as digitized from two maps [DZ02] was adjusted by using satellite imagery [DZ04]. The positions of 77 small scale schemes (<500 ha) and 38 medium scale schemes (500 - 1000 ha) were digitized from the same two maps [DZ02]. 250 ha irrigated area was assigned to each small scale scheme and 750 ha to each medium scale scheme respectively. Thus, the total irrigated area assigned to known irrigation schemes adds up to 219 300 ha. The remaining part of irrigated area was spread over cultivated land as digitized from satellite imagery [DZ04].

Area equipped for irrigation with groundwater for each of the five hydro geographic regions of Algeria was computed based on the reported percentages of groundwater use in full/partial control irrigation areas in these regions [DZ05] and was 368 489 ha (64.7 percent of total area equipped for irrigation) in total. Area actually irrigated in year 2001 was 453 300 ha (79.6 percent of area equipped for irrigation) [DZ01].

References:

[DZ01]: **FAO.** 2005. *AQUASTAT country profile Algeria.* FAO, Rome, http://www.fao.org/nr/water/aquastat/countries/algeria/indexfra.stm, 14/01/2011.

[DZ02]: **Côte, M.** 1993. L'irrigation en Algerie. Commentaire de la carte au 1/1,000,000. *In* H. Popp & K. Rother, eds. *Die Bewässerungsgebiete im Mittelmeerraum*, pp. 161-164. Passau, Germany, Passavia Universitätsverlag.

[DZ03]: **République algérienne démocratique et populaire, Conseil national économique et social, Commission sur les perspectives de développement économique et social.** 1999. *Problématique de développement agricole: Éléments pour un débat national.*

[DZ04]: **Earth Satellite Corporation.** 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-181, 071-192, 071-193, 071-194, 071-195, 071-204, 071-205, 071-206, 071-207, 071-208, 071-216, 071-217, 071-218, 071-219 and 071-220. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

[DZ05]: **FAO.** 2008. Etude sur la gestion des eaux souterraines dans des pays pilotes du Proche-Orient. Rapport Algerie. Bureau régional de la FAO pour le Proche-Orient, Cairo, Egypt.

Angola

Area equipped for irrigation is estimated at about 80 000 ha. The figures refer to year 1975 but are believed to be still valid [AO01]. In contrast, area equipped for irrigation was 340 478 ha in year 2005 according to a more recently published assessment [AO02]. In any case it is sure that large parts of this area are currently not in operation and area actually used for irrigation in year 1997 was estimated at 35 000 ha [AO01]. Differences may also be explained by the use of different definitions of irrigated land in [AO02] as compared to the FAO-definitions. Area equipped for irrigation per province was computed therefore by scaling the sum of area under irrigation and the area partially under irrigation given in [AO02] (in total 340 478 ha) to the area equipped for irrigation reported by FAO AQUASTAT (80 000 ha). This procedure maintained the regional differences reported in [AO02] and the total area reported in [AO01].

Irrigated area was distributed to 11 schemes indicated on an irrigation map [AO03] and to 7 schemes derived from an inventory of irrigation schemes [AO04]. Additionally a zone along the coastline and the southern border to Namibia, in which irrigation is concentrated, was digitized from the same map and irrigated areas were assigned to cultivated areas in that zone as digitized from satellite imagery [AO05]. Irrigated areas was then distributed to irrigation projects listed in [AO02] and described in these report as “in operation”. To locate these irrigation projects a geographical name server was used.

The information on water sources for irrigation is also very week. In year 1974 all irrigation was from surface water [AO01]. However, according to the SWECO Grøner assessment use of groundwater for irrigation is important in the coastal area and in the southwestern provinces, especially in the basins of Dande, Bengo, Cuanza, Longa, Queve, Cunene and Cubango were water is taken from the alluvium after rivers have dried up [AO02]. Based on this qualitative information area equipped for irrigation with groundwater was estimated at 20 percent.

References:

[AO01]: **FAO.** 2005. *AQUASTAT country profile Angola.* FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/angola/indexfra.stm, 06/10/2010.

[AO02]: **SWECO Grøner.** 2005. A rapid water resources and water use assessment. National Water Sector Management Project, activity C, Final Report to the National Directorate of Water, SWECO Grøner, Stockholm, Sweden, 259 pp. + appendix.

[AO03]: **MINADER, FAO, PNUD, Banque mondiale, PAM**. 2004. Review of agricultural sector and food security strategy and investment priority setting (TCP/ANG/ 2907) – Figure 1 of working paper n° 9: Irrigated agriculture development.

[AO04]: **MINADER, FAO, PNUD, Banque mondiale, PAM**. 2004. Review of agricultural sector and food security strategy and investment priority setting (TCP/ANG/ 2907) – Annex 1 of working paper n° 15.
[AO05]: **Earth Satellite Corporation.** 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-677, 071-678, 071-679, 071-680 and 071-687. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Benin

Area equipped for irrigation per department is summing up to 12 258 ha [BJ01]. The figures refer to year 2002 and comprise of 10 973 ha in registered schemes and 1 285 ha of equipped lowlands.

The location of 30 full/partial control schemes was digitized from two irrigations maps [BJ02]. The command area of these schemes and the location and extent of 39 other schemes (mainly equipped wetlands) was derived from another report [BJ03]. The command area of these 69 schemes is summing up to 10 621 ha. The remaining part of the formal irrigation and the informal irrigation was assigned to the surrounding of large urban centres as digitized from satellite imagery [BJ04].

20 percent of the area equipped for irrigation in the full/partial control schemes was from groundwater (2190 ha) [BJ01] while area actually irrigated was 7131 ha in year 2005 [BJ05].

References:

[BJ01]: **FAO**. 2005. *AQUASTAT country profile Benin*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/benin/indexfra.stm, 06/10/2010.
[BJ02]: **Republique du Benin**. 1994. *Statistique sur l'hydraulique agricole et rurale – Donnees de base et cartes*. 30 pp. Report available in the AQUASTAT-library.
[BJ03]: **FAO**. 2003. AQUASTAT – Benin. *Enquete sur l'utilisation de l'eau pour l'agriculture et le development rural au Benin*. Rapport General. Report available in the AQUASTAT-library.
[BJ04]: **Earth Satellite Corporation.** 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-202 and 071-203. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.
[BJ05]: **Gruber, I., Kloos, J., and Schopp, M.** 2009. Seasonal water demand in Benin's agriculture. *Journal of Environmental Management* 90, 196-205.

Botswana

Area equipped for irrigation is reported to be 1438.6 ha [BW01]. The figures refer to year 2002.

The location and command area of 11 irrigation projects was available from the FAO-irrigation map of Africa [BW02]. The command areas are summing up to 1855 ha and were scaled to meet the statistics reported for the specific regions. However, no irrigation project was known for the Francistown Region in the North-East of the country. Therefore two areas close to Francistown, that are likely to be irrigated (one of it is a center pivot scheme), were digitized from satellite imagery [BW03].

44.3 percent of the total area equipped for irrigation was using groundwater while 3.9 percent was using water from mixed sources. By assuming a 50 percent contribution of groundwater in mixed water area equipped for irrigation with groundwater is therefore 665.4 ha. Area actually irrigated was 620.1 ha (43 percent of total area equipped for irrigation) in the dry season 2002 [BW01].

References:

[BW01]:**FAO**. 2003. *Botswana. National irrigation policy and strategy – Irrigation situation analysis*. Report November 2003 (second draft) by Stephens T.F. TCP/BOT/0065 (A).
[BW02]:**FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[BW03]:**Earth Satellite Corporation.** 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-694 and 071-695. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Burkina Faso

Area equipped for irrigation was reported to be 25 000 ha. Full/partial control area was 18 600 ha in 2001 and equipped wetlands covered 6 400 ha in 1998 [BF01]. Sub-national statistics for full/partial control area summing up to 16 915 ha [BF02]. These statistics refer to year 1996 and obviously underestimate actual irrigated area in region Volta Noire (Mouhoun). The statistics reported for this region an irrigated area of 1705 ha although there are 3200 ha in one single project (AMVS-project). Therefore area equipped for irrigation was increased in that region so that the country total is equal to the value reported for 2001 (18 600 ha). Equipped wetlands were assigned to the regions Hauts Bassins and Volta Noire (Mouhoun) based on the statistics derived from the AQUASTAT library for the year 1992. Total area equipped for irrigation per region was then computed as the sum of full/partial control area and equipped wetland area.

The location and command area of 23 projects was derived from the FAO-irrigation map for Africa [BF03]. These areas got the highest priority in the distribution process. The command area of the registered schemes added up to 11 535 ha. The second highest priority was given to zones of private irrigation digitized from an irrigation map [BF04] and to areas classified as "irrigated agriculture" in the GLC2000 land cover map of Africa [BF05]. However, the area equipped for irrigation reported by the sub-national statistics was still larger in regions of Yatenga and Sud Ouest than the sum of the corresponding digitized areas. Therefore the remaining irrigated areas was assigned to agricultural land in inland valley bottoms in the larger surrounding of registered irrigation schemes (Yatenga) as digitized from satellite imagery [BF06] or to areas classified as "croplands" or "croplands with open woody vegetation" in the GLC2000 land cover map of Africa (Sud Ouest) [BF05].

Based on the classification of full/partial control schemes and equipped wetlands in the AQUASTAT country profile [BF01] irrigated area from groundwater was estimated being 3000 ha while area irrigated with surface water was estimated at 22 000 ha. Based on the harvested area of irrigated crops in full/partial control schemes it was assumed that the whole area equipped for irrigation is also actually used for irrigation.

References:

[BF01]: **FAO**. 2005. *AQUASTAT country profile Burkina Faso*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/burkina_faso/indexfra.stm, 06/10/2010.
[BF02]: **Dioma K.S., Douamba T.D., Kambou N.F., Nombre A., Traore T.M.** 2003. *Stratégie nationale de développement durable de l'irrigation au Burkina Faso (Rapport provisoire)*. Ministere de l'agriculture, de l'hydraulique, des ressources halieutiques.
[BF03]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[BF04]: **World Bank**. 1998. *Pilot private irrigation development project*. Project appraisal document. Report No. 18692-BUR (available at http://www-wds.worldbank.org).
[BF05]: **Mayaux, P., Bartholomé, E., Cabral, A., Cherlet, M., Defourny, P., Di Gregorio, A., Diallo, O., Massart, M., Nonguierma, A., Pekel, J.-F., Pretorius, C., Vancutsem, C., and Vasconcelos, M.** 2003. *The Land Cover Map for Africa in the Year 2000*. European Commision Joint Research Centre, available at: http://www-gem.jrc.it/glc2000).
[BF06]: **Earth Satellite Corporation.** 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-190 and 071-203. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Burundi

Area equipped for irrigation in Burundi is 21 430 ha [BI01]. The figures refer to the year 2000. No recent sub-national statistics on irrigated area have been available.

Irrigated area was assigned to specific grid cells by combining a database of irrigation projects in Africa [BI02], information on irrigated area per district representing the situation in year 1985 [BI03], indicative information on the location of irrigated areas as published in the AQUASTAT country profile [BI01], land cover information provided by the AFRICOVER project [BI04] and a map of micro-dams used in irrigation projects [BI05]. AFRICOVER lists two polygones of irrigated land cover type in the eastern part of the country. One was classified as irrigated sugar cane and the other one as irrigated herbaceous. 160 ha irrigated rice and 1450 ha irrigated sugar cane have been reported for the eastern part of the country [BI01]. Therefore these areas were assigned to the polygones derived from AFRICOVER. 2800 ha of irrigated land were assigned to 28 locations indicated on the map of micro-dams used for irrigation [BI05]. Information in the AQUASTAT country profile and the 1985-district data indicate that there exists much irrigation in l'Imbo-plain (districts of Gihanga, Mpanda and Mutimbuzi). Irrigated area was thus distributed to areas in that region covered by herbaceous crops [BI04]. Additionally the FAO-irrigation project database lists some very large projects in upland areas adjacent to the l'Imbo plain. These projects are assumed to represent rice cultivation and irrigated areas was distributed to herbaceous crop areas [BI04] surrounding these projects.

Since wells are only used for drinking water [BI01] irrigated area from groundwater was set to 0. Based on the harvested area of irrigated crops in full/partial control schemes it was assumed that the whole area equipped for irrigation is also actually used for irrigation.

References:

[BI01]: **FAO**. 2005. *AQUASTAT country profile Burundi*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/burundi/indexfra.stm, 06/10/2010.
[BI02]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[BI03]: **PNUD/FAO**. 1985. *La mise en valeur hydro-agricole au Burundi. Etat actuel et stratégie pour l'avenir*. Rapport préparé par N. Van Leeuwen. Rome.
[BI04]: **FAO**. 2005. *AFRICOVER, Burundi - Spatially Aggregated Multipurpose Landcover database*, FAO, Rome, Italy, http://www.africover.org, 13/12/2004.
[BI05]: **World Bank, Ministere de l'agriculture et de l'elevage**. 2004. *Projet de rehabilitation et d'appui au secteur agricole du Burundi (PRASAB)*. Rapport d'etude sur l'analyse d'impact environnemental et social du projet. http://www-wds.worldbank.org.

Cameroon

Area equipped for irrigation is reported to be 25 654 ha, of which 22 450 ha is in full/partial control schemes, 404 ha in equipped wetlands and 2800 ha in spate irrigation. The figures refer to year 2000. Irrigated area per province was computed as the sum of the command areas of irrigation projects mentioned in the AQUASTAT-country profile [CM01].

The command area and position of seven irrigation projects was derived from the FAO irrigation map for Africa [CM02]. The total area equipped for irrigation of these schemes is 17 270 ha. The outlines of five schemes larger than 1000 ha were adjusted using satellite imagery [CM03]. According to the statements in the country profile [CM01] there are about 1000 ha irrigated area close to the Lagdo reservoir. The outlines of the scheme were digitized from satellite imagery [CM03]. Cultivated land in the surrounding of Garoua and in the

provinces of Littoral and Sud-Ouest representing spate irrigation areas or banana plantations was digitized as well.

Irrigation in formal irrigation is completely from surface water resources [CM01] while farmers in small informal peri-urban irrigation around Yaounde also use groundwater from shallow wells [CM04]. Area equipped for irrigation with groundwater was therefore estimated at 100 ha. Area actually irrigated was assumed to be similar to area equipped for irrigation because harvested area of irrigated crops in year 2000 was much larger (at least 44 540 ha) than area equipped for irrigation indicating a high cropping intensity on irrigated land [CM01].

References:

[CM01]: **FAO**. 2005. *AQUASTAT country profile Cameroon*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/cameroon/indexfra.stm, 06/10/2010.

[CM02]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.

[CM03]: **Earth Satellite Corporation.** 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-213, 071-214, 071-227, 071-228 and 071-229. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

[CM04]: **Drechsel, P., Graefe, S., Sonou, M., Cofie, O.** 2006. Informal irrigation in urban West Africa: an overview. Research Report 102, International Water Management Institute (IWMI), Colombo, Sri Lanka, http://www.iwmi.cgiar.org/Publications/IWMI_Research_Reports/index.aspx, 06/10/2010.

Cape Verde

Area equipped for irrigation is 2 780 ha, while the area actually irrigated was 1 821 ha. The figures refer to year 1997. Irrigation potential was estimated at 3 109 ha in 1993. Irrigation potential and area actually irrigated were available per island and region [CV01]. Area equipped for irrigation per island and region was estimated as *area actually irrigated* + 0.7211 * (*irrigation potential – area actually irrigated*) with the exception of the regions Santa Catarina and Porto Novo. For these regions the area equipped for irrigation was set to the value reported for area actually irrigated because the irrigation potential reported for the year 1993 was lower here than the area actually irrigated in 1997.

Irrigated area was assigned to grid cells according to the GLC2000 land cover map for Africa [CV02] considering all areas classified as "Croplands with open woody vegetation".

22 percent (391 ha) of the area equipped for irrigation is irrigated with groundwater [CV01].

References:

[CV01]: **Ministère de l'agriculture de l'élevage et de la sylviculture**. 1997. *Plan national directeur de l'irrigation – Cap Vert*.

[CV02]: **Mayaux, P., Bartholomé, E., Cabral, A., Cherlet, M., Defourny, P., Di Gregorio, A., Diallo, O., Massart, M., Nonguierma, A., Pekel, J.-F., Pretorius, C., Vancutsem, C., and Vasconcelos, M.** 2003. *The Land Cover Map for Africa in the Year 2000*. European Commision Joint Research Centre, available at: http://www-gem.jrc.it/glc2000).

Central African Republic

Area equipped for irrigation is 135 ha [CF01]. The figures refer to year 1987, but no more recent statistics have been available. No sub-national statistics on irrigated area have been available.

Irrigated area was distributed to 6 projects with known location and command area as derived from the FAO irrigation project database for Africa [CF02]. Total command area reported for the six schemes was 160 ha and was therefore scaled to meet the country-totals of 135 ha.

Area actually irrigated in year 1987 was 69 ha. All irrigation was from surface water in that year [CF01].

References:

[CF01]: **FAO**. 1996. *République centrafricaine – Suivi du Sommet mondial de l'alimentation – Projet de stratégie pour le développement agricole national – Horizon 2010*.
[CF02]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.

Chad

Area equipped for irrigation is reported to be 30 273 ha [TD01]. The figures refer to year 2002.

Irrigated area was distributed first to 6 large-scale schemes. The position and command area (in total 10 050 ha) of the schemes was taken from the FAO irrigation project database for Africa [TD02]. The remaining part of the irrigated area was assigned to zones of traditional or private irrigation and to palm groves as digitized from an irrigation map [TD03]. The outlines of the large scale schemes and of the digitized irrigation zones were adjusted using satellite imagery [TD04].

Area actually irrigated was 26 200 ha in year 2002. Area equipped for irrigation with groundwater was 6000 ha (19.8 percent) in the same year [TD01].

References:

[TD01]: **FAO**. 2005. *AQUASTAT country profile Chad*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/chad/indexfra.stm, 06/10/2010.
[TD02]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[TD03]: **UN Division for Sustainable Development**. 2003. *The integrated plan for Chad's water development and management (SDEA). Chapter 1: Present situation of Chad's water development and management*. http://www.un.org/esa/sustdev/tech_coop/sdea/, 15/10/2010.
[TD04]: **Earth Satellite Corporation.** 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-228, 071-229, 071-230, 071-231, 071-240, 071-241, 071-242 and 071-243. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Comoros

Area equipped for irrigation is reported to be 130 ha, while area actually irrigated was 85 ha in year 1987 [KM01].

The 130 ha of area equipped for irrigation were assigned to 4 irrigation schemes with known position and extent as derived from the FAO irrigation project database for Africa [KM02].

Groundwater extracted by boreholes is the only water source on Grand Comoros while water use on the other two islands is from surface water (rivers). Irrigated area on Grand Comoros was 5 ha and thus about 4 percent of the total irrigated area [KM01]. Therefore percentage of irrigated area from groundwater sources was estimated at 4 percent.

References:

[KM01]: **FAO**. 2005. *AQUASTAT country profile Comoros*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/comores/indexfra.stm, 06/10/2010.

[KM02]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.

Congo

Area equipped for irrigation and area actually irrigated was 2000 ha in year 2003 [CG01]. No sub-national statistics on the extent of irrigated lands have been available.

Full/partial control irrigated area is 217 ha and located near the cities of Brazzaville and Pointe-Noire. The remaining area equipped for irrigation is lowland sugar cane cultivation near Nkayi [CG02]. Small-scale cultivated land near Brazzaville and Pointe-Noire and large-scale agriculture near Nkayi was digitized from satellite imagery [CG03].

In 1993 all irrigation was from surface water [CG02].

References:

[CG01]: **UNECA**. 2003. *Republic of Congo - National report on water resources development 2003*.
[CG02]: **FAO**. 2005. *AQUASTAT country profile Congo*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/congo_rep/indexfra.stm, 06/10/2010.
[CG03]: **Earth Satellite Corporation.** 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tile 071-677. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Côte d'Ivoire

Area equipped for irrigation is 72 750 ha. The figures refer to year 1994. Area in full/partial control areas is reported to be 47 750 ha while equipped wetlands cover 25 000 ha [CI01]. Equipped wetland as reported by the statistics for 10 regions [CI02] was 24 940 ha. The total area of 44 known irrigation schemes derived from the AQUASTAT irrigation project database [CI03] and from another irrigation map [CI04] is 39 605 ha and was also assigned to the 10 regions depending on the location of the schemes. To compute total area equipped for irrigation the figures per region were scaled to meet the country-totals of full/partial control area and the equipped wetland area respectively.

Irrigated area was distributed to the 44 known projects. The outlines of the five largest schemes (total command area of these schemes is 30 000 ha) were then adjusted using satellite imagery [CI05]. The satellite images were also used to digitize cultivated areas along the main rivers and in lowlands. The remaining irrigated area was distributed to those digitized areas.

Area actually irrigated was 66 930 ha in year 1994 and completely by using surface water sources [CI01].

References:

[CI01]: **FAO**. 2005. *AQUASTAT country profile Cote D'Ivoire*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/cote_divoire/indexfra.stm, 06/10/2010.
[CI02]: **FAO**. 1999. *Côte d'Ivoire – Éléments de stratégie nationale de développement de la petite irrigation et plan d'action opérationel. Document de travail 3: Valorisation de la production agricole*.
[CI03]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[CI04]: **Universite Nationale de Côte d'Ivoire**. 1988. *Atlas regional du Nord-Est de la Côte d'Ivoire*. Planche 24 (opérations agricole).
[CI05]: **Earth Satellite Corporation.** 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-176, 071-177, 071-178, 071-188, 071-189 and 071-190. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Democratic Republic of the Congo
Area equipped for irrigation is 10 500 ha [CD01]. The figures refer to year 1995. No sub-national statistics on the extent of irrigated lands have been available.

Irrigated area was assigned to areas in the western part of the country, that were classified as irrigated sugar cane in the AFRICOVER data set [CD02]. These areas are located close to two irrigation projects listed in the FAO irrigation project data base for Africa [CD03]. Additionally, 3760 ha irrigated area were assigned to projects that are listed in the same database and located near Bumba in the northern part of the country and near the boundaries to Burundi and Rwanda in the eastern part.

Area actually irrigated was 6800 ha in year 2000. In year 1995 irrigation was completely based on surface water resources [CD04].

References:
[CD01]: **FAO**. 2004. *Suivi du sommet mondial de l'alimentation : 5 ans après - Eléments de stratégie nationale pour la sécurité alimentaire et le développement agricole - Horizon 2015 - République Démocratique du Congo*.
[CD02]: **FAO**. 2005. *AFRICOVER, DR Congo - Spatially Aggregated Multipurpose Landcover database*. FAO, Rome, Italy, http://www.africover.org, 13/12/2004.
[CD03]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[CD04]: **FAO**. 2005. *AQUASTAT country profile Democratic Republic of the Congo*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/congo_dem_r/indexfra.stm, 06/10/2010.

Djibouti
Area equipped for irrigation is 1012 ha [DJ01]. The figures refer to year 1999.

No spatial information was available related to the location and extent of irrigation schemes. Therefore arable land was digitized from satellite imagery [DJ02] and the irrigated area distributed to these digitized areas.

Area actually irrigated was 388 ha in year 1999. Irrigation is completely based on groundwater resources [DJ01].

References:
[DJ01]: **FAO**. 2005. *AQUASTAT country profile Djibouti*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/djibouti/indexfra.stm, 06/10/2010.
[DJ02]: **Earth Satellite Corporation.** 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tile 071-295. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Egypt
Area equipped for irrigation is reported to be 3 422 178 ha [EG01]. The figures refer to year 2002.

Irrigated area was distributed within the districts by using AFRICOVER data on land cover [EG02]. First irrigated area was assigned to polygons classified as completely covered by irrigated crops and in a second step (if necessary) to polygons classified as mixture between irrigated crops and other land cover. However, in some districts the area reported as irrigated by the statistics was still larger than the total area of polygons classified by AFRICOVER as irrigated or partly irrigated. Therefore for the districts of Port Said, Cairo, Ismailia, Suez,

Fayoum and Gharbia the difference was assigned to areas adjacent to irrigated areas and classified as bare soil.

All the area equipped for irrigation was used for irrigation in year 2002. In year 2000 about 11 percent of the irrigated area of the country (361 176 ha) was irrigated from groundwater and 217 527 ha from mixed water while the remaining 2 843 475 ha were irrigated from surface water [EG03]. Groundwater extraction is concentrated in desert oases, on the Sinai peninsula and the New Valley [EG03] and therefore in the related provinces of Matruh, Al Wadi al Jadid, Al Jizah, Janub Sina and Shamal Sina. Total irrigated area in these provinces was 331 927 ha. The province Al Jizah was split in a western part representing oases agriculture and an eastern part representing irrigation using water from the Nile River. It was assumed that irrigation in the provinces mentioned before (except the eastern part of Al Jizah) was from groundwater. The remaining groundwater irrigation area, the area irrigated from mixed water and the irrigation area from surface water was assigned to the remaining part of the country representing mainly the use of River Nile water, reused drainage water and treated waste water.

References:

[EG01]: **Ministry of Agriculture and Land Reclamation**. 2003. *Agricultural statistics, Volume 2, summer and Nili crops 2002*. Sector of Economic Affairs. Arab Republic of Egypt.
[EG02]: **FAO**. 2005. *AFRICOVER, Egypt - Spatially Aggregated Multipurpose Landcover database*, FAO, Rome, Italy, http://www.africover.org, 13/12/2004.
[EG03]: **FAO**. 2009. *AQUASTAT country profile Egypt*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/egypt/index.stm, 06/10/2010.

Equatorial Guinea

No area equipped for irrigation was reported for Equatorial Guinea [EQ01].

References:

[GQ01]: **FAO**. 2005. *AQUASTAT country profile Equatorial Guinea*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/eq_guinea/indexfra.stm, 06/10/2010.

Eritrea

The total area equipped for irrigation is 21 590 ha. About 4100 ha are equipped for full/partial control irrigation and 17 490 ha for spate irrigation [ER01]. The figures relate to year 1993. No sub-national statistics for irrigated land were available.

540 ha irrigated area was assigned to the location of the Northern Horticulture Development Project as derived from the FAO irrigation project database for Africa [ER02]. Additionally irrigated area was assigned to all areas classified as irrigated by AFRICOVER [ER03].

The percentage of groundwater use in full/partial control schemes was 96.6 percent or 3 961 ha in year 1993 [ER01]. Area actually irrigated was about 62.5 percent of the equipped area in year 1993 [ER01].

References:

[ER01]: **FAO**. 2005. *AQUASTAT country profile of Eritrea, version 2005*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/eritrea/index.stm, 06/10/2010.
[ER02]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[ER03]: **FAO**. 2005. *AFRICOVER, Eritrea - Spatially Aggregated Multipurpose Landcover database*. FAO, Rome, Italy, http://www.africover.org, 13/12/2004.

Ethiopia

Area equipped for irrigation in year 2001 was 289 530 ha [ET01]. The figures for the district of Gambela (116 ha in year 2001) were updated by using a more recent inventory of 791 irrigation schemes [ET02] resulting in an area equipped for irrigation of 1315 ha for this district and of 290 729 ha for Ethiopia. Total AEI in this inventory was 107 266 ha. The irrigation scheme inventory did not report spate irrigation areas which may be practised on more than 100 000 ha in Ethiopia [ET03]. This may explain the difference to the total irrigated area reported by the Ministry of Water Resources (289 530 ha) and reported in the AQUASTAT country profile [ET01].

Additionally to schemes contained in the inventory described before [ET02], irrigated areas were localized by using the FAO irrigation project database for Africa [ET04] and a map of irrigation projects available from the AQUASTAT-library [ET05]. The irrigation schemes were then digitized by using satellite imagery [ET06]. Most of the medium- and large-scale projects and some regions in which small scale irrigation is present could be detected that way. Projects with a known command area got a priority of seven and projects with an unknown command area a priority of four when assigning irrigated area to specific grid cells. The remaining irrigated area was assigned to arable land in irrigated regions as indicated on the FAO-map of irrigated areas in Africa [ET04].

Groundwater use for irrigation (mainly from springs) is practised only on a small scale in the provinces of Dire Dawa, Harari, Oromia and Amhara [ET02]. Since no data were available for Addis Ababa it was assumed that the percentage of groundwater use is similar to that one computed for Harari. Total area irrigated with groundwater computed that way was 2611 ha. It was assumed that area actually irrigated is similar to area equipped for irrigation.

References:

[ET01]: **FAO**. 2005. *AQUASTAT country profile Ethiopia*. Table A6. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/ethiopia/index.stm, 06/10/2010.

[ET02]: **Awulachew, S. B., Yilma, A. D., Loulseged, M., Loiskandl, W., Ayana, M., Alamirew, T.** 2007. *Water Resources and Irrigation Development in Ethiopia*. International Water Management Institute, Working Paper 123, Colombo, Sri Lanka, 78pp.

[ET03]: **Government of Ethiopia**. 2008. *National investment brief Ethiopia*. High-level conference on water for agriculture and energy in Africa: the challenges of climate change, Sirte, Libyan Arab Jamahiriya, December 15-17, 2008, http://www.sirtewaterandenergy.org/, 18/08/2009.

[ET04]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.

[ET05]: **Unknown**. *Ethiopia – irrigation projects, dams and rivers*. Map available in the AQUASTAT-library.

[ET06]: **Earth Satellite Corporation.** 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-266, 071-267, 071-268, 071-281, 071-282, 071-283, 071-293, 071-294, 071-295. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Gabon

Area equipped for irrigation is 4450 ha [GA01]. The figures refer to year 1987. However, the figures were confirmed by a recently published report [GA02]. No sub-national statistics on the extent of irrigated lands have been available.

The locations of four irrigation areas were derived from the FAO-map of irrigated areas in Africa [GA03]. The irrigation schemes were then digitized by using satellite imagery [GA04].

Based on the qualitative information contained in the AQUASTAT country report [GA01] and groundwater use in neighbouring countries (Cameroon, Congo) it was assumed that all irrigation is from surface water.

References:

[GA01]: **FAO**. 2005. *AQUASTAT country profile Gabon*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/gabon/indexfra.stm, 06/10/2010.
[GA02]: **FAO**. 2004. *République du Gabon. Suivi du Sommet mondial de l'alimentation: Cinq ans après. Note sur la stratégie pour le développement agricole national – Horizon 2015*.
[GA03]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[GA04]: **Earth Satellite Corporation.** 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-213, 071-227, 071-673 and 071-677. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Gambia

Area equipped for irrigation is 2149 ha [GM01]. The figures refer to year 1999.

No sub-national statistics on the extent of irrigated lands have been available, but the location and corresponding area equipped for irrigation of the existing four projects JPSP, RIDEP, SSWC and Lamin/Bakau horticulture was available [GM02]. The outlines of the largest scheme (JPSP) were digitized from satellite imagery [GM03], while the other schemes were incorporated as point features using the positions indicated on [GM02].

Area actually irrigated was 1400 ha in year 1999 [GM04]. Only 15 ha were irrigated with groundwater from wells and boreholes in the Lamin Horticultural Project and the Bakau Horticultural Project. The other irrigation schemes used surface water provided by pumping from the river or by tidal irrigation [GM04].

References:

[GM01]: **International Cooperation and Development Fund (ICDF)**. 1999. *Development of tidal irrigation in the Gambia*. In: ICDF. 1999 ICDF Annual Report – Special Report. 67-70.
[GM02]: **Chancellor, F.** 1996. *Women in Irrigation: Case studies of schemes in the Gambia, Kenya and South Africa*. HR Wallingford, UK. Report no OD/TN 82.
[GM03]: **Earth Satellite Corporation.** 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tile 071-166. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.
[GM04]: **FAO**. 2005. *AQUASTAT country profile Gambia*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/gambia/index.stm, 06/10/2010.

Ghana

By year 2000, area equipped for irrigation in formal irrigation schemes consisted of 8587 ha in public schemes and 10 413 ha in private schemes [GH01]. The extent of informal peri-urban irrigation is not exactly known. In the area around Kumasi about 11 900 ha of peri-urban irrigation were reported [GH01] and the total extent of peri-urban irrigation in Ghana was estimated at 40 000 ha [GH02]. Total area equipped for irrigation is therefore 59 000 ha.

No sub-national statistics on the extent of irrigated lands have been available, but the location and corresponding area equipped for irrigation of the existing 22 public irrigation schemes was available (GH03]. The peri-urban irrigation was reported to appear in a 40 km radius around the city centre of Kumasi [GH04]. Additionally some peri-urban irrigation was assigned to the surrounding of Accra, Takoradi and Tamale [GH02]. The location of the private schemes was unknown. Their corresponding irrigation area was assigned to areas which were classified as irrigable on a map available in the AQUASTAT library [GH05].

While the area in formal irrigation schemes is irrigated with surface water [GH01], farmers in informal irrigation use different water sources like shallow wells, streams, waste water or pipe-born water [GH02]. Based on the information in [GH02] it was estimated that 3 percent

of the informal irrigation area is irrigated with waste water, 30 percent with groundwater and 67 percent with surface water resulting in 12 000 ha of area equipped for irrigation with groundwater, 45 800 ha of area equipped for irrigation with surface water and 1200 ha of area equipped for irrigation with water from non-conventional sources. It was assumed that 3000 ha of the area equipped for irrigation was not actually irrigated [GH01] resulting in an total area actually irrigated of 56 000 ha.

References:

[GH01]: **FAO**. 2005. *AQUASTAT country profile Ghana*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/ghana/index.stm, 06/10/2010.

[GH02]: **Drechsel, P., Graefe, S., Sonou, M., Cofie, O.** 2006. Informal irrigation in urban West Africa: an overview. Research Report 102, International Water Management Institute (IWMI), Colombo, Sri Lanka, http://www.iwmi.cgiar.org/Publications/IWMI_Research_Reports/index.aspx, 19/08/2009.

[GH03]: **Ghana Irrigation Development Authority (GIDA)**. 2001. *General information on public irrigation projects in Ghana*.

[GH04]: **HR Wallingford**. 2002. *Informal irrigation in peri-urban areas. Institutional aspects and options for improvement*. KAR Project R7132.

[GH05]: **Unknown**. 1985. *Existing and proposed irrigation projects in Ghana*. Map available in the AQUASTAT library.

Guinea

Area equipped for irrigation and area actually irrigated is 20 386 ha in full/partial control schemes, 74 528 ha in equipped wetlands and thus 94 914 ha in total [GN01]. The figures refer to year 2001.

The location and command area for 13 irrigation schemes was derived from the FAO-map of irrigated areas in Africa [GN02]. The total irrigated area in these schemes is summing up to 6870 ha. The remaining irrigated area was distributed according to the GLC2000 land cover map for Africa [GN03] to areas classified as "Mangrove", "Irrigated cropland", "Mosaic of cropland and woody vegetation" or "Mosaic of forest and cropland". First it was made sure that 50 850 ha irrigated area was assigned to areas classified as "Mangrove" (see [GN01]). After area equipped for irrigation was assigned also to the other land cover types beginning with "Irrigated cropland", then "Mosaic of cropland and woody vegetation" and finally if necessary also to areas classified as "Mosaic of forest and cropland" with the lowest priority.

2.3 percent (460 ha) of the area equipped for irrigation in full/partial control schemes is irrigated with groundwater while the remaining part is irrigated with water from surface water sources [GN01].

References:

[GN01]: **FAO**. 2005. *AQUASTAT country profile Guinea*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/guinea/indexfra.stm, 06/10/2010.

[GN02]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.

[GN03]: **Mayaux, P., Bartholomé, E., Cabral, A., Cherlet, M., Defourny, P., Di Gregorio, A., Diallo, O., Massart, M., Nonguierma, A., Pekel, J.-F., Pretorius, C., Vancutsem, C., and Vasconcelos, M.** 2003. *The Land Cover Map for Africa in the Year 2000*. European Commision Joint Research Centre, available at: http://www-gem.jrc.it/glc2000).

Guinea Bissau

Area equipped for irrigation is 8562 ha in full/partial control schemes, 13 996 ha in equipped wetlands and thus 22 558 ha in total [GW01]. The figures refer to year 1996. No sub-national statistics on the extent of irrigated lands have been available.

202.5 ha of irrigated area was first assigned to three known projects (Carantabà, Contubuol and Bafatà) as mentioned in the country profile [GW01]. The remaining fraction of full/partial control area (8449.5 ha) was assigned to areas along the Geba river [GW01] as digitized from satellite imagery [GW02]. The 13 996 ha of irrigated area reported to be in mangroves [GW01] was assigned to land locked areas classified as "Mangrove" or "Irrigated cropland" in the GLC2000 land cover dataset for Africa [GW03].

Area actually irrigated was similar to area equipped for irrigation in year 1996. 6 percent of the 8562 ha in full/partial control schemes are irrigated with groundwater, 8 percent with surface water and the remaining 86 percent with a mixture of water from both sources [GW01]. By assuming a contribution of 50 percent groundwater in water from mixed sources area equipped for irrigation with groundwater was computed as 4195 ha.

References:

[GW01]:**FAO**. 2005. *AQUASTAT country profile Guinea Bissau*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/guineabissau/indexfra.stm, 06/10/2010.

[GW02]:**Earth Satellite Corporation.** 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tile 071-166. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

[GW03]:**Mayaux, P., Bartholomé, E., Cabral, A., Cherlet, M., Defourny, P., Di Gregorio, A., Diallo, O., Massart, M., Nonguierma, A., Pekel, J.-F., Pretorius, C., Vancutsem, C., and Vasconcelos, M.** 2003. *The Land Cover Map for Africa in the Year 2000*. European Commision Joint Research Centre, available at: http://www-gem.jrc.it/glc2000).

Kenya

Area equipped for irrigation is 103 203 ha [KE01]. The figures refer to year 2003.

The irrigated was first assigned to projects as indicated by the FAO project database [KE02] and additionally 20 ha of irrigated area was assigned to projects identified by using a map of irrigation schemes [KE03]. The remaining area was distributed to areas that were classified by AFRICOVER as irrigated, rice or coffee [KE04] or as irrigated by the IGAD land use data base [KE05]. Additionally irrigated area was digitized from satellite imagery [KE06] for some areas where irrigation is known to be practised (map in [KE01]). This procedure worked fine for six of the eight provinces. For the Western province only 563 ha irrigated area were reported by the statistics but according to the geographical records there should be much more. The FAO project database lists three projects of together 1685 ha irrigated land for this province and additionally 98 schemes were identified on the map of irrigation schemes in Kenya. Thus we would expect to find about 4000 ha irrigated area there. However, to be consistent to the statistics it was decided to distribute 421 ha to the three large projects derived from the FAO project database (25 percent of their command area) and the remaining irrigated area was distributed to the 98 small scale schemes (about 1.4 ha to each of them). In contrast, the statistics reported 5803 ha irrigated area for the North Eastern province, while no schemes could be identified there. Because there is also no irrigated land, rice or coffee according to AFRICOVER or irrigated land according to the IGAD land use, it was decided to distribute the irrigated area over other cultivated land as derived from AFRICOVER [KE07].

Area actually irrigated was 94 percent (97011 ha) of area equipped for irrigation in year 2003 while 1 percent of the area equipped for irrigation was irrigated with groundwater [KE01].

References:

[KE01]: **FAO**. 2006. *AQUASTAT country profile Kenya*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/kenya/index.stm, 06/10/2010.
[KE02]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[KE03]: **Unknown**. *Irrigation schemes in Kenya*. Map available in the AQUASTAT-library.
[KE04]: **FAO**. 2005. *AFRICOVER, Kenya - Spatially Aggregated Multipurpose Landcover database*, FAO, Rome, Italy, http://www.africover.org, 13/12/2004.
[KE05]: **Intergovernmental Authority on Development (IGAD)**. *Land use classification of Kenya*. http://www.igad-data.org/, 14/07/2008.
[KE06]: **Earth Satellite Corporation**, 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-266, 071-281, 071-698 and 071-705. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.
[KE07]: **FAO**. 2005. *AFRICOVER, Kenya - Thematic Agriculture Aggregation*, FAO, Rome, Italy, http://www.africover.org, 13/12/2004.

Lesotho

Area equipped for irrigation is 2637 ha [LS01]. The figures refer to year 1999.

The location and extent of 6 irrigation schemes covering 570 ha were derived from the FAO irrigation map for Africa [LS02]. Additionally 17 areas classified as "Cultivated: temporary - commercial irrigated" covering 726 ha in total were derived from a land cover database for South Africa [LS03]. Areas classified as "Cultivated: temporary - commercial dryland", "Cultivated: temporary - semi-commercial/subsistence dryland", "Improved grassland" or "Herbland" were derived from the same data set. Irrigated area was assigned to those areas using the priorities documented in Table A2, if the areas were located in four zones marked as irrigated on the FAO irrigation map for Africa [LS02]. For the district of Leribe also areas outside these zones were considered.

Area actually irrigated was only 67 ha in year 1999. While the large scale schemes (mainly sprinkler irrigation) went completely out of operation, small scale irrigation for vegetable production was successful. Rivers are the water source of large scale schemes and water for small scale agriculture and home gardens is extracted from the domestic supply system or from small streams or ponds using pumps. Irrigation potential from groundwater is limited to the area around Maputsoe [LS04]. Based on this information area equipped for irrigation with groundwater was estimated at 50 ha (2 percent) of the total area equipped for irrigation.

TABLE A2
Priorities used to distribute irrigated area within the districts of Lesotho.

Data set	Attribute	Priority
[LS02]	Irrigation project (point feature)	6
[LS03]	Cultivated: temporary - commercial irrigated	6
[LS03]	Cultivated: temporary - commercial dryland	5
[LS03]	Improved grassland	4
[LS03]	Herbland	4
[LS03]	Cultivated: temporary - semi-commercial/subsistence dryland	3

References:

[LS01]: **FAO and World Bank**. 1999. *Lesotho smallholders irrigation initiative. Exploratory Mission Report*.
[LS02]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[LS03]: **Thompson, M.W.** 1999. *South African national land cover data set*. Council for Scientific and Industrial Research (CSIR), Satellite Applications Centre. CD-ROM, available at: http://www.sac.co.za.
[LS04]: **FAO**. 2006. *AQUASTAT country profile Lesotho*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/lesotho/index.stm, 06/10/2010.

Liberia

Area equipped for irrigation is 2100 ha with the majority (2000 ha) in equipped wetlands [LR01]. The figures refer to year 1987. No up-to-date information or sub-national information on irrigated areas in Liberia is available.

Irrigated area was assigned to areas which were classified as "Mosaic forest / cropland" in the GLC2000 land cover dataset for Africa [LR02] and which additionally were located within three zones marked as irrigated on the FAO irrigation map for Africa [LR03].

Based on the qualitative information contained in the AQUASTAT country reports [LR01] and groundwater use in neighbouring country Guinea, percentage of irrigation area from groundwater was estimated at 0.5 percent.

References:

[LR01]: **FAO**. 2005. *AQUASTAT country profile Liberia*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/liberia/index.stm, 06/10/2010.

[LR02]: **Mayaux, P., Bartholomé, E., Cabral, A., Cherlet, M., Defourny, P., Di Gregorio, A., Diallo, O., Massart, M., Nonguierma, A., Pekel, J.-F., Pretorius, C., Vancutsem, C., and Vasconcelos, M.** 2003. *The Land Cover Map for Africa in the Year 2000*. European Commision Joint Research Centre, available at: http://www-gem.jrc.it/glc2000).

[LR03]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.

Libya

Area equipped for irrigation is reported to be about 470 000 ha, while area actually irrigated was estimated at 316 000 ha [LY01]. The figures refer to year 2000. Irrigation infrastructure that is still functioning was reported for year 1999 by province [LY02]. The total area added up to 360 500 ha. However, it was also stated, that the study may underestimate the real extent of private irrigation, which is dominant in Libya. Therefore, to compute area equipped for irrigation by province, area equipped for irrigation in private schemes was scaled so that the total area equipped for irrigation meets the figures reported for the whole country for year 2000.

The position and extent of the public irrigation schemes was digitized from maps published in [LY02]. The command area of these schemes was also given in these report and summed up to about 88 000 ha. Additionally, some irrigated areas were digitized from maps published in [LY03] and from a map belonging to the AQUASTAT country profile [LY01]. These areas were assumed to represent the major areas of private irrigation. The shape of the boundaries of all digitized irrigation areas were improved by using satellite imagery [LY04].

By far the most irrigation schemes are using groundwater. Only 0.65 percent (3000 ha) of the total area equipped for irrigation is using water from surface water sources and on a similar acreage wastewater is used [LY01]. These areas were assigned to the northern plains while for the rest of the country it was assumed that irrigation is completely from groundwater.

References:

[LY01]: **FAO**. 2006. *AQUASTAT country profile Libya*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/libya/index.stm, 06/10/2010.

[LY02]: **Palas, P., and Salem, O.** 2000. Water resources utilisation and management of the Socialist People Arab Jamahiriya. 65 pp. Report available in the AQUASTAT-library.

[LY03]: **Schliephake, K.** 1993. Libyens Bewässerung und der "Große künstliche Fluß". *In* H. Popp & K. Rother, eds. *Die Bewässerungsgebiete im Mittelmeerraum*, pp. 185-192. Passau, Germany, Passavia Universitätsverlag.
[LY04]: **Earth Satellite Corporation**, 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-217, 071-218, 071-219, 071-231, 071-232, 071-233, 071-242, 071-243, 071-244 and 071-245. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Madagascar

Area equipped for irrigation is 1 086 291 ha [MG01]. The figures refer to year 2000. The disaggregation of the irrigated area to the province level is based on figures reported for the year 1992. The equipped area per province for this year added up to 1 087 000 ha in total and was scaled so that the sum fits to the national value reported for the year 2000.

The location and command area of 38 irrigation schemes was derived from the FAO irrigation map for Africa [MG02]. The total command area of these schemes was 154 520 ha. 13 polygons representing other irrigation areas where derived from the same map. The location of 158 irrigation projects was derived from another irrigation map [MG03]. The boundaries from 14 other irrigation areas where digitized from a map published in [MG04]. In the next step cultivated areas were digitized from satellite imagery [MG05] if they were located inside the polygons digitized before or around the points representing irrigation projects. Those areas that were marked as irrigated on the irrigation maps and additionally also found to be cultivated got the highest priority in the distribution process. After some irrigation was also distributed to the other areas assumed to represent widespread small scale irrigation.

Area actually irrigated was 1 080 691 ha in year 2000 and completely based on the use of surface water sources [MG01].

References:

[MG01]:**FAO**. 2005. *AQUASTAT country profile Madagascar*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/madagascar/indexfra.stm, 06/10/2010.
[MG02]:**FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[MG03]:**O.N.E.** (unknown). *Les perimeters irrigués*. Map showing the location of the GPI and PPI projects, available in the AQUASTAT library.
[MG04]:**Achtnich, W.** 1980. *Bewässerungslandbau*. Verlag Eugen Ulmer, Stuttgart, Germany.
[MG05]:**Earth Satellite Corporation**, 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-714, 071-715, 071-716, 071-717, 071-720, 071-721 and 071-722. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Malawi

Area equipped for irrigation is 56 390 ha [MW01]. The figures refer to year 2002. Irrigated area per province was available for the 25 550 ha of formal irrigation only and neglected informal irrigation and parts of the small-scale irrigation. Therefore total area equipped for irrigation was not available at the sub-national scale.

The location and command area of 16 irrigation schemes was derived from the FAO irrigation map for Africa [MW02]. The total irrigated area of these projects was 15 855 ha. The outlines of the two largest schemes (Sucoma and Dwanga) with a command area of 13 000 ha were digitized from Satellite Imagery [MW03]. The satellite images were also used in the background to digitize cultivated areas near Nkota-Kota, Mulanje and Thyolo representing the areas of irrigated sugar cane, coffee or tea mentioned in the AQUASTAT country profile [MW01]. The remaining irrigated area (about 8 000 ha of small scale rice and vegetable

growing areas) was assigned to areas classified as "cropland" in the GLC2000 land cover dataset for Africa [MW04].

In year 1992 about 96 percent of the area equipped for irrigation was actually irrigated and only 0.05 percent of the irrigated area was irrigated with groundwater [MW01]. It was assumed that these fractions were similar in year 2000.

References:

[MW01]: **FAO**. 2006. *AQUASTAT country profile Malawi*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/malawi/index.stm, 06/10/2010.
[MW02]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[MW03]: **Earth Satellite Corporation**, 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-699, 071-700 and 071-701. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.
[MW04]: **Mayaux, P., Bartholomé, E., Cabral, A., Cherlet, M., Defourny, P., Di Gregorio, A., Diallo, O., Massart, M., Nonguierma, A., Pekel, J.-F., Pretorius, C., Vancutsem, C., and Vasconcelos, M.** 2003. *The Land Cover Map for Africa in the Year 2000*. European Commision Joint Research Centre, available at: http://www-gem.jrc.it/glc2000).

Mali

Area equipped for irrigation is 235 791 ha [ML01]. The figures refer to year 2000. Table A4 in the AQUASTAT country profile [ML01] lists the different types of water managed areas per region. However, figures for managed wetlands are not given separately for equipped and non-equipped areas. To estimate total area equipped for irrigation per region it was assumed therefore, that the 60 000 ha of non-equipped wetlands are located in regions of Segou, Mopti and Tombouctou only and that the ratio of equipped versus non-equipped wetlands is the same for all three regions.

The outlines of the irrigated areas of the country were digitized from a irrigation map present in the AQUASTAT library [ML02]. The command area of 6 very large schemes covering 51 635 ha in total was derived from the FAO irrigation map for Africa [ML03]. The shapes of the boundaries of the digitized irrigation areas were improved by using satellite imagery [ML04].

75 percent of the total area equipped for irrigation was actually irrigated in year 2000 while the area equipped for irrigation with groundwater was about 1000 ha (1 percent of area equipped for irrigation in full/partial control schemes) [ML01].

References:

[ML01]: **FAO**. 2005. *AQUASTAT country profile Mali*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/mali/indexfra.stm, 06/10/2010.
[ML02]: **Ministere de l'Agriculture de l'Elevage et de la Peche**. 2003. *Carte d'Irrigation du Mali par Regions Hydrauliques*. Direction Nationale de L'Aménagement et de L'Equipement Rural (DNAER). Map available in the AQUASTAT library.
[ML03]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[ML04]: **Earth Satellite Corporation**, 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-178, 071-179, 071-180, 071-190, 071-191, 071-192, 071-204 and 071-205. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Mauritania

Area equipped for irrigation is 45 012 ha, of which 40 261 ha are located along the Senegal river and 4751 ha irrigated land is located in 218 oases [MR01]. The figures refer to year 1994.

The irrigated areas along the Senegal river were digitized from a map published as part of the AQUASTAT country profile [MR02]. The oases were located using the Geographic Name Server of the US National Geospatial-Intelligence Agency (http://gnswww.nga.mil/geonames/GNS/index.jsp). The outlines of the irrigated areas were improved by digitizing cultivated areas along the Senegal river and around the oases by using satellite imagery [MR03].

Area actually irrigated in year 2004 was 22 840. The irrigation areas along the Senegal river are using surface water for irrigation while groundwater is used for irrigation in the oases [MR02].

References:

[MR01]:**MDRE**. 1998. *Politiques et stratégies générales pour le développement du secteur rural – Horizon 2010*.
[MR02]:**FAO**. 2005. *AQUASTAT country profile Mauritania*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/mauritania/indexfra.stm, 06/10/2010.
[MR03]:**Earth Satellite Corporation**, 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-167, 071-168, 071-179, 071-180 and 071-181. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Mauritius

Area equipped for irrigation is 21 543 ha [MU01]. The figures refer to year 2009.

Irrigated areas were digitized from a map available in the AQUASTAT library [MU02]. The command area of the operating schemes of the Irrigation Authority was also indicated on this map (in total 4571 ha). Irrigated area was also distributed to schemes classified as "operating projects by private sector". The remaining irrigated area was distributed to areas classified as "projects under design or construction" or "potential irrigable". For the Central district irrigated area was additionally assigned to cultivated areas as digitized from satellite imagery [MU03].

About 98 percent of the area equipped for irrigation are actually irrigated [MU04]. Groundwater is used for irrigation on 25 percent of the areas equipped for irrigation [MU04] while the remaining areas are using water from surface water sources.

References:

[MU01]:**Central Statistics Office**. 2009. *Digest of agricultural statistics 2009*. http://www.gov.mu/portal/goc/cso/report/natacc/agri09/toc.htm, 06/10/2010.
[MU02]:**Unknown**. 2002. *Irrigation projects*. Map available in the AQUASTAT library.
[MU03]:**Earth Satellite Corporation**. 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tile 071-729. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.
[MU04]:**FAO**. 2005. *AQUASTAT country profile Mauritius*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/mauritius/index.stm, 06/10/2010.

Morocco

Area equipped for irrigation is 1 484 160 ha [MA01]. The figures refer to year 2004.

191 Irrigated areas for the northern part of the country were digitized from an irrigation map published in [MA02] while the main irrigated areas for the southern part were digitized from a map belonging to the AQUASTAT country profile [MA01]. For the northern part of the country additionally some irrigated areas were derived from the CORINE land cover database

for Europe [MA03]. Finally the shapes of the boundaries of the digitized irrigation areas were improved by using satellite imagery [MA04].

Area actually irrigated was 1 448 011 ha in year 2004 [MA01]. The separation of irrigated areas from groundwater and surface water for the public irrigation schemes was based on Table A3 in [MA05] and AQUASTAT data reported in Tables 12 and 13 of the country profile Morocco [MA01]. Irrigated area of private irrigation schemes was available for 16 regions distinguishing wells, springs, reservoirs, treated waste water, mixed sources and water from transfers [MA05]. The total area of private irrigation schemes in year 2002 was 626 609 ha and more than 90 percent used groundwater. In contrast, public irrigation schemes mainly used irrigation water extracted from surface water sources [MA01]. Total groundwater irrigation area computed that way was 677 201 ha (46 percent of total), area irrigated with surface water was 804 221 ha (54 percent) and the remaining 2738 ha represent areas irrigated with treated wastewater.

References:

[MA01]: **FAO**. 2005. *AQUASTAT country profile Morocco*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/morocco/indexfra.stm, 06/10/2010.
[MA02]: **Popp, H.** 1993. Morocco's "policy of dams" and its consequences for irrigation agriculture (in german). *In* H. Popp & K. Rother, eds. *Die Bewässerungsgebiete im Mittelmeerraum*, pp. 161-164. Passau, Germany, Passavia Universitätsverlag.
[MA03]: **EEA**. 1999. Corine land cover (CLC1990). http://dataservice.eea.europa.eu/dataservice/.
[MA04]: **Earth Satellite Corporation**, 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-169, 071-181, 071-182, 071-183, 071-193, 071-194 and 071-195. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.
[MA05]: **FAO**. 2008. *Etude sur la gestion des eaux souterraines dans des pays pilotes du Proche-Orient*. Etude de Cas du Maroc. Bureau régional de la FAO pour le Proche-Orient, Cairo, Egypt.

Mozambique

Area equipped for irrigation is 118 120 ha [MZ01]. The figures refer to the period 2001-2003.

The position of 448 irrigation schemes with a total area equipped for irrigation of 117 027 ha was derived from a detailed inventory of irrigation projects [MZ01]. The outlines of 14 irrigation schemes with a command area larger than 1000 ha were digitized from satellite imagery [MZ02], while the irrigated area of the other schemes was assigned to the positions of the projects as reported in the inventory.

Area actually irrigated was 40 463 ha in year 2002 [MZ01]. In most irrigation schemes of Mozambique surface water from rivers is being used. Groundwater is used to a very limited extent by the family smallholder sector [MZ03]. Based on this qualitative information it was assumed that groundwater is used by 10 percent of the small scale schemes (<50 ha). This resulted in a total of 639 ha (about 0.5 percent of the total irrigation area).

References:

[MZ01]: **Direccão nacional de hidraulica agricola (DNHA)**. 2003. *Sínteso do Levantamento nacional dos regadios 2001 e 2003*. Ministry of Agriculture and Rural Development. Republic of Mozambique. Maputo.
[MZ02]: **Earth Satellite Corporation**, 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-700, 071-701, 071-702, 071-703, 071-707 and 071-708. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.
[MZ03]: **FAO**. 2005. *AQUASTAT country profile Mozambique*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/mozambique/index.stm, 06/10/2010.

Namibia

Area equipped for irrigation is 7573 ha [NA01]. The figures refer to year 2002. Irrigated area per river basin was available for year 1999 and adds up to 7318 ha [NA02]. The statistics presented in both reports were combined to an inventory of schemes irrigating with groundwater [NA03] to compute area equipped for irrigation per basin for the year 2002. Irrigated area for the following basins were derived from report [NA02]: Orange (2054 ha), Fish (2312 ha), Nossob (67 ha), Swakop (174 ha), Omaruru (73 ha), Ugab (198 ha), Huab (38 ha) and Hoanib (64 ha). According to the project-based statistics reported in [NA01] irrigated area of Zambezi basin was set to 200 ha and that one of Okavango basin and its upstream sub-basins to 1350 ha. Area equipped for irrigation in the Auob basin was set to 329 ha according to [NA03]. The total area equipped for irrigation as assigned that way adds up to 6859 ha and the remaining area of 714 ha was assigned to the Cunene basin and the Cuvelai area.

The location and command area of five large irrigation schemes was derived from the FAO irrigation map for Africa [NA04]. The shapes of the boundaries of the digitized irrigation areas were improved by using satellite imagery [NA05]. The total area equipped for irrigation in these schemes was reported to be 5350 ha. The remaining irrigated area was assigned to small scale irrigated areas fed by ground water as indicated on an irrigation map available in the AQUASTAT library and to from an groundwater inventory related to the year 1999 [NA03].

Location and extent of schemes irrigating with groundwater was derived from an inventory related to year 1999 [NA03]. Total AEI irrigated with groundwater according to this inventory was 1632 ha or 22 percent of total AEI. The sum of AEI irrigated with groundwater was then computed for each of the 23 basins contained in version 4 of the GMIA as subnational units of Namibia. It was assumed that AAI was similar to AEI.

References:

[NA01]: **FAO**. 2005. *AQUASTAT country profile Namibia*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/namibia/index.stm, 06/10/2010.

[NA02]: **Windhoek Consulting Engineers (WCE)**. 2000. Analysis of Present and Future Water Demand in Namibia.

[NA03] **Christelis, G. and Struckmeier, W. (eds.)**. 2001. *Groundwater in Namibia – an explanation to the hydrogeological map*. Dept. of Water Affairs, Division Geohydrology, Geological Survey of Namibia, Namibia Water Corporation, Federal Institute for Geosciences and Mineral Resources, Windhoek, Namibia and Hannover, Germany, 128 pp.

[NA04]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.

[NA05]: **Earth Satellite Corporation**. 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-680, 071-681, 071-682, 071-687, 071-688, 071-689 and 071-694. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Niger

Area equipped for irrigation is 73 663 ha [NE01], of which about 60 000 ha are equipped wetlands. The figures refer to year 2005. Irrigated area per district was available for year 2002 and adds up to 67 323 ha [NE02]. Irrigated areas in the provinces of Tillaberi and Tahoua were scaled so that the country-totals meet the figures as reported for the year 2005.

The location and command area of 30 irrigation projects was derived from the FAO irrigation map for Africa [NE03]. The total area equipped for irrigation in these schemes is 7700 ha. Then irrigated area was also assigned to areas along the Niger river [NE01] and to cultivated areas on river valley bottoms as digitized from satellite imagery [NE03].

Area actually irrigated was 65 615 ha (89 percent of area equipped for irrigation) in year 2005 [NE01]. Percentage area irrigated from groundwater was set to the related percentage of irrigation water use from groundwater (1.86 percent).

References:

[NE01]: **FAO**. 2005. *AQUASTAT country profile Niger*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/niger/indexfra.stm, 06/10/2010.
[NE02]: **FAO**. 2002. *Niger – Stratégie nationale de développement de l'irrigation et de collecte des eaux de ruissellement*.
[NE03]: **Earth Satellite Corporation**, 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-203, 071-204, 071-205, 071-215, 071-216, 071-217, 071-229, 071-230 and 071-231. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Nigeria

Area equipped for irrigation is 293 117 ha [NG01]. Recently published sub-national statistics were available for the schemes controlled by the River Basin Development Authority (RBDA) only [NG01]. Therefore irrigated area was assigned to river basins according to figures originating from the AQUASTAT-library and refering to 1993. The irrigated area in large and medium scale schemes adds up to 119 350 ha. Areas indicated as "Fadama type irrigation" account for 181 000 ha, which brings the total to 300 350 ha. Irrigated area was scaled so that the country-totals meet the figures as reported for the year 2004.

The location and extent of 65 public irrigation schemes was derived from a map and an inventory published in [NG01] and from the FAO irrigation map for Africa [NA02]. The total command area of these schemes was 81 103 ha. The boundaries of the 7 largest schemes (total irrigated area of these schemes was 69 750 ha) were digitized from satellite imagery [NG03]. The remaining irrigated area was assigned to cultivated land in valley bottoms of the large rivers as digitized from satellite imagery. [NG03].

Area actually irrigated was 218 840 ha in year 2004 [NG04]. Irrigation in the public irrigation schemes is predominantly from surface water sources (rivers, lakes, reservoirs). An inventory of 62 public irrigation schemes covering 82 205 ha listed 60 irrigation schemes having surface water supply and two schemes (in total 240 ha) having supply from groundwater [NG01]. In contrast, water supply in the private sector was reported to be mainly from shallow wells or small streams [NG04]. It was assumed, that the percentage of irrigation area supplied from groundwater for public and state farms was similar to the percentage reported in [NG01] while for the private irrigation schemes 50 percent groundwater supply was assumed. Irrigation in the traditional fadama-system was assigned to surface water supply because this system represents wetland cultivation using flood recession water. Although it was reported that farmers in the fadama-system also use wells to extract the water [NG04], most of these structures are not permanent and move from year to year. This procedure resulted in 66 800 ha area equipped for irrigation with groundwater (about 23 percent of total equipped area).

References:

[NG01]: **Enplan Group**. 2004. *Review of the Public Irrigation Sector in Nigeria*. Draft Final Report of Project UTF/046/NIR/UTF.
[NG02]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[NG03]: **Earth Satellite Corporation**, 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-201, 071-202, 071-203, 071-213, 071-214, 071-215, 071-228 and 071-229. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.
[NG04]: **FAO**. 2005. *AQUASTAT country profile Nigeria*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/nigeria/index.stm, 06/10/2010.

Réunion (France)

Area equipped for irrigation is 8811 ha [RE01]. The figures refer to year 2007. No sub-national information on areas equipped for irrigation was available, but it was reported that irrigation is mainly related to sugar cane cultivation and that about 80 percent of the irrigated area is located in the southern part of the island [RE02].

Irrigated areas were digitized from irrigation maps published in [RE02], [RE03] and [RE04]. The shapes of the boundaries of the digitized irrigation areas were improved by using satellite imagery [RE05].

Area actually irrigated in year 2007 was 8276 ha [RE01]. According to the French farm structure survey undertaken in year 2003 the area irrigated from surface water was 4110 ha, the area irrigated from groundwater was 330 ha and the area irrigated from mixed sources or from the public network was 19 050 ha for the entire area of the French over-sea departments [RE06]. Groundwater was the source of 9 percent of the water withdrawals in the agricultural sector and of 46 percent of the water withdrawals in the domestic sector in Réunion and year 2007 [RE07]. Based on these statistics and considering the importance of public networks in irrigation water supply, area irrigated with groundwater was estimated at 20 percent for Réunion,

References:

[RE01]: **Ministère de l'agriculture, de l'alimentation, de la pêche, de la ruralité et de l'aménagement du territoire**. 2010. *AGRESTE, Données en ligne, Structure des exploitations*. http://agreste.maapar.lbn.fr/, 06/10/2010.

[RE02]: **Saque, C., Fusillier, J.-L., Choisis, J.-P.** 2003. *Canne à sucre, état des lieux : irrigation et diversification*. Institut National de la Statistique et des Études Économiques (INSEE), *Revue économie de La Réunion* 114, pp. 15-17 (available at: http://www.insee.fr/fr/insee_regions/reunion/publi/accueil_publi.htm).

[RE03]: **Centre National de la Recherche Scientifique**. 1975. *Atlas des Départements Francais d' Outre-Mer*, I – La Réunion.

[RE04]: **Achtnich, W.** 1980. *Bewässerungslandbau*. Verlag Eugen Ulmer, Stuttgart, Germany.

[RE05]: **Earth Satellite Corporation**, 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tile 071-729. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080/esdi/index.jsp.

[RE06]: **European Commission**. 2009. *Ad hoc tables from the farm structure survey*. European Commission, EUROSTAT, http://epp.eurostat.ec.europa.eu/portal/page/portal/agriculture/data/ad_hoc_tables_farm_structure_survey,12/08/2009.

[RE07]: **IFEN**, 2009. *Ensemble Intégré des Descripteurs de l'Environnement Régional (EIDER)*. Institut Français de l'Environnement (IFEN), http://eider.ifen.fr/Eider/, 06/10/2010.

Rwanda

Area equipped for irrigation is 8500 ha [RW01]. The figures refer to year 2000. No sub-national information on areas equipped for irrigation was available.

The location and command area of 6 irrigation projects was derived from the FAO irrigation map for Africa [RW02]. The total area equipped for irrigation in these schemes is 2005 ha. The remaining irrigated area was assigned to polygons classified as irrigated by the FAO-AFRICOVER data base [RW03].

Based on the qualitative information contained in the AQUASTAT country report [RW01] and groundwater use in neighbouring countries (Cameroon, Congo) it was assumed that only 1 percent of the irrigation area has groundwater supply.

References:

[RW01]: **FAO**. 2005. *AQUASTAT country profile Rwanda*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/rwanda/indexfra.stm, 06/10/2010.
[RW02]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[RW03]: **FAO**. 2005. *AFRICOVER, Rwanda - Spatially Aggregated Multipurpose Landcover database*, FAO, Rome, Italy, http://www.africover.org, 13/12/2004.

Sao Tome and Principe

Area equipped for irrigation was 9700 ha in year 1991 [ST01]. No sub-national information on areas equipped for irrigation was available.

The area equipped for irrigation was assigned to the North-Eastern part of the Sao Tome island which was reported to receive the lowest amount of annual precipitation and to temporary suffer from a precipitation deficit [ST01].

Based on the harvested area of irrigated crops reported in [ST01] for 1991 it was assumed that the whole area equipped for irrigation was actually irrigated in that year. All irrigation is reported to be from surface water sources [ST01].

References:

[ST01]: **FAO**. 2005. *AQUASTAT country profile Sao Tome and Principe*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/sao_tome_prn/indexfra.stm, 06/10/2010.

Senegal

Area equipped for irrigation is 119 680 ha [SN01]. The figures refer to year 2002. No sub-national information on areas equipped for irrigation was available. However, based on statistics in reports [SN02] and [SN03] 19 180 ha irrigated area were assigned to Casamance basin, 10 000 ha to West Coast basins (Saloum, Sine and Car Car), 600 ha to Senegal oriental (Gambia basin) and the remaining 89 900 ha were assigned to the Senegal river basin.

The location and extent of 7 large scale irrigation schemes (in total 15 500 ha) was derived from the FAO irrigation map for Africa [SN04]. Additionally, irrigated land mapped in a land use dataset [SN05] was extracted and cultivated land close to the Senegal river, in the Niayes zone and along the other major rivers was digitized from satellite imagery [SN06].

Area actually irrigated was 69 000 ha in year 1996 while area equipped for irrigation with groundwater was 10 218 ha (10 percent of irrigated area in full/partial control schemes) in year 2002 [SN01].

References:

[SN01]: **FAO**. 2005. *AQUASTAT country profile Senegal*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/senegal/indexfra.stm, 06/10/2010.
[SN02]: **FAO**. 1999. *Sénégal – Stratégie de développement de la petite irrigation et plan d'action*. 99/025 CP-SEN.
[SN03]: **Association Régionale de l'Irrigation et du Drainage en Afrique de l'Ouest et du Centre**. 2003. *Compte-rendu de l'atelier de lancement du projet APPIA au Sénégal*.
[SN04]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[SN05]: **Leonardi, U.** 2008. *Senegal Land Cover Mapping*. Food and Agriculture Organization of the United Nations, http://www.glcn.org/databases/se_landcover_en.jsp, 05/01/2010.
[SN06]: **Earth Satellite Corporation**, 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-166 and 071-167. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Seychelles
Area equipped for irrigation is 260 ha [SC01]. The figures refer to year 2003. Sub-national statistics on irrigated area per district added up to 362 ha [SC02] and were downscaled to meet the country-totals.

Information on the location of irrigation projects of the country was not available. Since the islands are also very small it was decided to distribute irrigated land equally within the districts.

The area actually irrigated was 200 ha in year 2003. Groundwater use for irrigation is very exceptional and occurs only in very dry periods when surface water bodies dry out [SC01]. Therefore it was assumed that water use for irrigation is completely from surface water sources.

References:
[SC01]: **FAO**. 2005. *AQUASTAT country profile Seychelles*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/seychelles/index.stm, 06/10/2010.
[SC02]: **Talma, W. and Bonne, G.** 2001. Farmers on state land. Ministry of Agriculture and Marine Resources.

Sierra Leone
Area equipped for irrigation is 29 360 ha, of which 1000 ha belong to full/partial control schemes and the remaining part to equipped wetlands [SL01]. The figures refer to year 1992. No sub-national information on areas equipped for irrigation was available.

The location of 14 irrigation projects was derived from the FAO irrigation map for Africa [SL02]. The related command area was given for 5 schemes and was summing up to 2030 ha. The remaining irrigated area was assigned to cultivated land in mangroves or along the major rivers as digitized from satellite imagery [SL03].

The land in full/partial control schemes was used to grow sugar cane in year 1992 but most of the area in equipped lowlands was not operational [SL01]. Therefore, area actually irrigated was estimated at 10 000 ha based on this qualitative information. Based on the qualitative information contained in the AQUASTAT country reports [SL01] and groundwater use in neighbouring country Guinea, percentage of irrigation area from groundwater was set to 20 ha (2 percent of the area equipped for irrigation in full/partial control schemes).

References:
[SL01]: **FAO**. 2005. *AQUASTAT country profile Sierra Leone*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/sierra_leone/index.stm, 06/10/2010.
[SL02]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[SL03]: **Earth Satellite Corporation**, 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-165, 071-166 and 071-177. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Somalia
Before the outbreak of the civil war in 1991 area equipped for irrigation was 200 000 ha of which 50 000 ha AEI was full/partial control surface irrigation and 150 000 ha spate irrigation [SO01]. No sub-national statistical information on areas equipped for irrigation was available but full/partial control irrigation was mainly practised along the Juba and Shabelle rivers in the southern part of the country while in the dryer northern part of Somalia irrigation is

practised as small-scale irrigation in dry riverbeds or adjacent areas, using water pumped from shallow wells and as spate irrigation.

Irrigated area was assigned to 15 irrigation projects according to their command area as reported by the FAO irrigation map for Africa [SO02]. The total command area of these schemes was 23 585 ha. Additionally, an irrigation area of 10 ha was assigned to 685 irrigation projects taken from an inventory of dams, drilled wells, dug wells and barrages [SO03]. The remaining irrigated area was assigned to all areas classified as irrigated by the AFRICOVER database [SO04]. These areas were grouped into three categories:

a) areas in which only irrigated crops are growing,
b) areas having a mixture of rainfed and irrigated crops with irrigated crops as main crop,
c) areas having a mixture of rainfed and irrigated crops with rainfed crops as main crop.

It was assumed, that the irrigation density in category b) is 67 percent of the density in category a) and that irrigation density in category c) is 33 percent of the density in category a).

The war has affected most of the full/partial control schemes in the south so that today hardly any scheme is fully operational [SO05]. In contrast most of the small-scale irrigation in the northern part is operational. To assign groundwater and surface water supplied irrigation areas, the country was split into a northern part and a southern part. Water supply is the southern part is from surface water [SO05]. 10 000 ha of groundwater irrigation representing extraction of irrigation water from springs and by wells was assigned to the northern part [SO06] and the remaining irrigation was assumed to be from surface water (representing spate irrigation areas). Areas actually irrigated were estimated at 20 000 ha for the northern region and 45 000 ha for the southern region.

References:

[SO01]: **FAO**. 2005. *AQUASTAT country profile Somalia*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/somalia/index.stm, 06/10/2010.
[SO02]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[SO03]: **SWALIM**. 2010. SWALIM GeoNetwork, http://geonetwork.faoswalim.org/geonetwork/srv/en/main.home, 20/12/2010.
[SO04]: **FAO**. 2005. *AFRICOVER, Somalia - Spatially Aggregated Multipurpose Landcover database*. FAO, Rome, Italy, http://www.africover.org, 13/12/2004.
[SO05]: **SWALIM**. 2007. *Status of medium to large irrigation schemes in Southern Somalia*. Project Report W-05, Somalia Water and Land Information Management Project (SWALIM), Nairobi, Kenya, http://www.faoswalim.org/index.php, 27/08/2009.
[SO06]: **SWALIM**, 2007. *Water Resources of Somalia*. Project Report W-11, Somalia Water and Land Information Management Project (SWALIM), Nairobi, Kenya, http://www.faoswalim.org/index.php, 27/08/2009.

South Africa

Area equipped for irrigation is 1 498 000 ha [ZA01]. The figures refer to year 2000 and are derived from a remote sensing based national land cover inventory [ZA02]. Sub-national information on areas equipped for irrigation is available in the downloadable PDF file or Excel file. However, the information refers to the same land cover inventory. To avoid a replication of information, the statistics have not been used.

Area equipped for irrigation was assigned to grid cells by using the areas classified as irrigated in the land cover inventory [ZA02].

Area actually irrigated was assumed to be similar to area equipped for irrigation [ZA01]. Area irrigated with groundwater was 8.5 percent of total area equipped for irrigation (127 330 ha) in year 2000 while the remaining part was irrigated with surface water resources [ZA01].

References:

[ZA01]: **FAO**. 2005. *AQUASTAT country profile South Africa*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/south_africa/index.stm, 06/10/2010.
[ZA02]: **Thompson, M.W.** 1999. *South African national land cover database project*. CSIR. Data set on CD-ROM, available at: http://www.sac.co.za

Sudan and South Sudan

Area equipped for irrigation is 1 863 000 ha [SD01]. The figures refer to year 2000. No sub-national statistics on areas equipped for irrigation were available.

Irrigated areas were derived from the AFRICOVER land cover data base [SD02]. However, it was found that several large irrigation schemes were not detected as irrigated by the land cover classification (e.g. Gash Delta, Tokar Delta, Aweil). Others were found to be incomplete. Therefore the missing schemes were derived from the FAO irrigation map for Africa [SD03] or digitized from another irrigation map [SD04]. The shapes of the boundaries of the digitized irrigation areas were improved by using satellite imagery [SD05].

Area actually irrigated was 800 000 ha in year 2000. 4 percent of the equipped area in full/partial control schemes (69 239 ha) was irrigated with groundwater in year 1995 while surface water sources were used in the remaining part [SD01].

References:

[SD01]: **FAO**. 2005. *AQUASTAT country profile Sudan*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/sudan/index.stm, 06/10/2010.
[SD02]: **FAO**. 2005. *AFRICOVER, Sudan - Spatially Aggregated Multipurpose Landcover database*. FAO, Rome, Italy, http://www.africover.org, 13/12/2004.
[SD03]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[SD04]: **unknown**. *Sudan. Irrigated and rainfed projects – hydropower project*. Map at scale 1 : 4 Mio, available in the AQUASTAT-library.
[SD05]: **Earth Satellite Corporation**, 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-201, 071-202, 071-203, 071-213, 071-214, 071-215, 071-228 and 071-229. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Swaziland

Area equipped for irrigation is 49 843 ha [SZ01]. The figures refer to year 2000. Sub-national statistics add up to 49 860 ha [SZ02] and were scaled to fit to the statistics reported in the AQUASTAT-country profile at the national level.

Areas equipped for irrigation were digitized from a map published in [SZ02] or derived from the South-African land cover data base [SZ03]. The shapes of the boundaries of the digitized irrigation areas were improved by using satellite imagery [SZ04].

In year 2002 area actually irrigated was 90 percent of the area equipped for irrigation (44 859 ha) [SZ01]. Public and private large scale schemes usually extract the irrigation water from reservoirs, while in small scale private schemes irrigation water is normally abstracted directly from the rivers using electric pumps [SZ02]. Based on this information area equipped for irrigation with groundwater was estimated at 1000 ha.

References:

[SZ01]: **FAO**. 2005. *AQUASTAT country profile Swaziland*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/swaziland/index.stm, 06/10/2010.
[SZ02]: **Riddell, P. J. and Manyatsi, A. M.** 2003. *Water use challenges and opportunities in the Swaziland agricultural sector*. FAO / Government of Swaziland, TCP/SWA/2801(A).
[SZ03]: **Thompson, M.W.** 1999. *South African national land cover database project*. CSIR. Data set on CD-ROM, available at: http://www.sac.co.za
[SZ04]: **Earth Satellite Corporation**. 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tile 071-703. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Togo

Area equipped for irrigation is 7300 ha [TG01]. The figures refer to year 1996. Sub-national statistics on areas equipped for irrigation were available for the full/partial control areas (2300 ha) only, but were missing for equipped wetlands (5000 ha). Therefore the sub-national statistics could not be used.

Irrigated area was assigned to 6 irrigation projects (point data) as derived from the FAO irrigation map for Africa [TG02]. The total area equipped for irrigation in these schemes was 2900 ha. The remaining area was assigned to 4 irrigation areas (polygon data) derived from the same map.

Area actually irrigated was 86 percent of the area equipped for irrigation (6278 ha) in year 1996 while area equipped for irrigation with groundwater was 2 percent of the area in full/partial control schemes (46 ha) in year 1990 [TG01].

References:

[TG01]: **FAO**. 2005. *AQUASTAT country profile Togo*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/togo/indexfra.stm, 06/10/2010.
[TG02]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.

Tunisia

Area equipped for irrigation for the 23 governorates was available for year 2000 and added up to 394 063 ha. Area equipped for irrigation in full/partial control schemes was 366 993 ha while spate irrigation areas covered 27 070 ha [TN01]. Area equipped for irrigation in full/partial control schemes increased to 428 000 ha in year 2006 [TN02] with 49.5 percent in the North, 36.2 percent in the Centre and 14.4 percent in the South. Area equipped for irrigation in full/partial control schemes per governorate was scaled so that the sum of the areas in the governorates was similar to the statistics reported for the entire region. Total area equipped for irrigation per governorate was then computed by adding the spate irrigation areas reported for year 2000.

The location and command area of 18 small scale irrigation projects was derived from the FAO irrigation map for Africa [TN03] while the large scale irrigation areas were digitized from several irrigation maps ([TN04], [TN05] and [TN06]). Finally the shapes of the boundaries of the digitized irrigation areas were improved by using satellite imagery [TN07].

Area actually irrigated was 405 000 ha in year 2005 [TN02]. Area equipped for irrigation with groundwater and with surface water was computed for the three regions North, Centre and South from another report [TN08]. The computed country totals agree well with statistics reported in the AQUASTAT country profile [TN01].

References:

[TN01]: **DGPDIA - S/D STAT**. 2000. *Résultats de l'enquête sur les périmètes irrigués en intensif. Ministère de l'Agriculture, de l'Environnement et des Ressources en Eau*.
[TN02]: **Government of Tunisia**. 2008. *Rapport d'investissement par pays Tunisie*. High-level conference on water for agriculture and energy in Africa: the challenges of climate change, Sirte, Libyan Arab Jamahiriya, December 15-17, 2008, http://www.sirtewaterandenergy.org/, 18/08/2009.
[TN03]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[TN04]: **Achenbach, H.** 1994. Tunesien – Zur Konkurrenz der Wassernutzung und der wasserabhängigen Wirtschaftszweige. *In* H. Popp & K. Rother, eds. *Die Bewässerungsgebiete im Mittelmeerraum*, map on p. 167. Passau, Germany, Passavia Universitätsverlag.
[TN05]: **Unknown**. Irrigation areas of Tunisia, map available from the AQUASTAT library.
[TN06]: **Framji, K., Garg, B., Luthra, S.** (1983): *Irrigation and Drainage in the World*, Volume III, p. 1366, ICID, New Delhi, India.
[TN07]: **Earth Satellite Corporation**, 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-219 and 071-220. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.
[TN08]: **AGRIDEV**. 2009. *Agriculture-périmètres irrigués*. AGRIDEV Consulting team-Tunisia, http://www.agridev.net/content/view/283/61/, 28/08/2009.

Uganda

Area equipped for irrigation is 9150 ha [UG01]. The figures refer to year 1998. Area equipped for irrigation in full or partial control irrigation [UG02] was 5580 ha, while the extent of equipped lowlands was 3570 ha [UG01].

The location and command area of 15 irrigation projects was derived from the FAO irrigation map for Africa [UG03]. The total area equipped for irrigation in these schemes was 8120 ha. The remaining area was assigned to areas classified as irrigated, rice or sugar cane in the FAO AFRICOVER data base [UG04].

Area actually irrigated was 5900 ha in year 1998 [UG01]. Based on the qualitative information contained in the AQUASTAT country report [UG01] and groundwater use in neighbouring countries (Cameroon, Congo) it was assumed that only 1 percent of the irrigation area has groundwater supply.

References:

[UG01]: **FAO**. 2006. *AQUASTAT country profile Uganda*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/uganda/index.stm, 06/10/2010.
[UG02]: **IPTRID**. 1998. *Irrigation sub-sector review, Uganda*. Draft Report.
[UG03]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[UG04]: **FAO**. 2005. *AFRICOVER, Uganda - Spatially Aggregated Multipurpose Landcover database*. FAO, Rome, Italy, http://www.africover.org, 13/12/2004.

United Republic of Tanzania

According to an inventory of irrigation schemes prepared for the National Irrigation Master Plan (NIMP), area equipped for irrigation was 184 330 ha in year 2002 [TZ01]. In contrast the agricultural census 2003 reported 166 710 ha of area equipped for irrigation in small-scale farms [TZ02] and 27 054 ha in large-scale farms [TZ03], which is summing up to 193 764 ha. Both inventories disagreed significantly in reported irrigated areas, in particular at the district level but also at the region level. Reasons for the disagreement maybe that the census was a sample census considering less than 30 percent of all villages and the use of different definitions for irrigated land (e.g. related to rainwater harvesting). Area equipped for irrigation was therefore computed as the average of the irrigated areas reported by the census reports and the NIMP (189 047 ha in total).

Irrigated area was assigned first to 517 irrigation projects derived from the FAO irrigation map for Africa [TZ04] or digitized from another irrigation map [TZ05]. The remaining irrigated area was assigned to areas classified as cultivated by the FAO AFRICOVER land cover data base ([TZ06], [TZ07]) using the priorities given in Table A3.

It was assumed that area actually irrigated was similar to area equipped for irrigation [TZ08]. Area equipped for irrigation with groundwater was computed based on the number of farms using the water sources river, lake, canal, dam, well, and borehole reported for each district in the census reports ([TZ02], [TZ03]), resulting in an area irrigated with groundwater of 17 465 ha (9.2 percent of total area equipped for irrigation) while the remaining area is irrigated by using surface water sources.

TABLE A3
Priorities used to assign irrigated area to the areas classified as cultivated in the AFRICOVER data base for Tanzania.

Attribute	Priority
Sugar cane	5
Rice	5
Tree or shrub crop	4
Herbaceous crop	4
Tree or shrub crop (60% polygon area)	3
Herbaceous crop (60% polygon area)	3
Tree or shrub crop (40% polygon area)	2
Herbaceous crop (40% polygon area)	2
Tree or shrub crop (15% polygon area)	1
Herbaceous crop (15% polygon area)	1

References:

[TZ01]: **Ministry of Agriculture and Food Security (MAFS) and Japan International Cooperation Agency (JICA)**. 2002. *The Study on the National Irrigation Master Plan in the United Republic of Tanzania*. Prepared by Nippon Koei CO. Ltd. and Nippon Giken Inc.

[TZ02]: **National Bureau of Statistics**. 2007. *National sample census of agriculture 2002 / 2003. Volume V, Regional reports*. National Bureau of Statistics, Ministry of Agriculture and Food Security, Ministry of Water and Livestock Development, Ministry of Cooperatives and Marketing, Presidents Office, Regional Administration and Local Government, Ministry of Finance and Economic Affairs – Zanzibar, Dar es Salaam, Tanzania, http://www.kilimo.go.tz/statistics/statistics.php, 28/08/2009.

[TZ03]: **National Bureau of Statistics**. 2006. *National sample census of agriculture 2002 / 2003. Large Scale Farm Report*. National Bureau of Statistics, Ministry of Agriculture and Food Security, Ministry of Water and Livestock Development, Ministry of Cooperatives and Marketing, Presidents Office, Regional Administration and Local Government, Ministry of Finance and Economic Affairs – Zanzibar, Dar es Salaam, Tanzania, http://www.kilimo.go.tz/statistics/statistics.php, 28/08/2009.

[TZ04]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.

[TZ05]: **Unknown**. *Distribution of irrigation schemes on irrigation development potential map*. Map available in the AQUASTAT library.

[TZ06]: **FAO**. 2005. *AFRICOVER, Tanzania - Spatially Aggregated Multipurpose Landcover database*. FAO, Rome, Italy, http://www.africover.org, 13/12/2004.

[TZ07]: **FAO**. 2005. *AFRICOVER, Tanzania - Thematically Aggregated Multipurpose Landcover database*. FAO, Rome, Italy, http://www.africover.org, 13/12/2004.

[TZ08]: **FAO**. 2005. *AQUASTAT country profile United Republic of Tanzania*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/tanzania/index.stm, 06/10/2010.

Zambia

Area equipped for irrigation is 155 912 ha [ZM01]. The figures refer to year 2002.

The location and command area of 10 irrigation projects was derived from the FAO irrigation map for Africa [ZM02]. The total area equipped for irrigation in these schemes was 15 757 ha. The location of 14 additional schemes was digitized from an irrigation map [ZM03]. For the provinces of Copperbelt, Central Lusaka and Southern center pivot schemes could be digitized from satellite imagery [ZM04]. The satellite imagery was also used to assign the remaining irrigated area to cultivated land in large river valleys or in the surrounding of existing irrigation schemes.

Area actually irrigated was similar to area equipped for irrigation in year 2002 [ZM05]. Area irrigated with groundwater was 6646 ha or 12 percent of the full/partial equipped irrigated area in year 2002 [ZM05], most of it located on dolomite or limestone aquifers in the copperbelt region (Jacob Burke, FAO, pers. communication). Based on this information and a geological map of the Kafue basin [ZM06], 3000 ha AEI irrigated with groundwater were assigned to each of the provinces of Copperbelt and Lusaka and the remaining part to the rest of the country.

References:

[ZM01]: **Ministry of Agriculture and Cooperatives**. 2002. *Strategic Plan for Irrigation Development 2002 - 2006*. Draft strategy paper. 33 pages.
[ZM02]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.
[ZM03]: **Unknown**. Irrigation Projects. Map available in the AQUASTAT library.
[ZM04]: **Earth Satellite Corporation**, 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-686, 071-687, 071-692, 071-693, 071-694, 071-699, 071-700 and 071-701. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.
[ZM05]: **FAO**. 2005. *AQUASTAT country profile Zambia*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/zambia/index.stm, 06/10/2010.
[ZM06]: **Burke, J.** 1994. *Approaches to integrated water resource development and management. The Kafue Basin, Zambia*. Natural Resources Forum 18(3), 181-192.

Zimbabwe

Area equipped for irrigation is 173 513 ha [ZW01]. The figures refer to year 1999. Irrigated area per province adds up to 173 412 ha [ZW02]. The remaining 101 ha were assigned to Bulawayo and Harare, because no statistics for these areas were available.

The location and command area of 33 irrigation projects was derived from the FAO irrigation map for Africa [ZW03]. The total area equipped for irrigation in these schemes was 3830 ha. The remaining irrigated area was assigned to center pivot schemes as digitized from satellite imagery [ZW04] or to cultivated land in the surrounding of center pivot schemes.

Area actually irrigated was 123 866 ha (71.4 percent of area equipped for irrigation) in year 1999 [ZW01]. Most formal irrigation schemes in the country depend on water stored in small- and medium-sized dams [ZW01]. It was estimated that more than 17 000 ha of agricultural land are irrigated commercially using groundwater [ZW05]. It is however not reported whether these statistics refer to the area actually irrigated or to the area equipped for irrigation. Based on this information area equipped for irrigation with groundwater was estimated at 20 000 ha.

References:

[ZW01]: **FAO**. 2005. *AQUASTAT country profile Zimbabwe*, FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/zimbabwe/index.stm, 06/10/2010.
[ZW02]: **Ministry of Lands, Agriculture and Rural Resettlement**. 2002. *Report on the status of irrigation development in Zimbabwe.*

[ZW03]: **FAO**. 1987 (updated in 2005). *Irrigated areas in Africa*. FAO, Rome, Italy.

[ZW04]: **Earth Satellite Corporation**, 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-694, 071-695, 071-701 and 071-702. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

[ZW05]: **Masiyandima, M. and Giordano, M. F.** 2007. *Sub-Saharan Africa: opportunistic exploitation*. In: Giordano, M. and Villholth, K. G., The agricultural groundwater revolution. Opportunities and threads to development. International water Management Institute (IWMI), Colombo, Sri Lanka, 79-99, http://www.iwmi.cgiar.org/Publications/CABI_Publications/index.aspx, 12/08/2009.

AMERICA

The update of the irrigation map to version 5 was the third update for Latin America and the Caribbean and the second update for North America. In addition to the separation of area equipped for irrigation according to the source of water, the following countries have been updated due to new available spatial information: Belize, Brazil, Canada, Chile, Colombia, Dominican Republic, Ecuador, El Salvador, French Guyana, Guadeloupe, Guatemala, Honduras, Jamaica, Martinique, Mexico, Nicaragua, Paraguay, Puerto Rico, Saint Lucia, United States of America, Uruguay and Venezuela. Total area equipped for irrigation in the Global Map of Irrigation for America changed due to this update from 48 384 877 ha in map version 4 to 51 332 312 ha in version 5 (Table A4).

TABLE A4

Area equipped for irrigation (AEI) and area actually irrigated (AAI) in America in the new version 5 of the Global Map of Irrigation Areas compared to area AEI in the previous version 4.

Country	AEI in GMIA4 (ha)	AEI in GMIA5, total (ha)	AEI in GMIA5, groundwater (ha)	AEI in GMIA5, surface water (ha)	AEI in GMIA5, non-conventional sources (ha)	AAI in GMIA5 (ha)
Antigua and Barbuda	130	130	20	111	0	130
Argentina	1,767,784	1,767,784	380,246	1,387,539	0	1,352,376
Bahamas	0	0	0	0	0	0
Barbados	1,000	1,000	900	100	0	1,000
Belize	3,000	3,548	792	2,756	0	3,548
Bolivia (Pluri-national State of)	128,240	128,240	8,955	119,285	0	128,240
Brazil	3,149,217	4,463,691	969,527	3,494,164	0	4,463,691
Canada	785,046	1,218,345	156,379	1,061,966	0	845,737
Chile	1,900,000	1,936,402	58,900	1,877,502	0	1,084,382
Colombia	900,000	900,000	45,000	855,000	0	900,000
Costa Rica	103,084	103,084	17,524	85,560	0	103,084
Cuba	870,319	870,319	392,742	477,577	0	180,900
Dominica	0	0	0	0	0	0
Dominican Republic	269,710	306,442	67,417	239,025	0	296,128
Ecuador	863,370	853,332	105,120	748,213	0	615,429
El Salvador	44,993	52,452	3,086	49,366	0	33,196
French Guyana (France)	2,000	5,931	297	5,634	0	5,895
Grenada	219	219	0	219	0	219
Guadeloupe (France)	2,000	6,635	664	5,972	0	3,583
Guatemala	129,803	142,499	31,011	111,488	0	142,499
Guyana	150,134	150,134	0	150,134	0	150,134
Haiti	91,502	91,502	13,725	77,777	0	65,469
Honduras	73,210	81,631	6,264	75,367	0	61,326
Jamaica	25,214	26,650	23,985	2,665	0	26,650
Martinique (France)	3,000	6,170	309	5,862	0	5,291
Mexico	6,435,800	6,817,240	2,815,434	4,001,805	0	5,310,622
Nicaragua	61,365	94,240	65,968	28,272	0	78,519
Panama	34,626	34,626	1,393	33,233	0	27,886
Paraguay	67,000	67,000	6,700	60,300	0	67,000
Peru	1,729,069	1,729,069	489,950	1,239,119	0	1,503,591
Puerto Rico (USA)	37,079	36,997	24,848	12,149	0	15,776
Saint Kitts and Nevis	18	18	9	9	0	18
Saint Lucia	297	3,321	0	3,321	0	3,321
Saint Vincent and the Grenadines	0	0	0	0	0	0
Suriname	51,180	51,180	0	51,180	0	51,180
Trinidad and Tobago	3,600	3,600	360	3,240	0	3,060

Country	AEI in GMIA4 (ha)	AEI in GMIA5, total (ha)	AEI in GMIA5, groundwater (ha)	AEI in GMIA5, surface water (ha)	AEI in GMIA5, non-conventional sources (ha)	AAI in GMIA5 (ha)
United States of America	27,913,872	28,375,752	18,384,053	9,991,699	0	22,904,924
United States Virgin Islands (USA)	185	185	168	17	0	98
Uruguay	217,593	243,419	19,255	224,164	0	217,593
Venezuela (Bolivarian Republic of)	570,219	759,524	151,905	607,619	0	683,095
AMERICA TOTAL	**48,384,877**	**51,332,312**	**24,242,905**	**27,089,857**	**0**	**41,335,590**

Antigua and Barbuda

For Antigua and Barbuda no information could be found on irrigated areas on sub-national level. The total area equipped for irrigation is about 130 ha. The figure refers to 1997 [AG01].

The irrigated area has been equally distributed to areas, which are classified as cropland according to the USGS Global Land Cover Classification map [AG02].

Area actually irrigated was similar to area equipped for irrigation in year 1997 [AG01]. Surface supplies were reported to be the main source of irrigation water with occasional use of groundwater when municipal demand allows (AG01]). Based on this qualitative information AEI irrigated with groundwater was estimated at 15 percent.

References:

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[AG02]: **USGS**. 2001. Global Land Cover Characterization, map version 2, http://edcdaac.usgs.gov/index.html, 10/08/2006.

Argentina

Area equipped for irrigation in 1997 was reported at 2 328 829 ha, but 778 596 ha were under rehabilitation so that only 1 550 233 ha were actually used [AR01]. According to the agricultural census, the area actually irrigated was 1 065 000 ha in 1970, 1 246 748 ha in 1988, 1 437 275 ha in 1995 [AR02] and 1 355 601 ha in 2002 [AR03]. Sub-national statistics were available by province and district but referred to the area actually irrigated. Area equipped for irrigation by province as shown in Table A5 was therefore estimated by selecting the maximum of the areas actually used for irrigation in the years 1995 and 2002 [AR02], [AR03], [AR04]. Total area equipped for irrigation estimated that way was summing up to 1 767 784 ha. Area equipped for irrigation by district was computed by scaling the area actually irrigated reported for the year 2002 [AR03] so that the sum of area actually irrigated by province was equal to the figures reported in Table A5.

To distribute irrigated area within the districts irrigated area was assigned to irrigated areas digitized from irrigation maps [AR05] and to areas classified as cropland in the GLC2000 land cover map for South America [AR06] located within polygons digitized from province maps showing the irrigation districts [AR07]. If districts were located completely outside the irrigation districts, area equipped for irrigation was assigned to all cells classified as cropland.

Area actually irrigated per district was available from the report of the agricultural census 2002 [AR03]. Area irrigated with groundwater was estimated for each district based on the

total number of farms irrigating by using different sources of water as reported by the agricultural census 2002 [AR03]. Percentage of AEI irrigated with groundwater was computed as 100 * NR_FARMS_GW / (NR_FARMS_GW + NR_FARMS_SW) where NR_FARMS_GW was the number of farms irrigating using groundwater and NR_FARMS_SW was the number of farms irrigating using surface water. The total area irrigated with groundwater computed this way was 323 415 ha or 24 percent of the total irrigated area reported by the census data base. This is close to the estimates reported by the AQUASTAT country profile for year 1999 (26 percent).

TABLE A5
Distribution of irrigated area in Argentina by Province.

Province	Area actually irrigated 2002 derived from [AR03] in ha	Area actually irrigated 1995 derived from [AR02] in ha	Area actually irrigated 1995 derived from [AR04] in ha	Area equipped for irrigation on global map (ha)
Buenos Aires	166,483	101,254	176,500	176,500
Catamarca	61,848	64,304	24,100	64,304
Chaco	7,550	6,000	4,700	7,550
Chubut	18,155	34,449	26,404	34,449
Córdoba	93,835	55,000	55,863	93,835
Corrientes	59,014	68,000	55,334	68,000
Entre Ríos	71,736	109,000	89,250	109,000
Formosa	4,002	11,513	5,200	11,513
Jujuy	91,575	120,000	105,500	120,000
La Pampa	4,715	6,104	6,815	6,815
La Rioja	41,817	5,447	21,247	41,817
Mendoza	267,889	339,600	359,523	359,523
Misiones	170			170
Neuquén	15,798	17,700	10,417	17,700
Río Negro	72,784	120,659	135,171	135,171
Salta	118,898	150,000	140,000	150,000
San Juan	79,516	68,900	68,400	79,516
San Luis	18,575	4,571	9,385	18,575
Santa Cruz	3,841	1,850	5,467	5,467
Santa Fe	37,421	9,000	20,500	37,421
Santiago del Estero	53,954	85,000	142,823	142,823
Tierra del Fuego	0			0
Tucumán	66,025	58,924	87,634	87,634
ARGENTINA TOTAL	**1,355,601**	**1,437,275**	**1,550,233**	**1,767,784**

References:

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[AR06]: **Eva, H.D., de Miranda, E.E., Di Bella, C.M., Gond, V., Huber, O., Sgrenzaroli, M., Jones, S., Coutinho, A., Dorado, A., Guimarães, M., Elvidge, C., Achard, F., Belward, A.S., Bartholomé, S., Baraldi, A., De Grandi, G., Vogt, P., Fritz, S. & Hartley, A.** 2003. *The land cover map for South America in the year 2000*. GLC2000 database, European Commision Joint Research Centre, available at http://www-gem.jrc.it/glc2000, 10/08/2006.

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Barbados

For Barbados no information could be found on irrigated areas on sub-national level. According to the agricultural census in 1989 the total area equipped for irrigation is about 1 000 ha [BB01].

The irrigated area was distributed over potential irrigation areas as indicated on a water resources map [BB02]. The map and the related study are available in the AQUASTAT-library.

Irrigation water use is mainly based on the use of 120 private hand-dug wells while use of dams and streams is very limited [BB01]. Based on this qualitative information amount of irrigation area supplied by groundwater was estimated to be 90 percent.

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[BB01]: **FAO**. 2000. *AQUASTAT country profile of Barbados*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/barbados/index.stm, 06/10/2010.

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Belize

According to the Ministry of Agriculture, area equipped for irrigation was 3548 ha in year 2005 [BZ01].

The irrigated area has been distributed to irrigated rice areas [BZ02] and the remaining irrigated area was equally distributed over area classified as “Agro-productive system” in the Central American Ecosystems Map [BZ03].

Area actually irrigated was assumed to be similar to area equipped for irrigation. Area irrigated with groundwater was 792 ha in year 2005, most of it located in the district Corozal. The remaining area was irrigated by using surface water (rivers) [BZ01].

References:

[BZ01]: **Ballestero, M., Reyes, V., & Astorga, Y.** 2007. *Groundwater in Central America: its importance, development and use, with particular reference to its role in irrigated agriculture*. In: Giordano, M. & Villholth, K. G., The agricultural groundwater revolution. Opportunities and threads to development. International water Management Institute (IWMI), Colombo, Sri Lanka, 100-128, http://www.iwmi.cgiar.org/Publications/CABI_Publications/index.aspx, 12/08/2009.

[BZ02]: **CIAT**. 1997. *Distribution of rice in Latin America (1000 ha irrigated rice)*. http://www.grida.no/prog/global/cgiar/, 07/04/2001.

[BZ03]: **World Bank and CCAD**. 2001. *Ecosystems of Central America (ArcView regional map files at 1:250,000)*. World Bank, Comisión Centroamericana de Ambiente y Desarrollo (CCAD), World Institute for Conservation and Environment (WICE), and the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Washington, D.C., http://www.birdlist.org/cam/themes/map_download_page.htm, 15/11/2010.

Bolivia (Plurinational State of)

In 1999 the total area equipped for irrigation added up to 128 240 ha [BO01]. More then 50 percent of the irrigated area is concentrated in the provinces Cochabamba and La Paz in the centre of the country.

The irrigated area has been distributed over departments using an inventory of irrigation projects in 1996 [BO04] and several other maps as available in the AQUASTAT-library [BO02], [BO03], [BO05].

Area actually irrigated was assumed to be similar to area equipped for irrigation, while area equipped for irrigation with groundwater was 8955 ha (7 percent of total AEI) in year 1999 [BO01].

References:

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[BO02]: **UNEP**. 1996. *Diagnostico Ambiental del Sistema Titicaca-Desaguadero-Poopo-Salar de Coipasa Bolivia-Peru*.
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[BO04]: **Ministerio de Desarrollo sostenible y medio Ambiente**. 1996. *Situacion de los Recursos Hidricos en Bolivia*.
[BO05]: **UNEP**. 1996. *Diagnostico Ambiental del Sistema Titicaca-Desaguadero-Poopo-Salar de Coipasa Bolivia-Peru*.

Brazil

Area equipped for irrigation was derived from the agricultural census report 2006 and added up to 4 463 691 ha [BR01]. The census report provided data for 5566 municipalities. However, data for 474 municipalities were suppressed in the census report to preserve confidentiality which required an aggregation of the “nodata” areas into larger units (248 micro-regions and 3 meso-regions). Area equipped for irrigation in these aggregated no-data regions was then computed as difference between total area equipped for irrigation reported for the whole micro- or meso-region and the sum of equipped for irrigation in municipalities for which data were reported. This finally resulted in 5341 subnational units for Brazil.

Irrigated area was first assigned to irrigation schemes as digitized from several irrigation maps ([BR02] – [BR11]). The remaining irrigated area was assigned to cells classified on the GLC2000 land cover map for South America [BR12] as agriculture (intensive) or mosaics of agriculture and other land uses.

Sub-national irrigation statistics available for Brazil do not distinguish the source of water supply for irrigation [BR13]. To estimate the percentage of irrigation areas supplied by groundwater we used therefore an inventory of wells used for irrigation [BR14] and reports showing the extent and describing the characteristics of the major aquifers of Brazil (BR15], [BR16]). The extent of the aquifers was digitized from the maps contained in these reports. The aquifers were classified into 5 groups depending on the reported mean capacity of wells fed by the aquifers (Table A6). For each county the sum of AEI covering these aquifers was computed and then, considering the weights shown in Table A6, the potential sum of AEI irrigated with groundwater, respectively. Next, for each county a sum of potential groundwater irrigation area defined by existing wells was computed. 6841 registered wells that were reported to be used for irrigation were considered and to each well an irrigation area depending on the aquifer in which the well was located was assigned (Table A6). The total potential groundwater irrigation area computed based on the coverage by major aquifers was 934 051 ha and the area computed based on the number and location of tube wells was 83 956 ha. Finally, we computed for each county the sum of both potential groundwater irrigation areas and limited this sum to be not larger than the total AEI reported in the agricultural census 2006 [BR01]. Total AEI from groundwater computed that way was 969 527 ha (22

percent of total AEI) and thus close to the area reported by AQUASTAT for year 1998 (19 percent of total AEI).

TABLE A6
Parameters used to estimate area irrigated with groundwater per municipal unit in Brazil.

Aquifer productivity class	Mean capacity of wells (m^3 h^{-1})	Weights assigned to compute irrigated area from groundwater (-)	Irrigated area assigned to each registered tube well (ha)
Very high	30	1.00	30
High	15	0.50	15
Medium	10	0.25	10
Low	5	0.10	5
Very low	2	0.00	2

References:

[BR01]: **IBGE**. 2006. Censo Agropecuario 2006. Online publication, http://www.ibge.gov.br/home/download/estatistica.shtm, 24/01/2012.

[BR02]: **CODEVASF**. 1999. Mapa da irrigacao publica - perimetros irrigados do Vale do Rio Sao Francisco. Maps available online at: http://www.codevasf.gov.br, 12/10/1999.

[BR03]: **Ministerio da Agricultura**. 1979. *Aptidao agricola das terras do Ceara*.

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[BR05]: **Ministerio da Agricultura**. 1979. *Aptidao agricola das terras do Rio Grande do Norte*.

[BR06]: **Ministerio da Agricultura**. 1979. *Aptidao agricola das terras do Paraiba*.

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[BR12]: **Eva, H.D., de Miranda, E.E., Di Bella, C.M., Gond, V., Huber, O., Sgrenzaroli, M., Jones, S., Coutinho, A., Dorado, A., Guimarães, M., Elvidge, C., Achard, F., Belward, A.S., Bartholomé, S., Baraldi, A., De Grandi, G., Vogt, P., Fritz, S. & Hartley, A.** 2003. *The land cover map for South America in the year 2000*. GLC2000 database, European Commision Joint Research Centre, available at http://www-gem.jrc.it/glc2000, 10/08/2006.

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Canada

Data on area equipped for irrigation were not available for entire Canada. In contrast, data on area actually irrigated were collected by the agricultural census 2006 for provinces, census agricultural regions, census divisions and census consolidated subdivisions ([CA01], [CA02]). Area equipped for irrigation was estimated by scaling area actually irrigated reported by the agricultural census so that the sum of irrigated area was similar to irrigated areas in inventories available at the province level for Alberta [CA03], British Columbia [CA04] and Saskatchewan [CA05]. Scaling coefficients were 1.201 for Alberta, 1.63 for British Columbia, 1.995 for Saskatchewan and were set to 2.0 for the other provinces similar to those

found for Saskatchewan. Total area equipped for irrigation computed that way was 1 218 345 ha while area actually irrigated according to the census 2006 was 845 737 ha.

The boundaries of the irrigation districts and the location of private irrigators were digitized from maps available for the provinces Alberta [CA03] and Saskatchewan [CA05]. All the other irrigated area was assigned to cells classified as cropland in the GLC2000 land cover classification for North America [CA06]. In some census divisions the irrigated area as reported by the census was larger than the area classified as cropland by the GLC2000. Then also cells classified as cropland mosaics were assumed to be irrigated.

Sources of irrigation water were available for the provinces of Alberta (per basin), British Columbia (per water region) and Ontario ([CA07], [CA04], [CA08]). More than 80 percent of the total irrigated area of the country is located in these three provinces. For the other provinces area irrigated from ground- and surface water was estimated based on statistics and information provided by similar reports ([CA09], [CA10], [CA11]). Total area equipped for irrigation with groundwater was 156 379 ha (13 percent of the total area equipped for irrigation) and mainly located in the provinces of Ontario, Manitoba and Quebec.

References:

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Chile

Area equipped for irrigation for each of the 13 regions was derived from the AQUASTAT country report ([CL01]). The data refer to year 1996. AEI was downscaled to the municipality level based on the land use statistics reported by the agricultural census 2007 ([CL02]). AEI was computed as the sum of AAI reported for each municipality (1 084 382 ha in total) and a second area calculated by scaling the difference between AAI and total cultivated land ([CL02]) for each district so that AEI per region was similar to AEI per region reported in the AQUASTAT country report ([CL01]). In regions where AAI reported for year 2007 was larger than AEI reported by AQUASTAT for year 1996, AEI was set to AAI reported for year 2007. This resulted in a total AEI of 1 936 402 ha.

The boundaries of the most important irrigation districts and the location of large public irrigation projects were digitized from several maps available in the AQUASTAT-library ([CL03], [CL04], [CL05]). The remaining area equipped for irrigation was distributed equally over the most suitable grid cells using the USGS land cover classification map [CL06].

Area irrigated from groundwater was 58 900 ha (3.2 percent of total AEI) in year 1999 ([CL01]). An inventory of registered irrigation schemes indicating the source of irrigation water was available ([CL07]) but covered only 1 010 113 ha and listed only 3800 ha of irrigation areas supplied by groundwater. Therefore an inventory of registered wells ([CL08]) showing the location of 4980 wells used for irrigation was used to define irrigated area from groundwater for each district by assigning a constant irrigated area to each well so that the total irrigated area from groundwater was equal to the 58 900 ha reported by FAO AQUASTAT. Area actually irrigated was derived from statistics collected by the agricultural census 2007 ([CL02]).

References:

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Colombia

The area equipped for irrigation in Colombia is about 900 000 ha [CO01]. AEI per province was computed based on the maximum of AEI reported per province in two studies in the AQUASTAT-library referring to years 1992 and 1997. The irrigated area in these studies adds up to 870 000 ha and was scaled to meet the AQUASTAT country value for 1998.

Areas of high irrigation density can be found in an interior valley which covers the provinces Valle del Cauca and Tolima and in the northwestern provinces. Location and extent of 528 public irrigation districts with a total AEI of 361 218 ha was extracted from a digital data set ([CO02]). Additionally, irrigation areas and the location of irrigation projects were digitized from several maps ([CO03], [CO04], [CO05]). The remaining irrigated area was assigned to

cells classified on the GLC2000 land cover map for South America [CO06] as agriculture (intensive).

Very little information has been available regarding the source of water used for irrigation. The available data indicate that surface water from rivers, reservoirs and lakes is by far the major source of irrigation water. In the inventory of public irrigation districts ([CO02]) only surface water sources (streams, lakes, reservoirs, and lagoons) were indicated. An inventory of wells per hydro-geological zone shows that only in the major irrigation areas along the Magdalena and Cauca Rivers and in the surrounding of Bogota there is a significant number of wells used for irrigation ([CO07]). Based on this indicative information and also considering the situation in neighbouring countries, percentage of AEI irrigated with groundwater was estimated at 5 percent.

References:

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Costa Rica

Areas equipped for irrigation in Costa Rica add up to 103 084 ha [CR01]. The figures per region originate from the AQUASTAT-library and refer to 1997 but are in good agreement to more recent estimates reporting a total area equipped for irrigation of 101 500 ha [CR02].

The distribution of irrigated areas within the provinces is based on a World Bank study on private irrigation from the year 1993 [CR03]. 54 irrigation projects were identified and 22 600 ha irrigated area was assigned to these projects. The Arenal Tempisque irrigation scheme (28 000 ha), which is the largest irrigation project in the country and mainly used to produce rice and sugar cane, was digitized from satellite imagery by using the maps provided by SENARA [CR04]. The remaining area equipped for irrigation was equally distributed over area classified as “Agro-productive system” in the Central American Ecosystems Map [CR05].

Area actually irrigated was assumed to be similar to area equipped for irrigation [CR01]. Area equipped for irrigation with groundwater was 17 524 ha (17 percent of total AEI) [CR01]. Data on concessions for irrigation water withdrawals granted by the Water Department of the Environmental Ministry indicate a lower contribution of groundwater irrigation with only 2 percent of the concessions for groundwater. Illegal extraction of water might be one reason for the differences to the FAO data [CR06].

References:

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Cuba

The total area equipped for irrigation in Cuba equals 870 319 ha [CU01]. The figures per province originate from the AQUASTAT-library and refer to 1996 and 1997.

Maps showing irrigated areas were not available for Cuba. The area under irrigated rice cultivation was taken from a continental study on the distribution of rice in Latin America [CU02]. The rest of the irrigated area was distributed within the provinces on the basis of land use maps [CU03].

AAI declined from 822 225 ha in 1997 [CU01] to 180 900 ha in year 2007 [CU04]. In year 1997 about half of the AEI was irrigated with groundwater [CU01]. It was assumed that the percentage of AEI irrigated with groundwater in year 2007 was similar to the percentage reported for year 1997.

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Dominica

A few farmers may use irrigation to grow vegetables on a small scale in Dominica. However, no information is available on the extent of these systems [DM01]. Therefore it was assumed that irrigation is not used in Dominica.

References:

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Dominican Republic

The total area equipped for irrigation in the Dominican Republic equals 4 873 434 tarea (306 442 ha) [DO01]. Area equipped for irrigation per province (in total 253 997 ha) was available from the AQUASTAT-library. The figures referred to year 1994 and were scaled to meet the total AEI reported for year 2010.

Most of the irrigated areas are located in the western part of the country ([DO02], [DO03]). Location and extent of the major irrigation schemes was digitized from maps in [DO03] and combined with areas classified as cropland in the MODIS land cover classification for year 2005 [DO04]. Irrigated area was assigned with the highest priority to areas mapped as irrigated in [DO03] and as cropland in [DO04]. The remaining irrigated area was assigned to pixels that were either irrigated on the maps in [DO03] or cropland in the MODIS land cover data set [DO04].

Total harvested area of irrigated crops was 296 128 ha in season 2003/2004, with rice as the major irrigated crop harvested on 160 102 ha (54 percent) [DO05]. About 22 percent of the AEI was irrigated with groundwater in year 1999 [DO06]. It was assumed that this percentage is also valid for current day conditions.

References:

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Ecuador

According to results of the agricultural census 2000 [EC01], area equipped for irrigation in Ecuador is 853 332 ha. This is in good agreement with data presented in the AQUSTAT country profile [EC02], reporting an AEI of 863 370 ha in year 1997. Most of the irrigated area is concentrated in the western part of the country.

The irrigated area within the 221 cantons was distributed based on a maps showing the outlines of 70 irrigated areas in 1993 [EC03] and 1997 [EC04]. Additional area for irrigated rice cultivation was taken from a continental study on the distribution of rice in Latin America [EC05]. The remaining irrigated land was assigned areas classified as cropland in the GLC2000 land cover data set [EC06].

Area equipped for irrigation with groundwater was 105 120 ha in year 2000 and derived for each of the cantons from the agricultural census data base [EC01]. Since the agricultural census database did not distinguish between equipped and actually irrigated areas it was assumed that the fraction AAI /AEI was similar to the fraction reported in the AQUASTAT country questionnaire per province for year 1997. This resulted in total area actually irrigated of 615 429 ha.

References:

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El Salvador

Area equipped for irrigation increased from 44 993 ha in year 1997 [SV01] to 45 027 ha in year 2005 [SV02], but according to the report of the agricultural census 2007/2008 area actually used for irrigation was only 47 504 Manzanas (33 196 ha) [SV03]. The maximum of AEI reported in [SV02] and AAI reported in [SV03] was assigned the each department as AEI (52 452 ha in total) while AAI was set to the acreage reported by the agricultural census [SV03].

The distribution of irrigated areas within the country is mainly based on a World Bank study on private irrigation from the year 1993 [SV04]. Additional information comes from a government register of irrigation water user associations [SV05]. The remaining area equipped for irrigation was equally distributed over area classified as “Agro-productive system” in the Central American Ecosystems Map [SV06].

Area equipped for irrigation with groundwater was 3086.3 ha in year 2005. These figures are based on statistics provided by the Department of Irrigation and Drainage, Ministry of Agriculture and Livestock reported in a report on groundwater use in Central America [SV07].

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French Guyana (France)

Area equipped for irrigation was 5931 ha in year 2007, while area actually irrigated was 5895 ha in the same year [GF01]. No information could be found on irrigated areas on a higher sub-national level.

The irrigated area within French Guyana was distributed based on a map of the major cropping areas in 1979 [GF02].

According to the farm structure survey undertaken in year 2003 the area irrigated from surface water was 4110 ha, the area irrigated from groundwater was 330 ha and the area irrigated from mixed sources or from the public network was 19 050 ha for the entire area of the French over-sea departments [GF03]. The only department for which the related water use statistics [GF04] explicitly reported a use of groundwater in agriculture was Réunion (5.6 km^3 yr^{-1} groundwater use as compared to 59.3 km^3 yr^{-1} surface water use in year 2005). The main extractions of groundwater were reported in general for the domestic sector. The fraction of municipal water supply from groundwater was about 47 percent for Réunion, 13 percent for Guadeloupe and 7 percent for Martinique [GF04]. Based on these statistics and considering the importance of public networks in irrigation water supply, area irrigated with groundwater was estimated at 5 percent for French Guyana.

References:

[GF01]: **Ministère de l'agriculture, de l'alimentation, de la pêche, de la ruralité et de l'aménagement du territoire**. 2010. *AGRESTE, Données en ligne, Structure des exploitations*. http://agreste.maapar.lbn.fr/, 06/10/2010.

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Grenada

In the whole of Grenada 219 ha are equipped for irrigation. The figure refers to 1997 [GD01]. For Grenada no information could be found on irrigated areas on sub-national level.

The irrigated area within the country was distributed to cropping areas as indicated on the USGS land cover characterization map [GD02].

All irrigation in Grenada is assumed to be based on surface water, 1 percent from river diversion, 6.5 percent from reservoirs and the remainder from direct pumping from rivers

[GD01]. It was assumed that area actually irrigated is similar to area equipped for irrigation reported for year 1997 [GD01].

References:

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[GD02]: **USGS**. 2001. *Global Land Cover Characterization*, map version 2, http://edcdaac.usgs.gov/index.html, 06/10/2010.

Guadeloupe (France)

Area equipped for irrigation was 6635 ha in year 2007, while area actually irrigated was 3583 ha in the same year [GP01]. No information could be found on irrigated areas on a higher sub-national level.

The irrigated area within the country was distributed based on a cropping area map of sugar cane, coffee, fruit trees, vineyards, bushes and orchard lands [GP02].

According to the farm structure survey undertaken in year 2003 the area irrigated from surface water was 4110 ha, the area irrigated from groundwater was 330 ha and the area irrigated from mixed sources or from the public network was 19 050 ha for the entire area of the French over-sea departments [GP03]. The only department for which the related water use statistics [GP04] explicitly reported a use of groundwater in agriculture was Réunion (5.6 km^3 yr^{-1} groundwater use as compared to 59.3 km^3 yr^{-1} surface water use in year 2005). The main extractions of groundwater were reported in general for the domestic sector. The fraction of municipal water supply from groundwater was about 47 percent for Réunion, 13 percent for Guadeloupe and 7 percent for Martinique [GP04]. Based on these statistics and considering the importance of public networks in irrigation water supply, area irrigated with groundwater was estimated at 10 percent for Guadeloupe.

References:

[GP01]: **Ministère de l'agriculture, de l'alimentation, de la pêche, de la ruralité et de l'aménagement du territoire**. 2010. *AGRESTE, Données en ligne, Structure des exploitations*. http://agreste.maapar.lbn.fr/, 06/10/2010.
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Guatemala

The total area equipped for irrigation in Guatemala increased from 129 803 ha [GT01] in year 1997 to 142 499 ha in year 2004 [GT02]. To assign area equipped for irrigation to departments, data were used from the Support Program for the Reconversion of Food and Agriculture Production (PARPA) as cited in [GT02].

The distribution of irrigated areas within the departments is mainly based on a World Bank study on private irrigation from the year 1993 [GT03] and on a national map showing the location of irrigation projects in 1967 [GT04]. Apart from this two other national sources were used with information on the location but without the extent of the areas under irrigation [GT05], [GT06]. The remaining area equipped for irrigation was equally distributed over area classified as "Agro-productive system" in the Central American Ecosystems Map [GT07].

Area equipped for irrigation with groundwater was 31 011 ha in year 2004 [GT02]. It was assumed that all area equipped for irrigation is actually being used [GT01].

References:

[GT01]: **FAO**. 2000. *AQUASTAT country profile of Guatemala*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/guatemala/indexesp.stm, 06/10/2010.

[GT02]: **Ballestero, M., Reyes, V., & Astorga, Y.** 2007. *Groundwater in Central America: its importance, development and use, with particular reference to its role in irrigated agriculture*. In: Giordano, M. & Villholth, K. G., The agricultural groundwater revolution. Opportunities and threads to development. International water Management Institute (IWMI), Colombo, Sri Lanka, 100-128, http://www.iwmi.cgiar.org/Publications/CABI_Publications/index.aspx, 12/08/2009.

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Guyana

The total area equipped for irrigation in Guyana equals 150 134 ha [GY01]. The figures per region originate from the AQUASTAT-library and refer to 1991. The irrigated area is concentrated in the northern provinces of the country along the coast line.

The irrigated area within the regions was distributed based on an irrigation map published as part of a World Bank study in 1992 [GY02].

Irrigation water supply in Guyana is from reservoirs (so called conservancies) using a network of main and secondary canals or from rivers through pumping. In contrast, domestic water supply in the coastal area is mainly depending on groundwater [GY01]. Based on this information it was assumed that all irrigation is from surface water.

References:

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[GY02]: **World Bank**. 1992. *Guyana Agricultural Sector Review*. Report No. 10410-GUA, World Bank, Washington, USA.

Haiti

The total area equipped for irrigation in Haiti equals 91 502 ha while area actually irrigated is 65 469 ha [HT01]. The figures per department originate from the AQUASTAT-library and refer to 1991.

The irrigated area within the departments was distributed based on a map showing the outlines of 84 irrigated areas in 1972 [HT02].

Very little information has been available related to sources of irrigation water in Haiti. The largest irrigation scheme in the country (35 411 ha area equipped for irrigation, 39 percent of total irrigation area in Haiti) is located in the Artibonite valley and uses water from the Artibonite River [HT01]. Also, it was reported, that total groundwater resources of the country account for 17 percent of the total water resources. Based on this information percentage of irrigated area from groundwater sources was estimated at 15 percent.

References:

[HT01]: **FAO**. 2000. *AQUASTAT country profile of Haiti*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/haiti/index.stm, 06/10/2010.

[HT02]: **Organisation des Etats Americans**. 1972. *Mission d'Assistance Technique Integree, Cartes, map: Donnees Hydrologiques et Utilisation des Eaux*.

Honduras

The total area equipped for irrigation in Honduras increased from 73 210 ha [HN01] in year 1997 to 81 631 ha in year 2005 [HN02]. To assign area equipped for irrigation to departments, data were used from the General Department of Irrigation and Drainage as cited in [HN02].

The irrigated area within the provinces was distributed using several irrigation maps which were published between 1970 and 1992 [HN03], [HN04], [HN05], [HN06]. The remaining area equipped for irrigation was equally distributed over area classified as "Agro-productive system" in the Central American Ecosystems Map [HN07].

Area equipped for irrigation with groundwater was 6264 ha in year 2005 [HN02]. It was assumed that 75 percent of the area equipped for irrigation is actually being used [HN01].

References:

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[HN06]: **World Bank**. 1993. *Central America - Subsector Study on private Irrigation*, Vol. 1, p. 193.

[HN07]: **World Bank and CCAD**. 2001. *Ecosystems of Central America (ArcView regional map files at 1:250,000)*. World Bank, Comisión Centroamericana de Ambiente y Desarrollo (CCAD), World Institute for Conservation and Environment (WICE), and the Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Washington, D.C., http://www.birdlist.org/cam/themes/map_download_page.htm, 15/11/2010.

Jamaica

The total area equipped for irrigation in Jamaica was 26 650 ha in year 1997 [JM01] and more recent reports indicate the extent of irrigation schemes has not changed much until year 2009 [JM02], [JM03]. The figures per parish originate from the National Irrigation Development

Plan [JM01] and refer to 1997. Most of the irrigated area is concentrated in the southern parish areas.

The irrigated area within the parish areas was distributed using a map showing the outlines of 15 major irrigation schemes in 1997 [JM01]. The remaining irrigated area (mainly located in the northern parishes) was distributed to cropland and plantations extracted from a land use map [JM04].

It was estimated that 92 percent of the total water withdrawal in year 1993 was from groundwater and that agriculture accounted for 75 percent of the withdrawals [JM05]. This gives evidence for the importance of groundwater use in irrigation. Based on this information percentage of irrigated areas supplied by groundwater was estimated at 90 percent.

References:

[JM01]: **Harza Engineering Company International L.P.** 1998. *Preparation of a National Irrigation Development Plan and preparation of an Irrigation Investment Project. Executive summary.* Report available in the AQUASTAT-library.

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Martinique (France)

Area equipped for irrigation was 6170 ha in year 2007, while area actually irrigated was 5291 ha in the same year [MQ01]. No information could be found on irrigated areas on a higher sub-national level.

The irrigated area within the country was distributed based on a map showing irrigable areas in 1977 [MQ02].

According to the farm structure survey undertaken in year 2003 the area irrigated from surface water was 4110 ha, the area irrigated from groundwater was 330 ha and the area irrigated from mixed sources or from the public network was 19 050 ha for the entire area of the French over-sea departments [MQ03]. The only department for which the related water use statistics [MQ04] explicitly reported a use of groundwater in agriculture was Réunion (5.6 km^3 yr^{-1} groundwater use as compared to 59.3 km^3 yr^{-1} surface water use in year 2005). The main extractions of groundwater were reported in general for the domestic sector. The fraction of municipal water supply from groundwater was about 47 percent for Réunion, 13 percent for Guadeloupe and 7 percent for Martinique [MQ04]. Based on these statistics and considering the importance of public networks in irrigation water supply, area irrigated with groundwater was estimated at 5 percent for Martinique.

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Mexico

Area equipped for irrigation was reported at 6 452 934 ha for the year 2008, of which 3 496 902 ha for was located in 88 large-scale irrigation districts and 2 956 032 ha in 39 492 irrigation units [MX01]. According to the agricultural census 2007, irrigated area was 5 310 622 ha [MX02]. Likely, these statistics refer to the area that was actually used for irrigation in this year. However, area actually irrigated reported by the census [MX02] was larger than the AEI reported in [MX01] for the provinces of Baja California, Baja California Sur, Chihuahua, Coahuila de Zaragoza, Durango, Nayarit, Querétaro Arteaga, and Sonora (Table A7). It should also be mentioned that statistics derived from remote sensing products reported a much larger extent of irrigated agriculture. Digital land use and vegetation maps developed by INEGI detected about 6 992 027 ha irrigated land in the reference period 1979-1991 [MX03], 8 507 266 ha irrigated land in the reference period 1993-1999 [MX04] and 9 245 612 ha in the reference period 2002-2005 [MX05]. In most of the northern provinces irrigated area as detected in the remote sensing surveys would be larger than the irrigation potential reported by province [MX06]. It maybe that at least the last two remote sensing based land use maps ([MX04], [MX05]) overestimated the extent of irrigated agriculture. On the other hand census based statistics mainly account for the registered part of irrigated land located in irrigation districts and irrigation units and may therefore miss unregistered informal irrigation. Thus it can be assumed that the physically existing total amount of irrigated land is somewhere between the census-based and remote sensing based estimates. Therefore, the data from the three sources were combined to compile this version of the global irrigation map. First, AEI per province was estimated as the maximum of AEI reported by CNA [MX01] and AAI reported by the agricultural census data base [MX02]. Then AEI per municipality AEI_{mun} (ha) was computed as:

$$AEI_{mun} = AAI\_CENS_{mun} + f_p\left(IRR\_LULC_{mun} - AAI\_CENS_{mun}\right) \quad (1)$$

where AAI_CENS_{mun} was the AAI reported for the municipality by the agricultural census [MX02], IRR_LULC_{mun} the sum of irrigated area derived from the INEGI land cover classification [MX05] and f_p a scaling coefficient that was constant for municipalities belonging to the same province. The coefficient f_p was selected so that the sum of the AEI of the municipalities equals the AEI computed before at the province level. This procedure resulted in a total AEI of 6 817 239 ha while AAI was set to the statistics extracted from the agricultural census 2007 [MX02].

The digital land use map for the reference period 2002-2005 [MX05] was used to distribute area equipped for irrigation within the municipalities. First the area equipped for irrigation reported for the single irrigation districts was assigned to areas classified on the land use map as "Agricultura de Riego". If AEI per municipality was larger than the area classified in the land cover map as "Agricultura de riego", the remaining difference was assigned to areas classified as "Agricultura de temporal" and if the sum of irrigated and rainfed cropland was still too small to areas classified in the land cover map as "Pastizal cultivado".

Ground- and surface water use for irrigation by county was extracted from a database provided by CONAGUA [MX07]. The data are consistent to statistics published per province in the annual water report [MX01]. It was assumed that the percentage of AEI irrigated with groundwater was similar to the percentage of water use for irrigation that was from groundwater. In 1102 municipalities with an AEI of 222 649 ha (3 percent of total AEI) agricultural water use was 0 while AEI was larger than 0. In this case the fraction of AEI irrigated with groundwater was set to the average computed at the province level. Total AEI irrigated with groundwater computed that way was 2 815 434 ha (41 percent) while total AEI irrigated with surface water was 4 001 805 ha (59 percent).

TABLE A7
Distribution of irrigated area in Mexico by Province.

Province	Area actually irri-gated 2007 derived from [MX02] in ha	Area equipped for irrigation derived from [MX01] in ha			Area classified as irrigated derived from [MX05] in ha	Area equipped for irrigation in GMIA version 5 in ha
		total	Irrigation districts 2007	Irrigation units 1998		
Aguascalientes	50,543	66,144	11,938	54,206	123,014	66,144
Baja California	261,295	247,174	184,980	62,194	340,821	261,295
Baja California Sur	94,233	62,897	38,101	24,796	182,034	94,233
Campeche	15,832	18,951	0	18,951	65,648	18,951
Chiapas	45,820	92,479	36,399	56,080	116,513	92,479
Chihuahua	479,375	355,362	170,275	185,087	826,660	479,375
Coahuila de Zaragoza	304,578	232,881	83,568	149,313	442,291	304,578
Colima	67,228	101,928	37,773	64,155	105,050	101,928
Distrito Federal	1,142	2,035	0	2,035	3,872	2,035
Durango	185,597	185,023	78,968	106,055	351,539	185,597
Guanajuato	341,955	415,201	123,595	291,606	627,858	415,201
Guerrero	93,652	102,077	62,791	39,286	90,311	102,077
Hidalgo	97,791	167,279	105,165	62,114	164,924	167,279
Jalisco	191,967	257,204	95,571	161,633	425,416	257,204
México	107,642	208,845	47,915	160,930	232,161	208,845
Michoacán de Ocampo	306,512	472,958	248,139	224,819	593,411	472,958
Morelos	41,922	57,684	33,654	24,030	80,924	57,684
Nayarit	110,895	102,670	47,253	55,417	228,629	110,895
Nuevo León	128,264	172,621	29,609	143,012	301,499	172,621
Oaxaca	73,240	101,739	49,104	52,635	159,229	101,739
Puebla	118,968	172,222	49,932	122,290	210,574	172,222
Querétaro Arteaga	68,260	50,020	11,048	38,972	86,810	68,260
Quintana Roo	4,591	38,128	27,182	10,946	39,087	38,128
San Luis Potosí	102,127	146,195	44,889	101,306	211,076	146,195
Sinaloa	618,813	797,231	752,218	45,013	1,056,448	797,231
Sonora	748,795	652,696	524,669	128,027	909,790	748,795
Tabasco	5,519	15,127	0	15,127	21,799	15,127
Tamaulipas	301,387	643,961	469,530	174,431	738,948	643,961
Tlaxcala	10,738	33,957	4,247	29,710	26,195	33,957
Veracruz de Ignacio de la Llave	88,377	197,013	100,640	96,373	181,945	197,013
Yucatán	45,092	45,421	9,689	35,732	42,126	45,421
Zacatecas	198,470	237,811	18,060	219,751	311,757	237,811
MEXICO TOTAL	**5,310,622**	**6,452,934**	**3,496,902**	**2,956,032**	**9,298,355**	**6,817,239**

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Nicaragua

Total area equipped for irrigation in Nicaragua equals 133 673 Manzanas or 94 240 ha [NI01]. The figures per province originate from the agricultural census in refer to year 2001. Most of the irrigation schemes are located in the western part of the country.

The irrigated area within the provinces was distributed based on a World Bank study on private irrigation from the year 1993 [NI02] and based on a CIAT map with irrigated rice [NI03]. The remaining area equipped for irrigation was equally distributed over area classified as “Agro-productive system” in the Central American Ecosystems Map [NI04].

No statistics on AAI or on the source of water for irrigation were available from the report of the agricultural census 2001. Therefore AAI was computed using the ratio between AAI and AEI reported for year 1998 [NI05]. The percentage of AEI irrigated using groundwater was derived from the same source. These statistics referred to year 1997.

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Panama

The total area equipped for irrigation in Panama equals 34 626 ha while area actually irrigated was 27 886 ha [PA01]. The figures per province originate from the AQUASTAT-library and refer to 1997.

The irrigated area within the provinces was distributed based on a map showing the location of 22 irrigation projects in 1997 [PA02]. The remaining area equipped for irrigation was equally distributed over area classified as "Agro-productive system" in the Central American Ecosystems Map [PA03].

Area equipped for irrigation with groundwater was 1393 ha in year 2005 and located in the provinces of Herrera and Los Santos [PA04].

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Paraguay

For Paraguay no information could be found on the area equipped for irrigation on the sub-national level. According to the AQUASTAT country survey there are about 67 000 ha equipped for irrigation in the entire country [PY01]. The figure refers to 1998. AEI equipped for irrigation per department was estimated by selecting for each department the maximum of sowing areas of irrigated rice reported for the period 2004/05 – 2008/09 [PY02]. These maximum rice growing areas (in total 74 475 ha) were then scaled so that the total AEI was equal to the area of 67 000 ha reported in the AQUASTAT country survey [PY01].

The irrigated area within the country was distributed based on an FAO study on irrigation development from 1973 [PY03] and on a CIAT map with irrigated rice [PY04]. The remaining irrigated land was assigned areas classified as cropland in the GLC2000 land cover data set [PY05].

Water extracted from small streams and rivers is the major source of irrigation water in Paraguay ([PY01], [PY06]) while artesian wells are used at some places. Based on this indicative information percentage of irrigated area from groundwater sources was estimated at 10 percent.

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Peru

Area equipped for irrigation was reported at 1 729 065 ha [PE01]. The figures originate from the last agricultural census and refer to year 1994. Census statistics down to the district level were used for the departments of Arequipa, Ica, Lambayeque, Loreto, Madre de Dios, Moquegua, Tacna and Ucayali while for the rest of the country statistics at province level were used. The total area equipped for irrigation in the 461 statistical units considered in Peru was summing up to 1 729 069 ha. The small difference of 4 ha to the figures reported at the national scale obviously originated from rounding errors and was thus neglected.

Irrigated area was assigned to 19 projects indicated of an irrigation map of the region around Lake Titicaca [PE02]. Additionally cultivated areas along the arid coastal zone were digitized from satellite imagery [PE03] and area equipped for irrigation was assigned to these polygons. The remaining irrigated area was assigned to cells classified on the GLC2000 land cover map for South America [PE04] as agriculture (intensive) or mosaics of agriculture and other land uses.

Irrigated area from wells, rivers, lakes, springs, reservoirs and combinations of these water sources were derived for each of the 193 provinces from the agricultural census database [PE01]. Irrigated area from groundwater was computed as the sum of irrigated area from wells, springs and half of the irrigated area of locations irrigated from both, wells and rivers. Total AEI irrigated with groundwater computed this way was 489 948 ha while AEI irrigated with surface water was 1 239 118 ha. AAI was computed based on the ratio between AAI and AEI available at the department level for year 1992 [PE05], resulting in a total AAI of 1 503 591 ha.

References:

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Puerto Rico (United States of America)

Area equipped for irrigation was estimated as the maximum of the area actually irrigated reported per municipality by the agricultural censuses 2007 [US01] and 2002 [US02] and by the water use censuses 2005 [US03] and 2000 [US04]. Total area equipped for irrigation computed that way was 91 421 acres (36 997 ha).

Irrigated area in Puerto Rico was distributed to areas classified as agriculture/hay/pasture on a recent land cover map published in [US05]. However, in some sub-national units of Puerto Rico the irrigated area according to the sub-national statistics was higher than the irrigated area distributed according to the land cover map. In these cases (mainly small islands along the coastline) the difference was distributed equally over the most suitable grid cells using the USGS land cover classification map [US06].

Area actually irrigated in year 2007 was 39 707 cuerdas (15 776 ha) [US01]. Areas equipped for irrigation with groundwater or with surface water were computed by combining data on groundwater and surface water use for irrigation in year 2005 [US03] to data on the number of farms irrigated with water from wells, rivers and streams, lakes and private ponds or from canals [US01]. The data showed some disagreement, in particular at the municipality level. The water use inventory [US03] reported for example for several municipalities that irrigation water use is completely from groundwater while, according to the agricultural census report, many farms used water from surface water sources and vice versa. Therefore it was decided to use both inventories and to separate the water sources for half of the area equipped for irrigation according to the water use inventory [US03] and for the other half of the equipped area according to the agricultural census report [US01]. Area equipped for irrigation with groundwater computed that way was 24 848 ha (67 percent of the total area equipped for irrigation).

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Saint Kitts and Nevis

For Saint Kitts and Nevis no information could be found on irrigated areas on sub-national level. In the whole of Saint Kitts and Nevis 18 ha are equipped for irrigation. The figure refers to 1997 [KN01].

The irrigated area within the country was distributed to cropping areas as indicated on the USGS land cover characterization map [KN02].

In Nevis approximately 10 ha of land are irrigated half from groundwater and half from surface water. On Saint Kitts 8 ha land are irrigated mainly from the domestic water supply which is from six surface water intakes (small streams) and five wells [KN01]. Based on this information AEI irrigated with groundwater was estimated to be 50 percent of total AEI.

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Saint Lucia

According to the agricultural census 2007 irrigation is used by 1463 farms with a total extent of 8206 acres (3321 ha) [LC01]. It was assumed that AEI is similar to the reported extent of irrigated farms.

The irrigated area within the country was distributed to agricultural areas as indicated on a land use map from 1987 [LC02].

It was assumed that the whole AEI is irrigated with surface water because even for domestic purposes water from groundwater is exceptional [LC03]. This assumption is supported by a description of two main irrigation projects extracting water from the Cul-de-Sac and Roseau rivers [LC04].

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Saint Vincent and the Grenadines

In 1995 there was no irrigation of importance on Saint Vincent and the Grenadines [VC01]. It was assumed that this has not changed in the meantime and AEI was set to 0 ha.

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Suriname

For Suriname no information could be found on irrigated areas on sub-national level. In total there are 51 180 ha equipped for irrigation. The figure refers to 1998 [SR01].

The irrigated area within the country was distributed to important agricultural projects as indicated on a map from the year 1969 [SR02].

Only surface water is used for irrigation, although suitable groundwater resources are available in many regions as well [SR03].

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Trinidad and Tobago

For Trinidad and Tobago no information could be found on irrigated areas on sub-national level. In the whole of Trinidad and Tobago 3 600 ha are equipped for irrigation. The figure refers to 1997 [TT01]. However, extent of AEI in the districts of Tobago (216 ha), Caroni (1739 ha) and Nariva (147 ha) was derived from the AQUASTAT country profile [TT01].

The irrigated area within the country was distributed over rice growing areas as indicated on a map from 1977 [TT02] and over cropping areas as indicated on an agricultural map of 1969 [TT03].

Data related to the source of irrigation water were not available for Trinidad and Tobago. However, surface water resources were reported to be much larger than groundwater resources and the largest irrigation scheme of the country uses water diverted from the Caroni River [TT01]. It was furthermore reported that small scale private developments use water extracted from small streams. Based on this information the percentage of irrigated area that is using groundwater was estimated at 10 percent.

References:

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United States of America (conterminous and Hawaii)
(American Samoa, Guam, Northern Mariana Islands, Puerto Rico and United States Virgin Islands are reported separately)

The area equipped for irrigation is not known for the United States of America. The 16th census of the United States, undertaken in 1940 and published in 1942, reported for the last time the so called "Area of irrigation works were capable of supplying with water" which comes close to the definition of area equipped for irrigation used here. At that time this area was 28 055 248 acres while the area actually irrigated in year 1939 (called "area irrigated" in the census report) was 21 003 739 acres (75 percent of the equipped area). Beginning with the 1950 Censuses of Agriculture, Irrigation and Drainage the area actually irrigated in the year of the census survey is reported, which is similar to the area actually irrigated used here.

Therefore, area equipped for irrigation was estimated by selecting for each county the maximum of the area actually irrigated reported in the agricultural censuses 2007 [US07] and 2002 [US08] and the water use censuses for year 2005 [US03] and year 2000 [US04]. Total area equipped for irrigation computed that way was 70 118 017 acres (28 375 752 ha). A similar procedure is also used by the Natural Resources Conservation Service (NRCS) of USDA, who defined irrigated land as "Land that shows evidence of being irrigated during the year of the inventory or during two or more years out of the last four years" (http://www.nrcs.usda.gov/technical/NRI/maps/meta/m5297.html). The irrigated area computed this by the NCRS was 67.5 million acres (27.3 million ha) for year 1997. However, the NRCS data were unfortunately not available at the county level.

A national land cover data set on a 30 m resolution [US09] was used to assign areas equipped for irrigation to specific cells within the sub-national units of the conterminous United States. Irrigated area of the sub-national units was equally distributed over all cells classified as orchards and vineyards (value 61), row crops (value 82), small grains (value 83) or fallow (value 84). If the sum of these cropland areas was smaller than the total irrigated area per sub-national unit, the remaining area was assigned to cells classified as pasture and hay (value 81). This appeared in the majority of the sub-national units in the states of Arizona, California, Colorado, Idaho, Nevada, New Mexico, Oregon, Utah, Washington and Wyoming and in some sub-national units located in the states of Arkansas, Florida, Massachusetts, Missouri, Montana, Nebraska and Texas. This land cover data set was not available for Alaska and Hawaii. Therefore, a similar land cover data set with the same resolution [US10] was used for the Hawaiian Islands. Irrigated area was assigned to all cells classified as cultivated land (class 4). Additionally areas close to cropland-cells and classified as grassland (class 5) were assumed to be irrigated on the islands of Honolulu and Kauai. The GLC2000 land cover classification for North America [US11] was used to distribute irrigated areas within the sub-national units of Alaska. The highest priority was given to cells classified as cropland (class 18). If the sum of the areas classified as cropland was lower than the irrigated area as reported by the statistical surveys also cells classified as mosaic of cropland and other land cover types were considered.

Area actually irrigated was 56 599 305 acres (22 904 924 ha) in year 2007 [US07]. The percentage of area irrigated with groundwater was derived for each federal state from the most recent Farm and Ranch Irrigation Survey (FRIS) of the US Department of Agriculture [US12]. The FRIS was used as the primary source of information for the United States because it is based on questionnaires filled by the irrigating farmers themselves and provides likely the most complete and detailed profiles of irrigation in the United States. These statistics reported the extent of irrigated areas using wells, on-farm surface water and off-farm surface water. According to this survey 66 percent of the irrigated land was irrigated from wells. However, the average amount of water applied per acre varied significantly by source with lower values for wells and largest values for off-farm surface water supply. Therefore, only 53 percent of the irrigation water application was from wells. Since the FRIS is only reporting statistics at the state level, these statistics were downscaled to the county level by using data on irrigation water extraction from ground- and surface water ([US03], [US04]) by assuming that the ratio between irrigated areas from ground- and surface water was similar to the ratio between groundwater use and surface water use for irrigation.

References:

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United States Virgin Islands (United States of America)

Area equipped for irrigation was estimated as the maximum of the area actually irrigated reported by the agricultural censuses 2007 [VI01] and 2002 [VI02] for the islands Saint Croix and Saint John / Saint Thomas. Total area equipped for irrigation computed that way was 457 acres (185 ha).

Since no direct or indirect information about the spatial distribution of irrigation within the municipalities was available, irrigated area was distributed according to a global land cover data set [VI03] to all areas classified as: “Dryland Cropland and Pasture”, “Irrigated Cropland and Pasture”, “Cropland/Grassland Mosaic”, “Cropland/Woodland Mosaic”, “Grassland”, “Shrubland”, “Mixed Shrubland/Grassland”, “Savanna”, “Herbaceous Wetland” or “Wooded Wetland”.

Area actually irrigated was 243 acres (98 ha) in year 2007 [VI01]. 13 farms used public utilities as water supplier for irrigation, 51 farms used wells or cisterns and 4 farms used water extracted from lakes or ponds [MP01]. Percentage area equipped for irrigation with groundwater was computed based on the number of farms reporting the different water sources and by assuming that the share of groundwater in the public supply system is 80 percent.

References:

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Uruguay

Area actually irrigated in year 2000 was 217 593 ha [UY01]. The crops with the largest extent in irrigation were rice (174 728 ha), vegetables (10 844 ha), pasture (8170 ha), and citrus fruits (6521 ha). The figures originate from the agricultural census undertaken in year 2000, but AEI was not reported by the census data base. The number of farms with irrigation equipment was 5608, but 595 farms that reported irrigation infrastructure, did not irrigate in year 2000. Based on this ratio, we estimated AEI at 243 419 ha. To estimate AEI per province, irrigated areas for rice, citrus, wine, other fruits and horticulture reported by the census data base were summed up. The total irrigated area of these crops was 197 492 ha. Area equipped for irrigation was scaled thereafter so that the sum of area equipped for irrigation at the national scale was equal to the figures estimated before (243 419 ha).

Since maps showing the location of irrigation areas were not available, irrigated area was assigned to all regions classified as agriculture (intensive) in the GLC2000 land cover classification for South America [UY02].

In year 2000, 2645 farms (47.1 percent) used groundwater sources for irrigation [UY01]. Unfortunately the area irrigated with groundwater was not reported in the agricultural census statistics. The most important irrigated crop was rice with an irrigated area of 174 728 ha or about 80 percent of the total AAI. However, in year 1998 only 4 percent of the rice area was irrigated with groundwater while about 50 percent of the horticultural area was irrigated with groundwater [UY03]. The number of horticulture farms using irrigation was 3793 in year 2000 while the irrigated horticulture area was 10 846 ha [UY01] which could explain the large total number of farms irrigating with groundwater but relative small areas involved. Based on these statistics we estimated that 6989 ha rice, 5423 ha horticulture and 4800 ha other crops were irrigated with groundwater.

References:

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Venezuela (Bolivarian Republic of)

AEI and AAI per Parroquia were derived from the data base of the agricultural census 2007/2008. The total area equipped for irrigation in the Bolivarian Republic of Venezuela equals 759 524 ha, while area actually irrigated in season 2007/2008 was 683 095 ha [VE01].

Most of the irrigated area is located in the northern part of the country. The irrigated area was distributed within the Parroquias according to irrigation maps originating from an FAO review on the irrigation and drainage sub-sector done in 1990 [VE02] and a CIAT map with irrigated rice [VE03]. The remaining irrigated area was assigned was assigned to all regions

classified as agriculture (intensive) in the GLC2000 land cover classification for South America [VE04] and if the extent of these areas was still to small to regions classified in the same data set as mosaic of agriculture and degraded vegetation or degraded forest respectively.

Data related to the source of irrigation water are scarce for Venezuela. In 1989 about 2 percent of the cropland in public irrigation schemes was irrigated with groundwater [VE05] while the contribution of groundwater to total water abstraction was reported at 50 percent [VE06]. There is evidence that groundwater extraction for irrigation resulted in an overuse of several important aquifers [VE06]. Since the majority of irrigation is in private schemes [VE05], AEI irrigated with groundwater was estimated at 20 percent for Venezuela.

References:

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ASIA

The update of the irrigation map to version 5 was the second update for Asia. In addition to the separation of area equipped for irrigation according to the source of water, the following countries have been updated due to new available spatial information: Armenia, Azerbajan, Bangladesh, Bhutan, Cambodia, China, Cyprus, Georgia, India, Indonesia, Iran, Iraq, Japan, Jordan, Kazakhstan, Kuwait, Kyrgyzstan, Lao PDR, Lebanon, Malaysia, Mongolia, Myanmar, Nepal, Occupied Palestinian Territory, Oman, Pakistan, Philippines, Qatar, Republic of Korea, Saudi Arabia, Sri Lanka, Syrian Arab Republic, Tajikistan, Thailand, Timor-Leste, Turkey, Turkmenistan, United Arab Emirates, Uzbekistan, and Yemen. Total area equipped for irrigation in the Global Map of Irrigation for Asia changed due to this update from 187 600 089 ha in map version 4 to 213 779 671 ha in version 5 (Table A8).

TABLE A8

Area equipped for irrigation (AEI) and area actually irrigated (AAI) in Asia in the new version 5 of the Global Map of Irrigation Areas compared to area AEI in the previous version 4.

Country	AEI in GMIA4 (ha)	AEI in GMIA5, total (ha)	AEI in GMIA5, groundwater (ha)	AEI in GMIA5, surface water (ha)	AEI in GMIA5, non-conventional sources (ha)	AAI in GMIA5 (ha)
Afghanistan	3,199,070	3,199,070	576,387	2,622,682	0	1,731,784
Armenia	286,027	273,530	50,877	222,653	0	176,000
Azerbaijan	1,453,318	1,426,000	96,700	1,329,300	0	1,100,000
Bahrain	4,060	4,060	3,666	0	394	4,060
Bangladesh	3,751,045	5,049,400	3,786,322	1,263,078	0	5,049,400
Bhutan	38,734	27,685	0	27,685	0	27,685
Brunei Darussalam	1,000	1,000	0	1,000	0	1,000
Cambodia	284,172	506,775	0	506,775	0	454,687
China	54,348,528	62,392,392	18,794,951	43,597,440	0	53,251,357
Cyprus	55,813	55,456	32,276	22,607	573	45,421
Democratic People's Republic of Korea	1,460,000	1,460,000	205,600	1,254,400	0	1,341,000
Georgia	300,000	432,790	0	432,790	0	135,955
India	57,291,407	61,907,846	39,425,869	22,481,977	0	58,129,630
Indonesia	4,459,000	6,722,299	67,220	6,655,079	0	6,722,299
Iran (Islamic Republic of)	6,913,800	8,847,818	5,494,495	3,353,323	0	6,407,307
Iraq	3,525,000	3,525,000	220,000	3,305,000	0	2,530,000
Israel	183,408	183,407	89,869	60,524	33,013	151,400
Japan	3,129,000	2,834,956	250,000	2,584,956	0	2,651,256
Jordan	76,912	83,450	44,479	38,971	0	76,200
Kazakhstan	1,855,200	2,482,500	179,000	2,303,500	0	2,141,330
Kuwait	6,968	10,142	7,742	0	2,400	10,142
Kyrgyzstan	1,075,040	1,045,131	7,000	1,038,131	0	1,021,400
Lao People’s Democratic Republic	295,535	309,657	200	309,457	0	271,704
Lebanon	117,113	104,010	54,070	49,940	0	90,000
Malaysia	362,600	362,687	27,260	335,427	0	362,687
Maldives	0	0	0	0	0	0
Mongolia	57,300	84,300	36,000	48,300	0	62,900
Myanmar	1,841,320	2,110,000	100,000	2,010,000	0	2,110,000
Nepal	1,168,349	1,168,349	229,327	939,021	0	1,168,349
Occupied Palestinian Territory	19,466	23,484	23,484	0	0	18,946
Oman	72,630	58,850	58,850	0	0	58,850
Pakistan	14,417,464	16,725,843	5,172,552	11,553,291	0	13,378,476
Papua New Guinea	0	0	0	0	0	0

Country	AEI in GMIA4 (ha)	AEI in GMIA5, total (ha)	AEI in GMIA5, groundwater (ha)	AEI in GMIA5, surface water (ha)	AEI in GMIA5, non-conventional sources (ha)	AAI in GMIA5 (ha)
Philippines	1,550,000	1,879,084	254,039	1,625,045	0	1,879,084
Qatar	12,520	12,935	12,081	0	854	6,322
Republic of Korea	880,365	806,475	45,300	761,175	0	806,475
Saudi Arabia	1,730,767	1,348,696	1,308,235	0	40,461	1,154,385
Singapore	0	0	0	0	0	0
Sri Lanka	570,000	600,730	6,829	593,901	0	462,500
Syrian Arab Republic	1,266,900	1,489,000	889,668	599,332	0	1,403,200
Tajikistan	719,200	742,051	39,038	703,013	0	674,416
Thailand	4,985,708	6,414,880	481,063	5,933,817	0	5,059,914
Timor-Leste	14,000	33,698	674	33,024	0	28,907
Turkey	4,185,910	5,215,144	1,621,546	3,484,931	108,668	3,415,144
Turkmenistan	1,744,100	1,990,800	9,608	1,981,192	0	1,990,800
United Arab Emirates	280,341	230,841	230,841	0	0	218,826
Uzbekistan	4,223,000	4,198,000	274,000	3,924,000	0	3,700,000
Viet Nam	3,000,000	4,585,500	45,855	4,539,645	0	4,585,500
Yemen	388,000	813,951	540,698	253,542	19,712	668,504
ASIA TOTAL	**187,600,089**	**213,779,671**	**80,793,672**	**132,779,924**	**206,075**	**186,735,200**

Afghanistan

The last available census-based inventory of irrigated areas dates back to 1967, giving a total of 2 385 290 ha [AF01]. However, land-cover maps, recently produced through the collaborative efforts of FAO, the United Nations Development Programme (UNDP) and the Afghan Geodesy and Cartography Office (Kabul), indicate that the extent of irrigated areas has not changed much in the last 35 years. About 190 000 ha are classified as intensively irrigated (two crops, rice–wheat), about 1 370 000 ha as cropped and irrigated at least once a year, and about 1 650 000 ha as irrigated occasionally (every two or three years) [AF02]. Area equipped for irrigation was computed on a district level based on the recently produced land-cover map [AF02] as the sum of areas classified as intensively or occasionally irrigated. This resulted in a total AEI of 3 199 070 ha.

The irrigated areas were derived from land-cover maps, produced through the collaborative efforts of FAO, the United Nations Development Programme and the Afghan Geodesy and Cartography Office Kabul [AF02] and referring to year 1993.

The census-based inventory related to year 1967 [AF01] listed areas irrigated from streams, canals, springs, kharezes and wells for each province. The total area irrigated with groundwater according to this inventory was 367 240 ha (15.4 percent) while area irrigated with surface water was 2 018 050 ha. The numbers found in this inventory agree very well with statistics reported in a more recent publication [AF03]. Therefore we used this inventory to compute the percentage of area irrigated with groundwater for each province. Total area equipped for irrigation with groundwater computed this way was 576 387 ha (18 percent of total AEI). AAI per region was derived from a report referring to season 2001/2002 [AF04]. Total AAI was 1 731 784 ha, of which 1 292 025 ha were used for one irrigated crop and 439 759 ha were under irrigated double-cropping.

References:

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[AF02]: **Afghanistan Information Management Service (AIMS), FAO**. 2003. *Land cover of Afghanistan (1993)*. http://www.fao.org/geonetwork/srv/en/metadata.show?id=1289, 30/03/2012.

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Armenia

Area equipped for irrigation per district was derived from a cadaster report [AM01] and totals 273 530 ha at the country level. The figures are for year 2006.

Irrigated areas were digitized from a map at the scale 1:750 000 [AM02]. The digitized areas have been in good agreement to irrigation schemes shown on other maps, e.g. in [AM03].

Area equipped for irrigation with groundwater was 50 900 ha (18.6 percent of total AEI) in year 2006 while area actually irrigated was 176 000 ha (64.3 percent of total AEI) in the same year [AM04].

References:

[AM01]: **Ministry of Territorial Administration**. 2007. *The cadaster of meliorative conditions of irrigated and drained areas of the Republic of Armenia*. Ministry of Territorial Administration, State Commity on Water Management, Melioration Organization.

[AM02]: **Unknown**. *Irrigation in Armenia*. Map at the scale 1:750 000 available from the AQUASTAT library.

[AM03]: **FAO**. 1993. *Irrigation sub-sector review and project identification*. FAO Investment Centre/ World Bank cooperative programme. Report No 79/93 CP - ARM 2. 66p. + 3 annexes.

[AM04]: **FAO**. 2009. *AQUASTAT country profile of Armenia, version 2008*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/armenia/index.stm, 06/10/2010.

Azerbaijan

Total area equipped for irrigation in Azerbaijan was 1 426 000 ha in year 2003 [AZ01]. For the region of Nakhichevan, area equipped for irrigation per district was derived from report [AZ02], which refers to the situation in year 2000. Area equipped for irrigation for the other regions was derived from statistics collected by the AQUASTAT country survey 2008. The sum of AEI in these regions was 1 318 466 ha. Therefore AEI was scaled to 1 369 800 ha so that total AEI for the whole country was similar to national sum (1 426 000 ha).

Irrigated areas were digitized from a map showing irrigation in the Caucasus region [AZ03]. The boundaries of the digitized irrigated areas were then adjusted using recent satellite imagery [AZ04].

Area equipped for irrigation with groundwater was 96 700 ha in year 1995 [AZ01], while area actually irrigated was about 1 100 000 ha in year 2001 [AZ05]. The total harvested area of irrigated crops was 1 391 521 ha in year 2004 [AZ01] indicating either multi-cropping of irrigated crops or an increase of the actual use of irrigation between 2001 and 2004.

References:

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Bahrain

The cultivated area increased between 1993 and 2000 from 3 160 ha to more than 4 000 ha [BH01] and it is completely equipped for irrigation. Irrigated area reported for 9 regions adds up to 4 060 ha [BH02]. The figures refer to the year 2001.

The location of irrigated areas was detected using a land-use map [BH03] showing the cultivated areas of the country. The irrigated areas were then digitized in detail from Landsat satellite imagery [BH04].

Because of the arid climate and limited surface water supply, irrigation water withdrawal is mainly from groundwater. Area equipped for irrigation with groundwater is 90.3 percent of total AEI [BH05], while the remaining 394 ha are irrigated with non-conventional water sources.

References:

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Bangladesh

The area equipped for irrigation per region was derived from [BD01] and add up to 5 049 400 ha. The figures refer to year 2008. Statistics for the 64 districts (zilas) at zila were available for 1998 [BD02] and 2007 [BD03], but in the more recent statistics for year 2007 data were missing or incomplete for several zilas. Therefore, it was decided to use for each district the maximum of the irrigated areas reported for years 1998 and 2007 and to scale the irrigated area per district so that the total at the region level was consistent with the area reported as equipped for irrigation in the minor irrigation survey [BD01].

Irrigated areas were digitized from a map showing irrigation accumulated in dot form [BD04]. Each dot represented 1 000 acres of irrigated area, and this also allowed the separation of areas with high and low irrigation density within the districts.

The fraction of AEI irrigated with groundwater was computed for each district based on the sum of areas reported to be irrigated with wells or tube-wells in [BD03]. For districts where information was missing in [BD03] we used the statistics in [BD02] referring to year 1998. Total AEI irrigated with groundwater computed that way was 3 786 322 ha (75 percent of total AEI) while the corresponding percentage reported in [BD01] was 79 percent. The small underestimate of AEI irrigated with groundwater may be the result of missing data in [BD03], because the importance of groundwater use for irrigation was rising within the last decade. It was assumed that AEI is similar to AAI [BD05].

References:

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Bhutan

Area equipped for irrigation is 27 685 ha [BT01]. The statistics refer to “wetlands” which is the local term for irrigated land [BT02]. Area equipped for irrigation is reported for 20 provinces (dzongkhag) and the statistics refer to year 2007.

The irrigated areas were digitized from a land use atlas with a scale of 1 : 250 000 [BT03].

The whole area equipped for irrigation is irrigated by using surface water sources [BT02].

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Brunei Darussalam

The irrigated area in Brunei Darussalam is reported to be about 1 000 ha [BN01]. The figures refer to 1995. No subnational statistics were available.

No map of irrigated areas was available. Therefore, arable land, mainly located in the north of the country, was digitized from satellite imagery [BN02].

Irrigation in Brunei Darussalam is completely based on using surface water sources [BN01].

References:

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Cambodia

A recent inventory reported 2129 irrigation systems in 15 provinces, covering a total area of 504 675 ha with existing irrigation infrastructure and 164 964 ha of irrigation schemes in the planning or construction phase [KH01]. Irrigated area is 273 767 ha in the wet season and 260 815 ha in the dry season, while 29 907 ha are irrigated in both seasons. The inventory is related to the situation in year 2009 and indicates a strong increase of area equipped for irrigation as compared to former versions of the same inventory reporting areas equipped for irrigation of 323 591 ha in year 2004 [KH02] or 284 177 ha in year 2001 [KH03]. Area equipped for full control irrigation in year 2006 was reported at 353 566 ha [KH04]. The irrigated area of the six provinces not included in the inventory (Preah Vihear, Stung Treng, Ratana Kiri, Mondul Kiri, Koh Kong and Tonle Sap) was reported to be about 2 100 ha in 1990 [KH05], so that the total irrigated area of the country is about 506 775 ha.

To distribute irrigated area within the country, digital maps of irrigated areas (polygon dataset) related to year 2001 [KH06] and a digital map of irrigation projects (point dataset) related to year 2009 [KH01] were used. Because the digital map of irrigation projects (point dataset) often referred to the position of the headwork (reservoir, weir, sluice structure or pump) it was used for small schemes (fewer than 300 ha) while the polygon dataset was used for large schemes (more than 300 ha). The assumption behind this descision was that small irrigation schemes are located closer to the source of irrigation water while large schemes might be located in a larger distance to the water source. The remainder of the irrigated area was distributed to paddy areas taken from a digital landcover map [KH03].

Area actually irrigated was 317 225 ha or 89.7 percent of area equipped for irrigation in year 2006 [KH04]. The ratio between AAI and AEI reported for year 2006 was applied for year 2009 as well resulting in an AAI of 454 687 ha. Irrigation is completely based on surface water sources (reservoirs, rivers) [KH04].

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China (excluding Macao and Taiwan)

Area equipped for irrigation reported for 31 provinces adds up to 61 897 940 ha [CN01]. The figures refer to year 2005 and are limited to the provinces in China mainland. The farm area for China Hong Kong SAR was reported to be 6 960 ha in the 2000 cropping season, while the area actually cropped was 2 710 ha [CN02]. Based on these statistics, the irrigated area in

China Hong Kong SAR was estimated to be 2 000 ha, resulting in a total AEI of 61 899 940 ha.

There are large uncertainties regarding the extent of irrigated land in China. Inventories based on remote sensing reported a much larger extent of areas under irrigation compared to the census based statistics. For example, irrigated area has been estimated at 78 million ha for the 1992–93 cropping season [CN03], while irrigation statistics derived from the data base of the agricultural census 1990 [CN04] reported a total AEI of 46 million ha. In addition, irrigated areas were digitized from a 1:1 000 000 land-use atlas [CN05]. The atlas was published in 1990 and is based on satellite images and large-scale aerial photographs taken in the 1980s. Irrigated areas and paddy rice areas derived from the land-use map totalled about 68 million ha. The use of different definitions for irrigated land may explain parts of the difference. Statistical yearbooks like the annual yearbooks of the National Bureau of Statistical [CN06] report for example the so called “effective irrigation area” which refers to irrigated area of annual crops [CN07]. In year 2005 the effective irrigation area was 56 562 360 ha in thus about 11 percent smaller than total area equipped for irrigation, while only 47 968 730 ha of the “effective irrigation area” was irrigated in year 2005.

In order to estimate irrigated area per county in year 2005, four inventories were combined. AEI per province was assumed to be as given in [CN01]. The downscaling to county values was achieved by combining the census results for the county level in 1990 [CN04] and the irrigated area per county as taken from the land-use atlas [CN05]. First, the upper and lower limits of irrigated area per province were computed by calculating the sum of minimum and maximum irrigated areas per county as taken from the two inventories. If the so computed maximum extent was larger than total cropland derived from the National Land Cover Database 2000 (NLCD2000) [CN08], the maximum was reduced to total cropland extent in the NLCD2000. It was then assumed that the irrigated area per county was at least as high as the minimum of irrigated area taken from the two inventories plus the difference from the maximum value scaled by a coefficient s. The coefficient s was constant for all counties within the same province and was chosen so that the sum of the irrigated area in all counties equalled the irrigated area per province. It was possible to use this method for 23 of the 30 provinces in China mainland. In the provinces Hebei, Heilongjiang, Inner Mongolia, Jilin, Liaoning, and Tibet the computed upper limit of irrigated area was lower than the AEI reported for 2005. This indicates a considerable increase in irrigated areas in these provinces between 1990 and 2005. Irrigated area per county was computed here as a maximum of the two inventories plus the rainfed agricultural land scaled by a coefficient so that the sum of the computed irrigated areas per county equalled the irrigated area per province in 2005.

The irrigated areas were derived from the land-use atlas published in 1990 (scale: 1:1 000 000). The atlas was available in a printed hardcover version [CN05] and in a digital version [CN09]. The digital version had a lower resolution and consisted of fewer classes than the printed version. Therefore, fields classified as irrigated or as paddy were digitized from the printed atlas version for 754 counties, covering about 67 percent of the country area. The digital version of the map was used for the other counties, which are mainly located in southeast China and usually very small. It was assumed that all the paddy-fields were irrigated. Additionally, irrigated area was assigned to pixels classified as paddy land in the NLCD2000. If the irrigated land identified that way was still smaller than total AEI, the difference from the irrigated area was distributed to rainfed agriculture fields derived from the NLCD2000.

Area equipped for irrigation with groundwater and area actually irrigated per province in year 2005 was extracted from [CH01]. It was thereby assumed that the AEI irrigated with groundwater is similar to the area covered by tube wells. Total area equipped for irrigation is 18 658 742 ha (30 percent of total AEI) while area actually irrigated in year 2005 was 52 758 905 ha (85 percent of AEI).

TABLE A9

Computed upper and lower limits of irrigated area in Chinese provinces compared to the area equipped for irrigation as reported by the Ministry of Water Resources [CN01] for the year 2005.

Province	Computed lower limit (ha)	Computed upper limit (ha)	AEI reported in the yearbook of MWR for year 2005 (ha)
Anhui	2,392,445	5,274,661	3,369,860
Beijing	345,700	452,795	367,870
Chongqing	544,546	1,677,412	618,090
Fujian	883,723	1,938,449	1,005,000
Gansu	795,407	2,107,809	1,355,480
Guangdong	1,734,872	3,684,428	2,230,740
Guangxi	1,440,496	3,037,587	1,532,220
Guizhou	513,849	1,978,353	711,920
Hainan	138,826	605,282	250,600
Hebei	3,187,790	4,451,145	4,885,720
Heilongjiang	468,484	2,316,997	2,400,060
Henan	3,152,490	5,241,801	4,941,210
Hong Kong	0	5,537	2,000
Hubei	1,999,137	4,150,791	2,457,630
Hunan	2,320,441	4,475,230	2,761,660
Inner Mongolia	1,091,745	2,522,336	3,332,520
Jiangsu	3,979,156	6,145,719	4,020,100
Jiangxi	1,808,576	3,561,707	1,883,720
Jilin	306,773	1,316,685	1,636,370
Liaoning	714,014	1,506,877	1,715,390
Ningxia	236,792	645,236	497,220
Qinghai	159,943	373,276	371,170
Shaanxi	1,170,126	2,678,166	1,443,620
Shandong	4,149,827	5,727,478	5,360,090
Shanghai	237,610	352,617	308,340
Shanxi	979,825	1,863,713	1,283,460
Sichuan	1,969,102	4,844,050	2,607,420
Tianjin	340,130	601,994	393,010
Tibet	93,272	245,377	306,980
Xinjiang	1,911,531	4,986,898	4,776,980
Yunnan	907,885	2,354,106	1,561,190
Zhejiang	1,452,609	2,673,558	1,512,300
CHINA TOTAL	41,427,122	83,798,073	61,899,940

References:

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China Macao Province

The total land area of Macao is about 2 680 ha of which 577 ha are classified as green area. The green area contains about 67 ha of gardens, parks and squares, 3 ha are classified as nurseries [MO01]. However, no information was available on agricultural land use and irrigation. Therefore, it was assumed that there is no irrigated area in Macao.

References:

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China Taiwan Province

Total cultivated area of Taiwan, Province of China, decreased from 667 602 ha in 1990 to 656 676 ha in 1995 [TW01], 627 160 ha in 2000 [TW02], and 597 438 ha in 2005 [TW03]. In contrast, the irrigated area increased from 510 500 ha in 1990 to 525 528 ha in 1995 [TW04], but decreased then to 492 452 ha in 2005 [TW03]. Area equipped for irrigation was derived for each county and city from the report of the agriculture, forestry, fishery and husbandry census 2005 [TW03].

Irrigated area was assigned to pixels classified as paddy land (priority 7) or non-paddy cropland (priority 6) in the National Land Cover Database of China for the year 2000 (NLCD2000) [TW05] and to irrigated areas shown on a land cover atlas related to year 1990 [TW06].

Area irrigated from groundwater and surface water sources was derived for each county and city from the report of the agriculture, forestry, fishery and husbandry census 2005 [TW03]. It was assumed that the area supplied by "irrigation associations", "rivers and ponds" and "other sources" represented area irrigated with surface water while area served with "groundwater" represented area irrigated with groundwater. Total area irrigated with groundwater was 136 209 ha. Area actually irrigated was assumed to be similar to area equipped for irrigation.

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Cyprus

Area equipped for irrigation per municipality in the Republic of Cyprus (in total 45 449 ha) was derived from the report of the agricultural census 2003 [CY01] while area equipped for irrigation in per district in Northern Cyprus (in total 10 006 ha) was derived from a report published in 2005 [CY02]. Therefore, AEI for the whole island of Cyprus was 55 456 ha.

Irrigated areas were extracted from the Corine 2000 land cover data base for Europe [CY03] or digitized from a land-use map produced in 1975 [CY04]. This map also shows irrigated areas in the Northern part of Cyprus. In addition, eleven government schemes were digitized from a recent inventory [CY05].

For the Republic of Cyprus it was assumed, that 51.2 percent of the area is irrigated with groundwater, 48.2 percent with surface water and 0.5 percent with water from nonconventional sources [CY06]. Based on the amount of water consumption from different sources reported in [CY02] we estimated that 90 percent of the AEI in Northern Cyprus was irrigated with groundwater, 7 percent with surface water and 3 percent with water from nonconventional sources. For the whole island of Cyprus, his resulted in 32 276 ha AEI irrigated with groundwater, 22 607 ha irrigated with surface water, and 573 ha irrigated with water from non-conventional sources. Area actually irrigated for the Republic of Cyprus was derived from the agricultural census report 2003 (in total 35 928 ha) while the area actually irrigated for Northern Cyprus (in total 9493 ha) was computed as average of annual irrigated areas reported for the period 2001-2005 [CY07].

References:

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Democratic People's Republic of Korea

The irrigated area in the Democratic People's Republic of Korea was 1 460 000 ha in 1995 [KP01]. More recent data were not available from national sources but according to statistics

provided by FAOSTAT [KP02], area equipped for irrigation has been constant until 2009. Subnational data on the extent of irrigated land were missing as well.

An inventory of land form, land cover and crop-use intensity [KP03] was used to assign area equipped for irrigation to specific pixels. The map is based on remote sensing and distinguishes land forms (alluvial land, upland, hilly or steep land, and wetland), land uses (paddy rice, forest, rangeland or pasture, and urban) as well as five different classes of cultivation intensity. It was assumed that the paddy-fields (about 557 000 ha) were completely equipped for irrigation. It was further assumed that the fields assigned to other crops were also equipped for irrigation where they were located in the plains or river valleys with alluvial land (about 637 000 ha). The difference from the total area equipped for irrigation (about 266 000 ha) was distributed to fields cropped with upland crops.

In 1990 about 200 000 ha were irrigated with groundwater and 1 220 000 ha with surface water. Based on this ratio area equipped for irrigation with groundwater was assumed to be 205 600 ha. Area actually irrigated was 1 341 000 ha in year 2006 [KP01].

References:

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Georgia

In the Soviet period, infrastructure was built to irrigate 469 000 ha of agricultural land, mainly located in the more arid east of the country [GE01]. In the 1990s, civil strife, war, vandalism and theft, as well as problems associated with land reform, the transition to a market economy, and the loss of markets with traditional trading partners, contributed to a significant reduction in the irrigated area. It has been reported that only about 160 000 ha were irrigated during the severe drought in 2000. Almost all pumping schemes (about 143 000 ha) were out of order. Therefore, a rehabilitation programme was started by Georgia's State Department of Amelioration and Water Economy to renew the infrastructure of existing irrigation and drainage schemes and to establish amelioration service cooperatives. About 255 000 ha were covered by this programme [GE02]. Total area equipped for irrigation in year 2007 was 432 790 ha, consisting of 31 500 ha equipped wetland and inland valley bottoms and 401 290 ha full or partial control irrigation [GE01]. AEI in full or partial control irrigation for 11 regions was derived from the Aquastat country questionnaire. No data have been available on the location of equipped wetland and inland valley bottoms. Therefore total AEI was estimated for each region by scaling AEI in full or partial control schemes (401 290 ha) to 432 790 ha.

Irrigated areas and main zones of irrigation development were digitized from an irrigation map published in a project report [GE02] and from a map showing irrigated areas in the Caucasus region [GE03]. Irrigated area was then assigned to all pixels classified in the Globcover 2009 landcover data set [GE04] as “Rainfed croplands”, “Mosaic cropland (50-70 percent) / vegetation (grassland/shrubland/forest) (20-50 percent)”, or “Mosaic vegetation (grassland/shrubland/forest) (50-70 percent) / cropland (20-50 percent)” and located within the digitized irrigation zones.

Irrigation is completely based on surface water resources (river diversion), groundwater is not used for irrigation in Georgia [GE01]. In year 2006 only 126 060 ha (31.4 percent) of the area equipped for irrigation in full/partial control irrigation schemes was irrigated. Based on this fraction, total area actually irrigated was estimated therefore at 135 955 ha.

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India

Data on the extent of area equipped for irrigation is not collected by statistical surveys in India. Therefore, statistics on the Net Irrigated Area (NIA) provided by the reports and data bases of the Agricultural Census 2000/2001 of the Ministry of Agriculture [IN01], the Input Survey 2001/2002 of the Ministry of Agriculture [IN02], and the Minor Irrigation Census 2000/2001 of the Ministry of Water Resources [IN03] were used to estimate AEI. NIA does not account for AEI that was left fallow or was completely rainfed in the year of the statistics. NIA is therefore likely to be lower than the AEI. AEI per district was computed as the maximum of NIA reported by the three inventories aforementioned resulting in a total sum of 61 907 846 ha.

In the northern part of India, irrigated areas were assigned to pixels classified as irrigated in the Himalaya land cover classification [IN04]. In addition, irrigated areas were digitized from a hydrological atlas published in 2005 [IN05] showing the outlines of the large-scale irrigation schemes of the country and distinguishing between existing schemes, schemes under construction and proposed schemes. In addition, the location of minor irrigation schemes is shown in the irrigation atlas in dot-map form, whereby each dot represents 4 000 ha of irrigated area outside the major irrigation schemes. These areas were digitized by enclosing areas around the dots on the map. The digitized irrigation areas were then combined with the Globcover landcover classification product for Central Asia [IN06] using the priorities shown in Table A10.

The percentage of area irrigated with groundwater was computed by using the agricultural census statistics and the minor irrigation census statistics because these inventories also reported the source of irrigation water. In general, percentage of area irrigated with groundwater (*P_AEI_GW*) was computed as follows:

$$P\_AEIGW = 100 \frac{Max(NIAGW\_AGC, NIAGW\_MIC)}{Max(NIAGW\_AGC, NIAGW\_MIC) + Max(NIASW\_AGC, NIASW\_MIC)} \quad (1)$$

where *NIAGW_AGC* was the NIA irrigated with groundwater according to the Agricultural Census (ha) , *NIAGW_MIC* was the NIA irrigated with groundwater according to the Minor Irrigation Census (ha) and *NIASW_AGC* and *NIASW_MIC* were the corresponding net irrigated areas irrigated with surface water as reported by the two census data bases (ha). Exceptions from this general procedure (mainly caused by missing data) are documented below by federal state:

Andaman and Nicobar Islands:
Only Minor Irrigation Census data was used.

Arunachal Pradesh:
Data from the Minor Irrigation Census was used because in the agricultural census data base most of the NIA was assigned to "other sources", it was assumed that "Major/medium schemes" in MIC represent surface water sources (862 ha of 39 958 ha total NIA).

Bihar:
In the agricultural census data base there was no data, therefore another inventory reporting NIA for season 1993/1994 [IN07] was used as second data source.

Daman and Diu:
Because of missing data in the Minor Irrigation Census, only the Agricultural Census data base was used.

Jharkhand:
In the agricultural census data base there was no data, therefore another inventory reporting NIA for season 1993/1994 [IN07] was used as second data source.

Lakshadweep:
It was assumed that all irrigation is from groundwater.

Meghalaya:
In the agricultural census data base there was no data, therefore the Minor Irrigation Census was used as the only data source.

Uttar Pradesh:
The percentage of AEI irrigated with groundwater was computed by assuming that all areas reported in category "others" refer to irrigation from surface water to account for the specific relevance of water extractions from rivers and reservoirs in some districts of the state.

Total area equipped for irrigation with groundwater computed that way for India was 39 425 869 ha (63.7 percent of total AEI) while 22 481 977 ha (36.3 percent of total AEI) were irrigated with surface water. AAI was computed for each district as maximum of net irrigated area reported by the Agricultural Census Database or the Minor Irrigation Census and neglected therefore the statistics collected by the Input survey in period 2001/02. Total AAI estimated that way for year 2001 was 58 129 630 ha.

TABLE A10
Criteria and corresponding priorities used to assign area equipped for irrigation to grid cells in India.

Criteria	Priority
Irrigated herbaceous crops in [IN04]	8
Operational irrigation schemes in [IN05] AND irrigated crops in [IN06]	7
Either operational irrigation scheme in [IN05] OR irrigated crops in [IN06]	6
Irrigation schemes under construction or planned in [IN05] AND rainfed crops in [IN06]	5
Either irrigation schemes under construction or planned in [IN05] OR rainfed crops in [IN06]	4

References:

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Indonesia

Area equipped for irrigation was 6 722 299 ha in year 2005 [ID01]. Following the categorization used by FAO, only technical, semi-technical, and simple irrigation schemes where considered. In addition to areas equipped for irrigation, non-equipped cultivated wetlands of Indonesia covered 3 133 317 ha, of which 2 088 622 ha were village managed and 1 044 695 cultivated by the state [ID02]. The statistics indicate a strong increase in areas equipped for irrigation during the last decade. About 46 percent of the irrigated area is located on the island of Java and about 34 percent on the island of Sumatra, respectively.

Irrigated areas were digitized from maps provided by the General Directorate of Water Resources [ID03]. About 28 percent of the AEI were assigned to irrigated areas shown on these irrigation maps. In addition, irrigated land was assigned to pixels classified as irrigated crops in a land cover classification based on the Globecover data set [ID04]. When the sum of irrigated area assigned to specific pixels was still smaller than the AEI reported by the statistics, the remaining irrigated land was assigned to pixels classified in [ID04] as rainfed crops.

Irrigation from groundwater covered an area of 1 percent of total AEI or about 67 220 ha [ID02]. Subnational data on the share of groundwater irrigation or on the AEI actually irrigated were not available. However, the harvested area of irrigated crops was 13 388 358 ha in year 2005 [ID02], indicating a very high cropping intensity on irrigated land. It was therefore assumed, that the total AEI was actually irrigated in year 2005.

References:

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Iran (Islamic Republic of)

Area equipped for irrigation was 8 131 564 ha in year 2003 [IR01]. However, statistics reported per province were 8 297 031 ha in total for the same year, of which an area of 5 141

157 ha was used for annual crops, 1 282 188 ha for orchards and nurseries and the remaining area was fallow in that year [IR02]. AEI per province for year 2003 was derived from the Statistical Yearbook of Iran [IR02] and increased in 11 out of the 30 provinces to the maximum of the area actually irrigated reported in annual steps for the period 2004/2005 – 2009/2010 [IR03]. Total AEI estimated that way for the whole country was 8 847 818 ha.

Irrigated areas were assigned to regions classified as irrigated (priority 8) or as mosaic of irrigated land and other land use (priority 7) in a land cover inventory that is based on Landsat imagery and was developed in year 2006 [IR04]. The distribution of irrigated land in this inventory fitted very well to former maps showing the extent of irrigated land in Iran, e.g. [IR05] and [IR06].

Percentage of irrigation water use from ground- and surface water reported for 8 water regions and year 1995 [IR07]. It was assumed that the ratio between AEI irrigated with groundwater and total AEI was similar to the ratio between irrigation water use from groundwater and total irrigation water use. AEI from groundwater computed that way for the whole country was 56.7 percent of total AEI and scaled to meet the 62.1 percent percentage irrigated area with groundwater supply reported in the AQUASTAT data base for year 2003 [IR01]. Area actually irrigated was 6 423 342 ha in year 2003 [IR02], while total harvested irrigated cropped area was 8 592 554 ha in the same year [IR01]. This indicates that multicropping is practised on a large extent of the land used for irrigated annual crops. Area actually irrigated varied between 5 849 455 ha and 6 739 810 ha in period 2005 – 2010 [IR03]. AAI per province was computed therefore as the mean of the annual AAI reported for the period 2004/2005 – 2009/2010 [IR03]. Total AAI estimated that way for the whole country was 6 407 307 ha.

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Iraq

Area equipped for irrigation is reported to be 3 525 000 ha [IQ01]. The figures refer to 1990. A large part of this area is not irrigated. Because of waterlogging and salinity, the area irrigated in 1993 was about 1 936 000 ha [IQ02] and this had decreased to 1 775 750 ha in 2001 [IQ03] and varied between 2.1 Million ha and 2.6 Million ha in period 2004 to 2009 [IQ04]. However, the three Kurdish provinces in the north of the country (Dahoak, Arbil and Sulaimania) are not included in these figures. Therefore, statistics originating from a land

survey in 1992 and provided by the Kurdistan Democratic Party [IQ05] were used for these provinces. Statistics on the area equipped for irrigation were not available on a province level. Therefore, it was estimated by combining areas computed from digitized land-use maps [IQ06], tactical pilot charts [IQ07] and satellite imagery [IQ08] with province-level statistics of the area actually irrigated in 1993 [IQ02] and 2001 [IQ03]. It was assumed that the area equipped for irrigation was as least as high as the maximum of the area actually irrigated in 1993 and 2001. In order to estimate the area of the irrigated areas not in use, the land-use maps, pilot charts and satellite imagery were used for the downstream provinces of Muthannia, Qadisiya, Najaf, Babil, Baghdad, Thegar, Diala, Misan and Wasit. The estimates for the northern provinces of Dahoak, Arbil and Sulaimania are as reported in the land survey.

Irrigated areas were digitized from land-use maps [IQ06], tactical pilot charts [IQ07] and satellite imagery [IQ08].

Area equipped for irrigation with groundwater was 220 000 ha or 6.2 percent of total AEI in year 1990 and 146 000 ha in year 1997 [IQ01]. Area actually irrigated was set to 2 530 000 ha representing the annual mean reported in [IQ04] for the period 2004-2009. Subnational information on area actually irrigated or area equipped for irrigation with groundwater was not available.

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Israel

According to the official statistics AEI in year 2004 was 225 000 ha [IL01]. However, the area actually used for irrigation reached its maximum extent in the mid-1980s at about 230 000 ha and declined then to 205 700 ha in 1990 [IL02], 186 600 ha in 2000 [IL02], and 151 400 ha in 2009 [IL03]. This means that a growing part of the irrigation infrastructure has been out of use. Subnational statistics on the extent of AEI were not available. To account for the decline in the extent of irrigated land, AEI per natural region was estimated based on the extent of the major irrigated crops reported for year 2000 [IL02]. As indicated at the national scale [IL02], it was assumed that the flower and garden-plant area was completely irrigated, that citrus plantations were completely irrigated, that 91.88 percent of the vegetable area was irrigated, and that 74.08 percent of the other plantations (except citrus) was irrigated. Total AEI computed this way was 186 600 ha of which an irrigated area of about 3 200 ha is located in enclosed settlements in the West Bank and Gaza territories.

The irrigated areas were digitized from two irrigation maps ([IL04]; [IL05]). The outlines of the digitized areas were then adjusted using satellite imagery [IL06]. Some smaller irrigation schemes visible on the satellite images were also digitized and incorporated.

49 percent of the total water use in Israel is from groundwater, 33 percent from surface water (extraction from the Jordan River) and 13 percent from treated wastewater and 5 percent from desalination plants [IL07]. About two third of the water use is for irrigation. About 90 percent of the fresh water resources have been incorporated into a single system that enables implementation of a uniform national policy of water production and regular supply to the different sectors of consumers [IL08]. This also means that water from different sources is mixed and transported over long distances. Therefore it was assumed that the partitioning of water supply into different water sources also represents the percentages of irrigated area irrigated from the corresponding water sources. Area actually irrigated was 151 400 ha in year 2009 [IL03]. Subnational data on AAI were not available.

References:

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Japan

Area equipped for irrigation was 3 128 079 ha in year 1993, comprising of 2 781 411 ha irrigated paddy fields and 346 668 ha irrigated upland fields [JP01]. Almost all paddy fields are equipped for irrigation. In contrast, irrigation of non-paddy fields (upland crops) started after World War II and extended to about 10 percent irrigated upland fields at the beginning 1990s [JP02]. Area equipped for irrigation per prefecture was estimated as the sum of paddy field area reported for year 2010 [JP03] and irrigated area of upland crops which was computed based on the percentage of irrigated upland area reported for each province in year 1993 [JP04] and the total growing area of upland crops in year 2010 [JP03]. Total area equipped for irrigation estimated this way was 2 834 956 ha. The declining trend in AEI (compared to the data reported for year 1993) has been caused mainly by the reduction in the extent of paddy land to 2 496 000 ha in year 2010 [JP03].

The irrigated areas were digitized from an irrigation map sent to FAO with the AQUASTAT country questionnaire [JP05].

The area equipped for irrigation is in general irrigated with surface water withdrawn from reservoirs and streams. In addition, groundwater is used supplementary on about 500 000 ha during the low water season from April to September, especially in August [JP01]. To account for the area irrigated with a mix of both, surface water and groundwater, area irrigated with groundwater was set to 250 000 ha and the remaining area was assumed to be irrigated with surface water. Area actually irrigated per prefecture was computed as the difference between the area equipped for irrigation and the extent of unplanted paddy land reported for year 2010 [JP06]. Total area actually irrigated estimated this way was 2 651 256 ha. This should be considered as the maximum extent because more than 27 percent of the paddy land was cropped in year 2010 with non-rice crops (e.g. vegetables) [JP06] and it maybe that a fraction of these crops was cultivated as rainfed crops.

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Jordan

The area equipped for irrigation increased from 64 300 ha in 1990 [JO01] to 78 860 ha in 2004 [JO02] and 83 450 ha in year 2006 [JO03]. Irrigated area per province was extracted from the report of the Agricultural Census 2007 [JO04]. However, total irrigated area reported by the agricultural census (125 870 ha) was larger than the area reported in the aforementioned statistics, while total cultivated area was similar. One reason maybe that the limited availability of water resources was not reflected in these statistics. Therefore total AEI was scaled to 83 450 ha reported by the Department of Statistics for year 2006 [JO03].

The irrigated areas were localized using an irrigation map of the Jordan Valley and a map showing irrigated areas outside the Jordan Valley [JO05]. The irrigation schemes were then digitized using satellite imagery [JO06]. The extent of the areas digitized that way in the four northern provinces Ajlun, Irbid, Jarash and Mafraq was smaller than the AEI reported by the statistics. Therefore, the remaining AEI was assigned in these provinces to areas classified as rainfed cropland in the regional Globcover landcover classification for North Africa [JO07].

The percentage of area irrigated with groundwater was extracted for each province from the report of the agricultural census 2007 [JO04]. Total area equipped for irrigation with groundwater calculated this way was 44 479 ha or 53 percent of the total AEI and thus similar to the percentage reported in the FAO Aquastat country report [JO02]. In contrast, AEI irrigated with a mixture of treated wastewater and surface water was 15.9 percent according to FAO [JO02] but 0 according to the agricultural census database [JO04]. The reason for this difference could be that treated waste water is released into rivers and the mixed water is later extracted downstream by the farmers for irrigation [JO02]. Therefore it is very likely that

farmers consider the part of treated waste water extracted from the river or reservoir as surface water. Area actually irrigated was 72 009 ha or 91 percent of AEI in year 2004 [JO02]. The same ratio between AAI and AEI was used to estimate AAI in year 2006.

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Kazakhstan

Total area equipped for irrigation in year 1993 was 3 556 400 ha and consisted of 2 313 100 ha full or partial control irrigation, 138 700 ha equipped wetlands and inland valley bottoms and 1 104 600 ha spate irrigation area [KZ01]. However, it has been estimated that about 680 000 ha of the land were out of use in the 1994 cropping season because of soil salinization, waterlogging, broken or incomplete distribution systems or because of other reasons [KZ02]. The irrigated areas in 2002 consisted of 1 220 000 ha of full or partial control irrigation and 580 600 ha of so-called "engineering-liman irrigation and inundated hay lands" [KZ03] representing spate irrigation areas and equipped wetlands and inland valley bottoms. Area equipped for irrigation per province in year 2006 was estimated by selecting for each province the maximum of the irrigated areas reported in the statistical yearbook “Environmental protection and sustainable development in Kazakhstan 2010” [KZ04] and the report of the agricultural census 2006/2007 [KZ05]. The extent of irrigated land in the western part of Kazakhstan, where mainly spate irrigation is practised, was larger in the yearbook [KZ04] while irrigated areas in the southern part, where most of the full or partial control irrigation schemes are located, was larger in the agricultural census report [KZ05]. Total area equipped for irrigation estimated this way was 2 482 500 ha.

The irrigated areas were localized using a map of irrigation projects [KZ02] and two course-scale maps showing the outlines of the major irrigated areas of the country ([KZ06]; [KZ07]). By using Landsat satellite imagery [KZ08] and a map of irrigation areas in the Aral Sea Basin [KZ09], the outlines of the irrigated areas were then digitized in more detail. These digitized irrigated areas were combined with irrigated cropland derived from the Globcover regional classification for Central Asia [KZ10]. Irrigated area was then assigned with the highest priority to pixels being irrigated according to both data sources and after that, if required, to pixels that were either covered by the digitized irrigated areas or classified as irrigated by Globcover.

Area actually irrigated was estimated for each province based on the ratio between irrigated arable land (1 392 100 ha in total) and arable land equipped for irrigation (1 573 600 ha in total) reported by the agricultural census 2006/2007 for the full or partial control irrigation schemes [KZ05]. Total area actually irrigated computed this way was 2 141 300 ha. The

difference between AEI and AAI (341 200 ha) is in good agreement with the so called "reserve land" reported by the statistical yearbook [KZ04] for year 2006 (368 400 ha). Area equipped for irrigation with groundwater was 179 000 ha in year 1993 [KZ01]. It was assumed that this infrastructure is still operational. Area equipped for irrigation with groundwater was assigned to each province relative to the share on equipped arable land reported by the agricultural census 2006/2007 [KZ05].

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Kuwait

The total cultivated area of the 4545 holdings in Kuwait was 10 142 ha in year 2006, of which 3935 ha of cultivated land were located in district Al-Ahmadi and 6207 ha in district Al-Jahra [KW01]. Because of the climate conditions, all the cultivated area is irrigated and it was therefore assumed that area equipped for irrigation was similar to the farm area. Harvested area of irrigated crops was 13 463 ha in the same year, of which winter crops accounted for 5970 ha, summer crops for 1764 ha, perennial crops for 3913 ha and green house crops for 1815 ha [KW01].

The irrigated areas were digitized from Landsat satellite images [KW02]. The digitized areas were in good agreement with areas shown as vegetated in recent governorate and municipality maps [KW03].

Area actually irrigated in year 2003 was similar to area equipped for irrigation [KW04]. Therefore and because of the high harvested area of irrigated crops it was assumed that area actually irrigated in year 2006 was also equal to area equipped for irrigation. The share of area equipped for irrigation with groundwater was set to 76.3 percent of the total area equipped for irrigation (7742 ha), similar to the share of groundwater use in agriculture reported for year 2002 [KW04]. The remaining area equipped for irrigation was irrigated with treated waste water or desalinated water.

References:

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Kyrgyzstan

Area equipped for irrigation for the seven regions (1 045 131 ha in total) was derived from a melioration inventory related to year 2005 [KG01]. To estimate area equipped for irrigation for each of the 40 districts an inventory for year 1994 was used [KG02]. AEI reported in this inventory for each district (1 075 040 ha in total) was scaled so that the sum of AEI in each region was similar to the AEI reported in [KG01] for year 2005.

The irrigated areas were localized using a map of irrigation projects [KG03] and then digitized using satellite imagery [KG04] and a map of irrigated areas in the Aral Sea Basin [KG05]. These digitized irrigated areas were combined with irrigated cropland derived from the Globcover regional classification for Central Asia [KG06]. Irrigated area was then assigned with the highest priority to pixels being irrigated according to both data sources and after that, if required, to pixels that were either covered by the digitized irrigated areas or classified as irrigated by Globcover.

Area equipped for irrigation with groundwater was 7000 ha in year 1994 [KG06] while area actually irrigated was 1 021 400 ha in year 2005 [KG07].

References:

[KG01]: **Department of Water Resources**. 2005. *Melioration Sector's Summary Information of Water Resources Department on 01.09.2005*. Report sent to FAO as part of the country questionnaire 2009.
[KG02]: **Asian Development Bank**. 1995. *Agriculture sector program loan to the government of the Kyrgyz Republic*. Project Preparation Technical Assistance, Annex 4 - Irrigation, report prepared by S. Gardiner, ULG Consultants Ltd, available in the AQUASTAT library.
[KG03]: **World Bank**. 1998. *Kyrgyz Republic - Irrigation Rehabilitation Project. Project appraisal document*. Report No. 17531 KG.
[KG04]: **Earth Satellite Corporation**. 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-344, 071-345, 071-360, 071-361 and 071-373. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.
[KG05]: **Unknown**. *Aral Sea Basin 1:2,500 000 - administrative boundaries and irrigated areas*. Map available in the FAO-AGL library.
[KG06]: **ESA.** 2008. *Regional Globcover Land Cover – Central Asia.* Version 2.2. http://postel.mediasfrance.org/en/DOWNLOAD/, 24/03/2009.
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Lao People's Democratic Republic

Area equipped for irrigation was reported at 310 000 ha [LA01]. The figures refer to year 2005. Areas equipped for irrigation and area actually irrigated per province were derived from an inventory reporting areas equipped for irrigation by weirs, reservoirs, pump schemes, temporary weirs, gabions, gates and dikes and area actually irrigated in the wet and dry season [LA02]. Area actually irrigated was set to the average of the areas irrigated in the wet season in the period 2001-2005 (271 704 ha in total). Area equipped for irrigation was set to the area

irrigated in the wet season 2002, with the exception of the provinces Bokeo, Luangnamtha and Oudomxay, where the AAI computed as the average of the years 2001-2005 was larger than the AAI in year 2002. For these provinces AEI was assumed to be similar to AAI. Total AEI computed that way summed up to 309 657 ha.

Digital maps of irrigated areas (polygon dataset) and irrigation projects (point dataset) were used as compiled by the Mekong River Commission [LA03]. In general, the point dataset was used for small schemes (fewer than 300 ha) while the polygon dataset was used for large schemes (more than 300 ha) - 265 000 ha of irrigated area was located in this way. The remaining part of the irrigated area was distributed to paddy areas taken from a digital landcover map [LA04].

Area equipped for irrigation with groundwater is 200 ha [LA05].

References:

[LA01]: **Pheddara, P.** 2007. *Large rice-based irrigation systems in Lao PDR.* In: Proceedings of the regional workshop on the future of large rice-based irrigation systems in Southeast Asia held in Ho Chi Minh City, Viet Nam, October 26-28, 2005. RAP Publication 2007/28, FAO, Rome, Italy, 101-107, http://www.fao.org/docrep/010/ai408e/ai408e00.htm, 18/08/2009.

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[LA04]: **FAO**. 2004. *Dataset Landcover.zip*, provided by FAO ASIACOVER project.

[LA05]: **FAO**. 2012. *AQUASTAT country profile of Lao People´s Democratic Republic, version 2010*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/laos/index.stm, 02/04/2012.

Lebanon

Area equipped for irrigation per district was derived from the Agricultural Atlas of Lebanon, that is based on the results of an agricultural census undertaken in year 1998 [LB01]. Total AEI according to this inventory was 104 009 ha.

Irrigated areas were digitized from a land-use map [LB02] and from satellite imagery [LB03]. In several districts, the extent of the areas digitized that way was smaller than the AEI reported by the statistics. Therefore, the remaining AEI was assigned in these districts to areas classified in the regional Globcover landcover classification for North Africa [LB04] as rainfed cropland and, if required, to areas classified as mosaics of rainfed cropland with other land uses. The resulting pattern of irrigated land was quite similar to a map showing irrigation schemes in Lebanon in year 2004 [LB05].

Area irrigated with surface water and area irrigated with groundwater per district was derived from the Agricultural Atlas of Lebanon [LB01. Total AEI irrigated with groundwater was 54 070 ha (52 percent of total AEI) while the remaining area was irrigated with water extracted from surface water bodies.

References:

[LB01]: **Ministry of Agriculture and FAO**. 2009. *Atlas Agricole du Liban*. Ministry of Agriculture and FAO, Beirut, Lebanon, http://www.agriculture.gov.lb/ATLAS_%20AGRICOLE/atlas.html, 21/08/2009.

[LB02]: **Universität Tübingen**. 1993. *Tübinger Atlas des Vorderen Orients (TAVO)*. Plate AX6, Reichert, Germany, Wiesbaden.

[LB03]: **Earth Satellite Corporation**. 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tile 071-272. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.
[LB04]: **POSTEL**. 2008. *GLOBCOVER landcover classification, Version 2.2, North Africa*. Globcover database. http://toyo.mediasfrance.org/?GLOBCOVER, 24/03/2009.
[LB05]: **Ministry of Energy and Water**. 2004. *Water Integrated Management Plan*. Location of Existing Irrigation Scheme in Lebanon, map available from the FAO AQUASTAT library.

Malaysia

Total area equipped for irrigation is 362 687 ha [MY01]. The figures refer to 1994. Irrigated area per state was available for 1993 and totalled 321 696 ha [MY02]. Therefore, irrigated area per state was scaled so that the sum was equal to the value given by the AQUASTAT report for the entire country.

The boundaries of nine large, government irrigation schemes, designated as granary schemes and totalling 210 552 ha, were digitized from maps provided by the Department of Irrigation and Drainage [MY03]. The remaining part of the irrigated area was assigned to a large number of small-scale irrigation schemes as digitized from another irrigation map [MY04].

Area equipped for irrigation with groundwater was 27 260 ha in year 1994 [MY01]. Subnational statistics on the fraction of groundwater use were not available. The fraction of the area equipped for irrigation that is actually used for irrigation was not reported. However, the because of the high cropping intensity on the full control irrigated area (140 percent in year 1996) it was assumed that the all area equipped for irrigation is actually irrigated.

References:

[MY01]: **FAO**. 2013. *AQUASTAT country profile of Malaysia, version 2011*. FAO, Rome, Italy, http://www.fao.org/nr/water/aquastat/countries_regions/MYS/index.stm, 06/02/2013.
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[MY03]: **Department of Irrigation and Drainage**. 2004. *Granary areas in Malaysia*. http://agrolink.moa.my, 24/03/2004.
[MY04]: **Wong, K.F., Shahrin, B.Y. & Adnan, M.N.M.** 1991. *Management arrangements for diversifying rice irrigation systems in Malaysia*, Figure 1. In S.M. Miranda & A.R. Maglinao, eds. Management arrangements for accommodating non-rice crops ricebased irrigation systems, pp. 53-66. Proc. first progress review and coordination workshop of the research network on irrigation management for crop diversification in rice based systems, Quezon City, the Philippines, 10-14 December 1990.

Maldives

The cultivated area was estimated to be about 3 000 ha in 2000, but there is no irrigation of importance on the Maldives [MV01].

References:

[MV01]: **FAO**. 2013. *AQUASTAT country profile of Malaysia, version 2011*. FAO, Rome, Italy, http://www.fao.org/nr/water/aquastat/countries_regions/MDV/index.stm, 06/02/2013..

Mongolia

Area equipped for irrigation in year 1993 comprised of 43 400 ha registered schemes using sprinkler irrigation, 13 900 ha of unregistered schemes using surface irrigation methods and 27 000 ha of traditional spate irrigation. However, in 1992 only 52 percent of the sprinkler irrigation area was operational [MN01]. An inventory of the irrigated area per aimag (district) was only available for the sprinkler-irrigation schemes [MN02]. Most of the sprinkler-

irrigated area is located in the west and the north of the country. It was also reported that about 80 percent of the surface-irrigation schemes are located in the west of the country [MN03]. Therefore, in order to estimate the total f/p control area equipped for irrigation at aimag level, the sprinkler-irrigated area per aimag was scaled so that the sum of the irrigated areas was 57 300 ha (sum of sprinkler irrigation and full control surface irrigation). The extent of spate irrigation was estimated by computing for each district the difference between the area classified as irrigated cropland in the Globcover landcover classification for Central Asia (MN04) and the AEI under f/p control and by scaling this computed difference using a constant coefficient so that the total area equalled the reported 27 000 ha.

The location of 156 sprinkler-irrigation schemes was derived from a recent inventory [MN02]. The total area equipped for irrigation in these schemes was reported as being 43 381 ha. Geographical coordinates of the schemes were missing in the inventory. However, the name of the project and the name of the closest village were given. Therefore, the geographical coordinates of the villages were detected by using the Geographical Names Server of the National Geospatial-Intelligence Agency (available at http://earth-info.nga.mil), and the related irrigated areas were assigned to these locations. However, the location of 13 schemes covering 2 060 ha in total could not be found in this way. In addition, the location of the unregistered schemes (covering about 13 900 ha in total) and the location of the spate irrigation schemes (covering about 27 000 ha in total) was unknown. Therefore, area classified as irrigated cropland was extracted from the Globcover regional land cover product for Central Asia [MN04] and irrigated land in unregistered schemes or spate irrigation was distributed to these areas.

According to a report published more recently [MN05] there were 43 000 ha irrigated area in 1990, of which 16 000 ha (37 percent) were irrigated with surface water. Likely these statistics referred to the registered schemes only. Based on this information it was assumed that 37 percent of the registered and unregistered irrigation schemes and additionally all of the spate irrigation areas are irrigated with surface water resulting in 48 300 ha (57.3 percent) of equipped area irrigated with surface water and 36 000 ha (42.7 percent) irrigated with groundwater. Area actually irrigated was estimated at 62 900 ha [MN01].

References:

[MN01]: **FAO**. 2013. *AQUASTAT country profile of Mongolia, version 2011*. FAO, Rome, Italy, http://www.fao.org/nr/water/aquastat/countries_regions/MNG/index.stm, 21/02/2013.
[MN02]: **FAO**. 1994. *Irrigation rehabilitation project, Working Paper 1*. FAO, Rome, Italy.
[MN03]: **FAO**. 1995. *Irrigation rehabilitation project. Working Paper 3*. FAO, Rome, Italy.
[MN04]: **ESA.** 2008. *Regional Globcover Land Cover – Central Asia.* Version 2.2. http://postel.mediasfrance.org/en/DOWNLOAD/, 24/03/2009.
[MN05]: **Tuinhof, A. and Nemer, B.** 2009. *Groundwater assessment in the Gobi region*. Report to the World Bank, prepared by Acacia Water, http://siteresources.worldbank.org/INTMONGOLIA/Resources/Southern_mongolia_groundwater_assessment_eng.pdf, 24/08/2009.

Myanmar

The irrigated area in Myanmar increased from about 1 000 000 ha in the 1991–92 cropping season to 1 841 320 ha in the 1999–2000 cropping season and to 2 110 000 ha in year 2004 [MM01]. Area equipped for irrigation in each of the 63 districts was extracted from the Digital Agricultural Atlas of Myanmar which contained statistical information for the cropping season 2001/2002 [MM02]. Area equipped for irrigation derived from the digital atlas (1 888 141 ha in total) was scaled for each district using the same scaling coefficient so that total area equipped for irrigation was 2 110 000 ha as reported for year 2004.

The location of 135 major irrigation works (dams, weirs and tanks) was digitized using three maps showing irrigation works constructed in the periods before independence, between 1969 and 1988, and post-1988 [MM03]. However, many projects are large and the irrigated fields may be located far from the major reservoir or weir belonging to the project. Therefore, area classified as irrigated cropland or as rainfed cropland was extracted from the Globcover regional land cover product for Central Asia [MM04]. Irrigated area was first assigned to small scale projects (< 4000 ha) identified according to the three irrigation maps, then to areas classified as irrigated cropland according to Globcover and finally, if required, to areas classified by Globcover as rainfed cropland.

Area equipped for irrigation with groundwater was 55 175 ha in year 1995 [MM05] and increased to 81 000 ha in year 2000 and 100 000 ha in year 2003 [MM01]. The large harvested area of irrigated crops (2 722 000 ha in year 2006) indicates a high cropping intensity on irrigated land [MM05]. It was therefore assumed that the whole area equipped for irrigation is actually being used.

References:

[MM01]: **Ministry of Agriculture and Irrigation**. 2013. *Irrigation & crop area*. http://id.moai.gov.mm/website/croparea/areasandmultiplecropping.html, 06/03/2013.
[MM02]: **FAO, UNDP, MOAI**. 2009. *Digital Agricultural Atlas of the Union of Myanmar*. http://dwms.fao.org/atlases/myanmar/content_en.htm, 06/03/2013.
[MM03]: **Ministry of Agriculture and Irrigation**. 2013. Irrigation works in Myanmar. http://id.moai.gov.mm/website/works/historyofmyanmarirrigationwork.html, 06/03/2013.
[MM04]: **ESA.** 2008. *Regional Globcover Land Cover – Central Asia.* Version 2.2. http://postel.mediasfrance.org/en/DOWNLOAD/, 24/03/2009.
[MM05]: **FAO**. 2013. *AQUASTAT main country database*. http://www.fao.org/nr/water/aquastat/dbase/index.stm, 06/03/2013.
[MM06]: **FAO**. 2013. *AQUASTAT country profile of Myanmar, version 2011*. FAO, Rome, Italy, http://www.fao.org/nr/water/aquastat/countries_regions/MMR/index.stm, 06/03/2013.

Nepal

Area equipped for irrigation in Nepal is 1 168 349 ha [NP01]. The figures refer to cropping season 2001/2002 and were provided by the agricultural census for 75 districts.

Area classified as irrigated cropland or as rainfed cropland was extracted from the Globcover regional land cover product for Central Asia [NP02]. Irrigated area was first assigned to pixels classified as irrigated cropland and then, if required, to areas classified as rainfed crops.

The extent of areas irrigated with ground- and surface water was derived for each district from the agricultural census database 2001/02 [NP01]. AEI irrigated with surface water was computed as the sum of net irrigated area from seasonal canals, perennial canals, ponds and tanks while AEI irrigated with groundwater was similar to irrigated area from tube-wells and wells. Additionally it was assumed that there is a similar fraction of AEI irrigated with groundwater in categories “other sources” and “mixed”. The large harvested area of irrigated crops (1 926 000 ha in year 2006) indicates a high cropping intensity on irrigated land [NP03]. It was therefore assumed that the whole area equipped for irrigation is actually irrigated.

References:

[NP01]: **Central Bureau of Statistics**. 2013. *National Sample Census of Agriculture 2001/02 - District Level Contents*. http://cbs.gov.np/?p=570, 06/03/2013.
[NP02]: **ESA.** 2008. *Regional Globcover Land Cover – Central Asia.* Version 2.2. http://postel.mediasfrance.org/en/DOWNLOAD/, 24/03/2009.

[NP03]: **FAO**. 2013. *AQUASTAT country profile of Nepal, version 2011*. FAO, Rome, Italy, http://www.fao.org/nr/water/aquastat/countries_regions/NPL/index.stm, 06/03/2013.

Occupied Palestinian Territory

Area equipped for irrigation was about 24 000 ha in year 2003 [PS01], while the extent of irrigated agricultural land varied between 15 300 ha and 17 600 ha in period 2002 – 2008 [PS02]. Subnational statistics of AEI were not available. AEI per district was therefore estimated by selecting for each district the maximum of area actually irrigated reported for period 2002 – 2008 [PS02]. Based on the methodology described in the section on Israel, the irrigated area located in enclosed Israeli settlements was estimated to be 3 244 ha. Total AEI computed this way for the Occupied Palestinian Territory was 23 484 ha.

The irrigated areas were digitized from a land-use map [PS03]. In addition, satellite imagery was used to map schemes developed more recently [PS04]. The extent of the digitized irrigated areas in the districts Tulkarem, Qualquiya and Salfit was smaller than the AEI calculated from the statistics. Therefore, the remaining AEI was assigned in these districts to areas classified as rainfed cropland in the regional Globcover landcover classification for North Africa [PS05].

Irrigation is completely based on groundwater resources (wells in the Gaza Strip, wells and springs in the West Bank) [PS01]. Area actually irrigated was computed as the mean of the AAI reported for each district in period 2002 – 2008 [PS02].

References:

[PS01]: **FAO**. 2012. *AQUASTAT country profile of the Occupied Palestinian Territory, version 2008*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/PSE/index.stm, 07/12/2012.
[PS02]: **Palestinian Central Bureau of Statistics**. 2003-2008. *Agricultural Statistics 2002/2003 – 2007/2008*. http://www.pcbs.gov.ps/pcbs_2012/Publications.aspx, 04/12/2012.
[PS03]: **Universität Tübingen**. 1993. *Tübinger Atlas des Vorderen Orients (TAVO)*, Plate AX7. Reichert, Germany, Wiesbaden.
[PS04]: **Earth Satellite Corporation**. 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tile 071-272. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.
[PS05]: **POSTEL**. 2008. *GLOBCOVER landcover classification, Version 2.2, North Africa*. Globcover database. http://toyo.mediasfrance.org/?GLOBCOVER, 24/03/2009.

Oman

Area equipped for irrigation according to the agricultural census 2004 was 58 850 ha [OM01]. Area equipped for irrigation per region in year 2004 was derived from the census report [OM02]. Most of the irrigated land was located in the Al Batinah coastal plain (31 696 ha).

The cultivated area, which is completely under irrigation [OM01], was digitized from Landsat satellite imagery [OM03].

Groundwater extracted from wells or springs is the only source of irrigation water [OM01]. Area actually irrigated in year 2004 was assumed to be similar to area equipped for irrigation because of the high harvested area of irrigated crops (63 607 ha in year 2004) and the high share of perennial crops (83 percent of the total harvested area).

References:

[OM01]: **FAO**. 2013. *AQUASTAT country profile of Oman, version 2008*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/OMN/index.stm, 20/01/2013.

[OM02]: **Ministry of Agriculture and Fisheries**. 2005. *Agricultural census 2004*. http://omanagriculture.net/Pages/PageCreator.aspx?lang=AR&I=0&DId=0&CId=0&CMSId=800645, 20/01/2013.

[OM03]: **Earth Satellite Corporation**. 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-308, 071-318, 071-319 and 071-320. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

Pakistan

Data on the extent of area equipped for irrigation is not collected by statistical surveys in Pakistan. Statistics available from the Central government (e.g. the Agricultural Census Organization) or institutions of the province governments (e.g. the Ministries of agriculture) distinguish the net area under irrigation and the sown area of irrigated crops. The net area under irrigation does not account for structures that were not operating in the year of the survey. It is therefore similar to the definition of area actually irrigated used in this inventory but does not account consistently for spate irrigation. The sown area of irrigated crops is typically higher than the area equipped for irrigation because double cropping is practised in many regions of Pakistan. Area equipped for irrigation reported by FAO-AQUASTAT is therefore based on additional information provided by the FAO country questionnaire. According to this questionnaire total area equipped for irrigation was 19 990 000 ha in year 2008 consisting of 19 270 000 ha full control irrigation and 720 000 ha spate irrigation area while the harvested area of irrigated crops was 21 451 674 ha [PK01]. To estimate area equipped for irrigation, area actually irrigated and area irrigated with groundwater or water extracted from surface water bodies at the district level, data provided by different institutions under the responsibility of the provinces have been used for this inventory. Data availability has been very different resulting in different base years of the statistics used here but if possible, data related to year 2005 were used. The specific references are given below for each federal state. It is necessary to point out that some statistics were no more available for download at the time of the preparation of this report because important parts of the data infrastructure of Pakistan were offline (e.g. the servers of the Sustainable Development Networking Programme that hosted many databases and statistics at the district level). Statistics cited in this report that are no more available for download can be obtained from the authors on request.

Total area equipped for irrigation estimated using the references and methods described below was 16 725 843 ha of which 5 172 552 ha were irrigated with groundwater and the remaining area with water extracted from surface water bodies. Area actually irrigated was 13 378 476 ha. Total area equipped for irrigation in this inventory is therefore lower than the one reported in the FAO AQUASTAT country report [PK01] but agrees quite well with recent data originating from the agricultural census 2010 [PK02]. According to the census report cultivated area with irrigation facilities is 13 801 088 ha while another 3 184 009 ha are classified as Barani (areas depending on flood or seepage water). The spate irrigation areas belong therefore, together with non-equipped flood recession cropping areas, to the Barani category. Cultivated area is the area that was cropped at least once in the year of the census or the year before. There might be therefore some additional area with irrigation infrastructure that was not cultivated for a longer period and therefore assigned to the farm area classified as culturable waste (3 592 202 ha in total). According to the census terminology culturable waste is “that uncultivated farm area which is otherwise fit for cultivation but was not cropped during the census year or in the year before due to presence of any of the constraints like water logging, non-availability of irrigation water, salinity, un-levelling of land, manpower and / or funds shortage, etc” [PK02]. The total area equipped for irrigation of 16 725 843 ha computed in this inventory seems therefore to be a quite reasonable estimate. The area

irrigated with groundwater alone was 2 852 092 ha according to the census report while 5 623 067 ha were irrigated with water from both, canals (surface water) and tubewells (groundwater).

The large-scale canal-irrigated area was digitized from a map showing the irrigation infrastructure and the irrigated areas of the country [PK03]. Satellite imagery [PK04] was used to incorporate the small-scale schemes and to adjust the outlines of the digitized canal-irrigated areas. The so digitized irrigated area was then intersected with areas classified as cropland in the Globcover regional land cover classification for Central Asia [PK05] or Northern Africa [PK06]. Irrigated area was first assigned to pixels belonging to both, digitized irrigation regions and irrigated cropland according to Globcover. If the irrigated area in the district was larger than the sum of the areas assigned in the first step, irrigated areas was assigned in addition to pixels belonging to just one the two categories. In the final step, if required, irrigated area was assigned to pixels classified in Globcover as rainfed cropland.

The following sections present subnational irrigation figures for each of the federal states:

Balochistan
District data on irrigated areas and the source of irrigation water were derived from an inventory reporting the water sources of the irrigation areas in season 1994/95 [PK07]. AEI irrigated from wells and tube wells was scaled so that the total sum of these areas for whole Balochistan were similar to the statistics published by the Ministry of Agriculture for season 2004/05 [PK08]. Total AEI was increased that way by 180 854 ha to 1 173 099 ha, of which 490 000 ha were irrigated from groundwater and the remaining area from surface water (canals or spate irrigation).

N.W.F.P. and F.A.T.A.
Irrigated area from canals, tanks, tube wells, wells, lift pumps and others were available at the district level for season 2006/2007 [PK09], [PK10]. It was assumed that areas irrigated from wells and tube wells represented areas irrigated with groundwater while areas irrigated from canals, tanks and lift pumps represented areas irrigated with surface water. Percentage irrigation from groundwater was computed by assuming that the contribution of groundwater in the group of others is similar to the contribution of groundwater when only considering the groundwater and surface water sources specified before. Total Area equipped for irrigation was 959 691 ha, of which 168 900 ha were irrigated with groundwater.

Punjab
According to the National Water Sector Profile [PK11] area equipped for irrigation in Punjab is 8.62 million ha, while the harvested area of irrigated crops is about 14 million ha per year indicating a high cropping intensity on irrigated land. More than half of the irrigated land is supplied by canal wells and canal tube wells meaning that there is conjunctive use of groundwater and surface water. Percentage irrigation from groundwater was computed at the district level by using data related to the season 2005/2006 [PK12]. Areas with conjunctive use were thus assumed to have 50 percent groundwater and 50 percent surface water supply. Furthermore we assumed that the fraction of area equipped for irrigation from groundwater is similar to the fraction of harvested irrigated crop area from groundwater. Area equipped for irrigation per district was estimated by subtracting the reported rainfed area from the reported net sown area in season 2005/2006 [PK13]. Area equipped for irrigation computed that way was 9 133 000 ha, of which 4 293 258 ha were irrigated with groundwater and 4 839 742 ha were irrigated with surface water.

Sindh

According to the National Water Sector Profile [PK11].Area equipped for irrigation in Sindh is 5.39 million ha. Area equipped for irrigation per district was estimated by subtracting the reported rainfed area in season 1997/1998 from the reported cultivated area [PK14]. Area equipped for irrigation computed that way was 5 369 589 ha. However, only small portions of this area are actually used, mainly because of the shortage of water supply from the Indus River System. In season 2004/2005 the net area sown was only 2.5 million ha in Sindh and the total harvested area was about 3.3 million ha [PK08]. Area actually irrigated was computed at the district level by using data on the area supplied by canals related to the season 2004/2005 [PK15] and data on the area supplied by wells, tube wells, canal wells and canal tube wells related to the season 1994/1995 [PK14]. Total AAI computed this way was 2 438 244 ha.

Northern Areas and AJ&K

Irrigated area per district, totals 90 464 ha. It was assumed that all the cultivated area as reported by the 1990 agricultural census [PK16] was irrigated. However, other studies indicate that the irrigated area in this very remote, mountainous region might be even larger than that reported by the census [PK17]. It was assumed that the whole AEI is irrigated with surface water.

References:

[PK01]: **FAO**. 2013. *AQUASTAT country profile of Pakistan, version 2011*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/PAK/index.stm, 07/03/2013.

[PK02]: **Agricultural Census Organization**. 2012. *Agricultural census 2010 - Pakistan report*. Government of Pakistan, Statistics Division, http://www.pbs.gov.pk/node/484, 07/03/2010.

[PK03]: **Ministry of Water and Power**. 1994. *Irrigation system of Pakistan*. Islamabad, Chief Engineering Adviser's Organisation.

[PK04]: **Earth Satellite Corporation**. 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-332, 071-333, 071-341, 071-342, 071-343, 071-344, 071-358, 071-359, 071-360 and 071-370. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

[PK05]: **ESA.** 2008. *Regional Globcover Land Cover – Central Asia.* Version 2.2. http://postel.mediasfrance.org/en/DOWNLOAD/, 24/03/2009.

[PK06]: **POSTEL**. 2008. *GLOBCOVER landcover classification, Version 2.2, North Africa*. Globcover database. http://toyo.mediasfrance.org/?GLOBCOVER, 24/03/2009.

[PK07]: **Government of Balochistan**. 2004. *District database*. Government of Balochistan, http://bdd.sdnpk.org, 27/07/2004.

[PK08]: **MINFAL**. 2006. *Agricultural statistics of Pakistan 2004 – 2005*. Government of Pakistan, Ministry of Food, Agriculture and Livestock (MINFAL), Economic Wing, Islamabad, Pakistan, http://faorap-apcas.org/pakistan/Agriculture%20Statistics%20of%20Pakistan%202004-05/index.htm, 25/08/2009.

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Philippines

Area equipped for irrigation was 1 879 084 ha in year 2006 [PH01]. To compute area equipped for irrigation at the province level, area equipped for irrigation in the National Irrigation System (NIS) and area equipped for irrigation in the Communal Irrigation system (CIS) was derived from an inventory provided by the National Irrigation Administration and related to year 2007 [PH02]. This inventory reported area equipped for irrigation of private schemes as well, but these data were related to year 1998. Therefore area equipped for irrigation in private schemes was computed as the difference between the total area equipped for irrigation in the National Irrigation System, the Communal Irrigation System and the Individual Irrigation System reported by the Agricultural Census 2002 [PH03] and area equipped for irrigation in the NIS and the CIS reported by the National Irrigation Administration for year 2006 [PH02]. The so computed difference was then scaled to fit to the total AEI reported in the AQUASTAT country questionnaire, resulting in an area equipped for irrigation of 721 040 ha in the NIS, 559 045 ha in the CIS and 598 639 ha in private schemes.

Irrigated areas were digitized from a map provided by the Bureau of Soil and Water Management showing the extent of irrigated areas in the National Irrigation System (NIS) and the Communal Irrigation system (CIS) [PH04]. Since irrigated area in private schemes was not shown on this map, irrigated area related to private schemes was assigned to areas classified as cropland by the Globcover land cover classification [PH05].

In year 2006, 106 697 ha of the area equipped for irrigation was irrigated with groundwater, 1 477 703 ha with surface water and 294 684 ha with mixed surface and groundwater [PH01]. By assuming a groundwater contribution of 50 percent to areas irrigated with mixed sources, total area irrigated with groundwater was 254 039 ha or 14 percent of total area equipped for irrigation. While irrigation in the NIS and the CIS is predominantly from surface water resources (river diversion and reservoirs), private irrigation schemes are supplied also by pumping from aquifers and surface water bodies [PH01]. Therefore we assumed that in each province a constant fraction of 42.4 percent of the area equipped for irrigation in private schemes is irrigated with groundwater, while the area equipped for irrigation in the NIS and CIS schemes was assumed to be entirely irrigated with surface water. Because of the large harvested area of irrigated crops (2 695 825 ha in year 2006) it was assumed that area actually irrigated is similar to area equipped for irrigation.

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Qatar

Area equipped for irrigation was 12 935 ha in 2001 [QT01]. The share of area equipped for irrigation per municipality was assumed to be similar to the share of total farmland reported in the Qatar Socio-Economic Atlas [QT02].

The outlines of the farms in Qatar were digitized from a land use map (map plate 84) published in the Qatar Socio-Economic Atlas [QT02] and irrigated area was assigned to these digitized polygones.

Area equipped for irrigation with groundwater is 93.4 percent of total area equipped for irrigation (12 081 ha), while the remaining area refers to irrigation with non-conventional water sources [QT01]. Area actually irrigated was 6322 ha in year 2004 [QT01].

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Republic of Korea

Area equipped for irrigation in the Republic of Korea declined from 888 800 ha in year 1996 [KR01] to 880 365 ha in year 2002 and 806 475 ha in year 2009 [KR02]. Area equipped for irrigation per province was derived from the statistical yearbook 2010 [KR02]. The figures refer to irrigated paddy lands in the year 2009 cropping season. In addition, 203 812 ha of paddy lands are classified in the same inventory as "partially irrigated" [KR02].

The outlines of paddy areas were digitized from a land-use map provided by the Perry-Castañeda Library of the University of Texas [KR03]. Because this map dates back to the year 1973, the shape of the single paddy areas was then adjusted using Landsat satellite imagery [KR04].

In 1996, out of a total irrigated area of 888 800 ha the area served by surface water was an estimated 843 500 ha (95 percent) of which 65 percent was fed by 18 000 reservoirs, 21 percent by 6 000 pumping stations, and 14 percent by 18 000 headworks. The area served by groundwater accounted for 45 300 ha [KR01]. It was assumed, that area equipped for irrigation with groundwater remained constant at 45 300 ha while area equipped for irrigation with surface water declined to 761 175 ha. Area actually irrigated was assumed to be similar to area equipped for irrigation.

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Russian Federation
(reported under Europe)

Saudi Arabia
In 2005, the cultivated area was 1 213 586 ha, of which 1 011 923 ha consisted of annual crops and 201 663 ha of permanent crops. The cultivated area in 2005 was 23 percent less than it was in 1992. All agriculture is irrigated, and the extent of cultivation depends mainly on the availability of irrigation water as a limiting factor [SA01]. The area equipped for irrigation per province was estimated by using the maximum value of the cultivated areas reported for each province within the period 2001-2007 [SA02]. Total area equipped for irrigation estimated that way was 1 348 696 ha.

The irrigated areas were digitized using Landsat satellite imagery [SA03], MODIS Vegetation Indices [SA04] and several large-scale irrigation maps ([SA05]; [SA06]; [SA07]). The approximate position and extent of the major irrigation schemes was detected based on the corse-scale maps, and their more precise extent was derived by digitizing vegetated areas from the satellite imagery. The polygons digitized that way were then combined with cropland extracted from the Globcover regional landcover classification for North Africa [SA08] and irrigated area was first assigned to pixels that were covered by both data layers (digitized polygons AND cropland in Globcover) and after, if required, to pixels covered by just one of the two layers (digitized polygons OR cropland in Globcover).

97 percent of the area equipped for irrigation is irrigated with groundwater while the remaining area is irrigated with non-conventional water sources [SA01]. Area actually irrigated per province was estimated by computing the mean of cultivated land reported for period 2001-2007 [SA02].

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Singapore

Agrotechnology parks, which are agriculture estates developed with the necessary infrastructure for farming, cover about 1 465 ha. Of this total, 937 ha were used for farming in 2000 [SG01]. However, there are no records that would indicate irrigation in Singapore.

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Sri Lanka

Area equipped for irrigation increased from 457 200 ha in year 1980 to 570 000 ha in year 1995 and was assumed to be constant at this level until year 2011 [LK01]. Subnational information on total area equipped for irrigation was not available. Area equipped for irrigation was estimated therefore at the division level based on the irrigated paddy land extracted from an inventory related to year 2010 [LK02] and an inventory of irrigated land for crops different from paddy rice for each district related to season 1990-1991 [LK03]. Total irrigated paddy rice area was 556 630 ha while the area of other irrigated field crops was 60 916 ha in season 1990-1991 and then scaled to the area of 44 100 ha reported for year 2006. Total area equipped for irrigation estimated this way was 600 730 ha.

The locations of 308 major irrigation schemes (more than 40 ha) and 12 lift-irrigation schemes covering 246 700 ha in total were digitized from an irrigation map [LK04]. The rest of the irrigated area was assigned to paddy areas as digitized from a land-use map [LK05], from another map with a higher resolution but dating from 1972 [LK06], and from a map that was part of the 1976 Water Resources Development Plan [LK07]. In divisions where area equipped for irrigation was larger than the sum of area in the registered irrigation schemes and the digitized paddy fields, the remaining difference was assigned to pixels classified as cropland by Globcover regional landcover classification for Central Asia [LK08].

Area equipped for irrigation with groundwater was computed based on statistics on the use of agrowells collected by the agricultural census 2002 [LK09] (Department of Census and Statistics, 2009). It was assumed that the maximum of area irrigated by agrowells in the Maha 2001/02 and the Yala 2002 seasons reported for each district represented the area irrigated with groundwater (6828 ha in total). Area actually irrigated was 462 500 ha in year 2006 but subnational information on areas actually irrigated was not available.

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Syrian Arab Republic

The extent of irrigated land in the Syrian Arab Republic increased from 670 134 ha in 1989 to 1 088 891 ha in 1995 [SY01] and to 1 439 100 ha in 2004 [SY02], [SY03]. Then it declined again to 1 238 300 ha in year 2009 [SY03]. Area equipped for irrigation was calculated for each province as the maximum of irrigated areas reported for period 2004 – 2008 [SY03]. Total AEI calculated for the Syrian Arab Republic was 1 489 000 ha.

The irrigated areas were digitized from an irrigation map covering the west of the country [SY04] and from two land-use maps ([SY05]; [SY06]). In addition, satellite imagery [SY07] was used to locate recently developed schemes and to adjust the outlines of the digitized polygons. Digitized areas have been in good agreement to irrigated land shown on a land use map prepared by ICARDA [SY08].

In year 2004, in which irrigated land reached its maximum extent, irrigated area with water supply from wells was 864 700 ha while government projects (mainly reservoirs) provided water for 340 200 ha and streams provided water for 234 200 ha [SY03]. For each province, the fraction of AEI that was irrigated with groundwater was set to the fraction of AEI irrigated from wells in year 2004. This procedure resulted in a total AEI irrigated with groundwater of 889 668 ha (59.7 percent of total AEI). Area actually irrigated was calculated for each province as the annual mean of the AAI reported for period 2004 – 2008 [SY03]. Total AAI calculated that way was 1 403 200 ha.

References:

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Tajikistan

Area equipped for irrigation was 742 051 ha in year 2008 [TJ01]. Subnational statistics have been available for four regions.

The irrigated areas were digitized from a map showing irrigated areas in the Aral Sea Basin [TJ02]. The shape of the boundaries of the irrigated areas was then adjusted using satellite imagery [TJ03]. The digitized irrigated areas were combined with irrigated cropland derived from the Globcover regional classification for Central Asia [TJ04]. Irrigated area was then assigned with the highest priority to pixels being irrigated according to both data sources and after that, if required, to pixels that were either covered by the digitized irrigated areas or classified as irrigated by Globcover.

Area actually irrigated was 674 416 ha in year 2008. Area equipped for irrigation with groundwater was 32 500 ha in year 2009 while 13 075 ha were irrigated with mixed surface and groundwater [TJ05]. Therefore total area equipped for irrigation with groundwater was set to 39 038 ha.

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Thailand

Area equipped for irrigation per province in year 2007 was derived from then country questionnaire used as base for the AQUASTAT country profile [TH01]. Area equipped for irrigation per province added up to 6 414 880 ha.

Digital maps of irrigated areas (polygon dataset) and irrigation projects (point dataset) were used as compiled by the Mekong River Commission [TH02]. However, these inventories covered only the part of the country that belongs to the Mekong river watershed. In the other part of the country two similar datasets provided by the remote sensing department of FAO were used ([TH03]; [TH04]). In general, the point dataset was used for small schemes (less than 1 000 ha) while the polygon dataset was used for large schemes (more than 1 000 ha). Exceptions had to be made in cases where schemes were available only in the polygon dataset or only in the point dataset. In addition, irrigated area was assigned to agricultural land as taken from a digital land-cover map [TH05] using the priorities shown in Table A11.

In the wet season, the whole irrigated area is irrigated by using surface water resources. In the dry season, a second or third rice crop can be cultivated if the water supply is ensured. This is often realized by private shallow tube wells, resulting in dry season paddy areas that are larger nowadays than the potential area estimated before based on available (surface) water resources [TH06]. Total area planted with a second rice crop was 495 712 ha in year 1994 and increased to 1 584 446 ha in year 2006 [TH07]. Detailed statistics on the area irrigated with groundwater were not available but it was reported that almost all farmers in the Phitsanulok

irrigation project (104 000 ha) have access to groundwater extracted by tube wells [TH08]. Another area for which groundwater irrigation was reported is the Sukhotai irrigation project [TH09]. It was assumed therefore that the area irrigated with groundwater in the Phitsanulok and Sukhotai provinces is similar to the area planted with a second rice crop in season 2006, while for all the other provinces area irrigated with groundwater was set to 50 percent of the reported increase of the area planted with a second rice crop within the period 1994-2006. Total area equipped for irrigation with groundwater computed that way was 481 063 ha. Area actually irrigated in year 2007 was reported at 5 059 914 ha [TH01].

TABLE A11

Priorities assigned to specific land uses to distribute irrigated areas within the provinces of Thailand.

Attribute information	Priority
Broadcasted paddy-field	5
Paddy-field	5
Paddy-field 50%; broadcasted paddy-field 50%	5
Paddy-field 70%; broadcasted paddy-field 30%	5
Transplanted paddy-field	5
Broadcasted paddy-field 70%; bush and shrubs 30%	4
Coconut 50%; transplanted paddy-field 50%	4
Coconut 70%; paddy-field 30%	4
Coconut 70%; transplanted paddy-field 30%	4
Corn 70%; paddy-field 30%	4
Field crops 70%; paddy-field 30%	4
Mixed field crops 50%; paddy-field 50%	4
Mixed field crops 70%; paddy-field 30%	4
Mixed orchards 50%; transplanted paddy-field 50%	4
Mixed orchards 70%; transplanted paddy-field 30%	4
Mixed orchards 70%; paddy-field 30%	4
Mixed perennial crops 70%; broadcasted paddy-field 30%	4
Mixed perennial crops 70%; paddy-field 30%	4
Paddy-field 50%; bush and shrubs 50%	4
Paddy-field 50%; corn 50%	4
Paddy-field 50%; deciduous forest 50%	4
Paddy-field 50%; evergreen forest 50%	4
Paddy-field 50%; field crops 50%	4
Paddy-field 50%; mixed orchards 50%	4
Paddy-field 50%; para rubber 50%	4
Paddy-field 50%; perennial crops 50%	4
Paddy-field 50%; swidden cultivation 50%	4
Paddy-field 70%; bush and shrubs 30%	4
Paddy-field 70%; corn 30%	4
Paddy-field 70%; deciduous forest 30%	4
Paddy-field 70%; evergreen forest 30%	4
Paddy-field 70%; field crops 30%	4
Paddy-field 70%; mixed field crops 30%	4
Paddy-field 70%; mixed orchards 30%	4
Paddy-field 70%; mixed perennial crops 30%	4
Paddy-field 70%; sugar cane 30%	4
Paddy-field 70%; swidden cultivation 30%	4
Paddy-field 70%; disturbed deciduous forest 30%	4
Sugar cane 50%; paddy-field 50%	4
Transplanted paddy-field 50%; bush and shrubs 50%	4
Transplanted paddy-field 50%; para rubber 50%	4
Transplanted paddy-field 50%; wetland 50%	4
Transplanted paddy-field 70%; bush and shrubs 30%	4
Transplanted paddy-field 70%; coconut 30%	4
Transplanted paddy-field 70%; mixed field crops 30%	4
Transplanted paddy-field 70%; mixed orchards 30%	4

Attribute information	Priority
Transplanted paddy-field 70%; para rubber 30%	4
Village 70%; paddy-field 30%	4
Bush and shrubs 50%; paddy-field 50%	3
Bush and shrubs 70%; paddy-field 30%	3
Bush and shrubs 70%; transplanted paddy-field 30%	3
Deciduous forest 70%; paddy-field 30%	3
Disturbed deciduous forest 50%; paddy-field 50%	3
Disturbed deciduous forest 70%; paddy-field 30%	3
Disturbed evergreen forest 70%; paddy-field 30%	3
Disturbed tropical rain forest 70%; transplanted paddy-field	3
Marsh 50%; paddy-field 50%	3
Marsh 70%; paddy-field 30%	3
Para rubber 50%; transplanted paddy-field 50%	3
Para rubber 70%; transplanted paddy-field 30%	3
Swidden cultivation 70%; paddy-field 30%	3
Wetland 70%; transplanted paddy-field 30%	3
Beans and Peas 70%; sugar cane 30%	2
Cassava	2
Cassava 50%; coconut 50%	2
Cassava 50%; mixed orchards 50%	2
Cassava 50%; pineapple 50%	2
Cassava 70%; corn 30%	2
Cassava 70%; sugar cane 30%	2
Coconut	2
Coconut 50%; mixed orchards 50%	2
Coconut 50%; para rubber 50%	2
Coconut 70%; corn 30%	2
Coconut 70%; mixed field crops 30%	2
Coconut 70%; mixed orchards 30%	2
Coconut 70%; para rubber 30%	2
Coffee	2
Coffee 50%; para rubber 50%	2
Corn	2
Corn 50%; cassava 50%	2
Corn 50%; mixed orchards 50%	2
Corn 50%; sugar cane 50%	2
Corn 70%; beans and peas 30%	2
Corn 70%; cassava 30%	2
Corn 70%; mixed field crops 30%	2
Corn 70%; mixed orchards 30%	2
Corn 70%; sugar cane 30%	2
Field crops	2
Field crops 50%; orchard 50%	2
Field crops 50%; perennial crops 50%	2
Field crops 70%; orchard 30%	2
Mixed field crops	2
Mixed field crops 50%; mixed orchards 50%	2
Mixed field crops 70%; coconut 30%	2
Mixed field crops 70%; mixed horticulture 30%	2
Mixed field crops 70%; mixed orchards 30%	2
Mixed orchards 50%; coconut 50%	2
Mixed orchards 50%; mixed field crops 50%	2
Mixed orchards 50%; para rubber 50%	2
Mixed orchards 70%; coconut 30%	2
Mixed orchards 70%; corn 30%	2
Mixed orchards 70%; mixed field crops 30%	2
Mixed orchards 70%; para rubber 30%	2
Mixed orchards 70%; mixed horticulture 30%	2
Mixed perennial crops	2
Mixed perennial crops 50%; mixed field crops 50%	2

Attribute information	Priority
Mixed perennial crops 50%; mixed orchards 50%	2
Mixed perennial crops 70%; coconut 30%	2
Mixed perennial crops 70%; mixed orchards 30%	2
Perennial crops	2
Sugar cane	2
Sugar cane 50%; cassava 50%	2
Sugar cane 50%; corn 50%	2
Sugar cane 50%; mixed orchards 50%	2
Sugar cane 70%; cassava 30%	2
Sugar cane 70%; corn 30%	2
Sugar cane 70%; mixed horticulture 30%	2
Sugar cane 70%; mixed orchards 30%	2
Sugar cane 70%; pineapple 30%	2

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Timor-Leste

The total irrigated area of the country was about 72 159 ha until August 1999 when pro-Jakarta militias destroyed most of the infrastructure of the country, including irrigation and water supply systems. Since October 1999, rehabilitation works supported by the United Nations Development Programme (UNDP) have been reconstructed a part of the damaged rice watering systems [TL01]. According to an inventory compiled for the Strategic Development Plan 2011-2030 [TL02], 33 698 ha of irrigation schemes were functional in year 2005. Area equipped for irrigation per district was derived from this inventory.

Irrigated rice fields were digitized from a map published as part of the Strategic Development Plan 2011-2030 [TL02].

Irrigation water in most of the irrigated rice areas is mainly extracted from rivers and reservoirs [TL02], which is also in accordance to the situation in neighbouring Indonesia. Based on this information, percentage of irrigated area from groundwater sources was estimated at 2 percent. Area actually irrigated was 28 907 ha in year 2002 [TL01].

References:

[TL01]: **FAO**. 2011. *AQUASTAT country profile of Timor-Leste, version 2010*. FAO, Rome, Italy, http://www.fao.org/nr/water/aquastat/countries_regions/TLS/index.stm, 05/11/2012.

[TL02]: **Democratic Republic of Timor Leste**. 2010. *Draft of the RDTL Strategic Development Plan 2011-2030*. http://www.laohamutuk.org/econ/SDP/SDPDraft.htm, 26/11/2010.

Turkey

Total area equipped for irrigation was 5 280 000 ha in year 2008 [TR01]. AEI per province was derived from the Village Survey of the Agricultural Census 2001 [TR02]. Total AEI according to this survey was 5 215 144 ha.

Growing areas of irrigated crops and paddy rice cultivation areas were derived from the Corine Landcover Classification 2006 [TR03]. Additional irrigated areas were digitized from a land-use map [TR04]. The outlines of digitized polygons were adjusted by using satellite imagery [TR05]. In the provinces of Karabük, Giresun, Erzurum, Tunceli, Bingöl and Bitlis AEI reported by the census statistics was larger than the extent of irrigation schemes derived from Corine or digitized from land use maps. Therefore, irrigated land was also assigned to regions classified by the Corine Landcover Classification 2006 as rainfed cropping area by using the priorities shown in Table A12.

AAI and the percentage of AAI irrigated by groundwater, surface water and non-conventional water sources were derived from the Household Survey of the Agricultural Census 2001 [TR06]. It was assumed that areas irrigated with water extracted from wells and springs represented irrigation with groundwater, areas irrigated with water extracted from streams, lakes, artificial lakes and dams represented irrigation with surface water sources and areas irrigated with water from other sources represented irrigation with non-conventional water sources. The percentage of irrigated area supplied by groundwater was only 19 percent according to the statistics provided by the General Directorate of State Hydraulic Works (DSI) [TR01] and reported by the FAO AQUASTAT country profile [TR07] but 48 percent according to the agricultural census information collected at the household level [TR06]. However, total irrigated area according to the Household Survey was only 3.5 million ha. As a compromise it was therefore decided to assign the difference between the irrigated area reported by the Household Survey report [TR06] and the AEI derived from the Village Survey [TR02] completely to AEI irrigated with surface water. This procedure resulted in a total AEI irrigated with groundwater of 1 621 546 ha (31 percent of total AEI), an AEI irrigated with surface water of 3 484 931 ha (67 percent of total AEI) and an AEI irrigated with water from non-conventional water sources of 108 668 ha (2 percent of total AEI).

TABLE A12

Priorities assigned to specific land uses to distribute irrigated areas within the provinces of Turkey.

Attribute information	Priority
Irrigated crops (212) or paddy rice (213) according to Corine Land Cover 2006 [TR03]	7
Irrigated crops according to [TR04]	6
Arable land (211), vineyards (221), fruit trees, permanent crops and berries (222), olives (223) or mosaic of annual and permanent crops (241)	5
Pasture (231), complex cultivation patterns (242) or mosaic between agricultural land and natural vegetation (243)	4

References:

[TR01]: **DSI**. 2009. *Turkey water report 2009*. General Directorate of State Hydraulic Works (DSI), Ankara, Turkey, http://www2.dsi.gov.tr/english/pdf_files/TurkeyWaterReport.pdf, 07/12/2012.

[TR02]: **Turkish Statistical Institute**. 2012. *Agricultural Census 2001. General Agricultural Census Village Information Survey Results*, Table: Land use, http://www.turkstat.gov.tr/PreIstatistikTablo.do?istab_id=286, 07/12/2012.
[TR03]: **EEA**. 2012. *Corine Land Cover 2006 seamless vector data - version 15*. http://www.eea.europa.eu/data-and-maps/data/ds_resolveuid/f7d1b28c05ce9810df31852becd1c645, 07/04/2012.
[TR04]: **Universität Tübingen**. 1993. *Tübinger Atlas des Vorderen Orients (TAVO)*, Plate AX2. Reichert, Germany, Wiesbaden.
[TR05]: **Earth Satellite Corporation**. 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-261, 071-262, 071-273, 071-274, 071-288, 071-289, 071-300 and 071-301. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.
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[TR07]: **FAO**. 2012. *AQUASTAT country profile of Turkey, version 2008*. FAO, Rome, Italy, http://www.fao.org/nr/water/aquastat/countries_regions/TUR/index.stm, 05/11/2012.

Turkmenistan

Area equipped for irrigation (1 990 800 ha in total) was derived for five regions from a report provided with the AQUASTAT country questionnaire [TM01]. The figures refer to year 2006 and indicate that the extent of irrigated land has still been increasing in Turkmenistan.

The irrigated areas were digitized from a map showing irrigated areas in the Aral Sea Basin [TM02]. The shape of the boundaries of the irrigated areas was then adjusted using satellite imagery [TM03]. The location of the digitized irrigated areas was in good agreement with a map showing the irrigation infrastructure of the country [TM04]. These digitized irrigated areas were combined with irrigated cropland derived from the Globcover regional classification for Central Asia [TM05]. Irrigated area was then assigned with the highest priority to pixels being irrigated according to both data sources and after that, if required, to pixels that were either covered by the digitized irrigated areas or classified as irrigated by Globcover.

Area equipped for irrigation with groundwater declined to 9608 ha in year 2006 [TM06]. Area actually irrigated was similar to area equipped for irrigation in year 2006 [TM06].

References:

[TM01]: **Ministry of Water Economy**. 2007. *Programme for development of agriculture for the period up to year 2030*. Report of a joint inter-sectoral working group, in Turkmen.
[TM02]: **Unknown**. *Aral Sea Basin 1:2 500 000 - administrative boundaries and irrigated areas*. Map available in the FAO-AGL library.
[TM03]: **Earth Satellite Corporation**. 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-312, 071-313, 071-322, 071-323, 071-334 and 071-335. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.
[TM04]: **FAO**. 1998. *Turkmenistan - FAO special programme for food security.* Exploratory mission report. FAO, Rome, Italy.
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[TM06]: **FAO**. 2013. *AQUASTAT main country database*. http://www.fao.org/nr/water/aquastat/dbase/index.stm, 15/02/2013.

United Arab Emirates

Total cultivated area in year 2003 was 254 918 ha while area equipped for irrigation was 226 600 ha [AE01]. Area equipped for irrigation per emirate was estimated as the difference

between total cultivated land and so called shifting area, both reported for year 2003 [AE01]. Total area equipped for irrigation computed this way was 230 841 ha.

The cultivated area of the country, which is completely irrigated, was digitized from Landsat satellite imagery [AE02]. The digitized areas were in good agreement with areas classified as "agricultural areas and plantations" in an atlas published in 1993 [AE03].

Irrigation in the United Arab Emirates is completely based on groundwater [AE01]. Area actually irrigated per emirate was computed as average of cultivated land reported for the period 2006-2008 [AE04]. Total area actually irrigated computed this way was 218 826 ha.

References:

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[AE03]: **United Arab Emirates University**. 1993. *The national atlas of the United Arab Emirates*. Al Ain.
[AE04]: **Ministry of Environment and Water**. 2013. *Agricultural area, quantity and value according to Emirates*, versions 2006-2008, http://www.moew.gov.ae/Portal/en/knowledge-and-statistics.aspx#page=1, 20/01/2013.

Uzbekistan

Area equipped for irrigation was 4 198 000 ha in year 2005 [UZ01]. Irrigated area in 13 regions was available for year 1996 and totalled 4 223 000 ha [UZ02]. Area equipped for irrigation per region in year 2005 was estimated by scaling the area reported for year 1996 so that the total sum was similar to the extent reported at the national scale for year 2005.

The irrigated areas were digitized from a map showing irrigated areas in the Aral Sea Basin [UZ03]. The shape of the boundaries of the irrigated areas was then adjusted using satellite imagery [UZ04]. The digitized irrigated areas were combined with irrigated cropland derived from the Globcover regional classification for Central Asia [UZ05]. Irrigated area was then assigned with the highest priority to pixels being irrigated according to both data sources and after that, if required, to pixels that were either covered by the digitized irrigated areas or classified as irrigated by Globcover.

Area equipped for irrigation with groundwater was 274 000 ha in year 1994 [UZ01]. More recent estimates were not available. Since the quantity of groundwater extractions is restricted to volumes that do not cause surface flow reduction [UZ06], area equipped for irrigation with groundwater was set to the figures reported for year 1994. Area actually irrigated was 3 700 000 ha in year 2005.

References:

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[UZ03]: **Unknown**. *Aral Sea Basin 1:2 500 000 - administrative boundaries and irrigated areas*. Map available in the FAO-AGL library.

[UZ04]: **Earth Satellite Corporation**. 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-323, 071-324, 071-334, 071-335, 071-344 and 071-345. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.
[UZ05]: **ESA.** 2008. *Regional Globcover Land Cover – Central Asia.* Version 2.2. http://postel.mediasfrance.org/en/DOWNLOAD/, 24/03/2009.
[UZ06]: **FAO**. 2013. *AQUASTAT country profile of the Uzbekistan, version 1997*. FAO, Rome, Italy, http://www.fao.org/nr/water/aquastat/countries_regions/UZB/index.stm, 15/02/2013.

Viet Nam

Area equipped for irrigation in Viet Nam was 4 585 500 ha in year 2005, while the area harvested on irrigated fields was 8 728 192 ha in the same year, which indicates a high cropping intensity [VN01]. Area equipped for irrigation in 8 regions was derived from the AQUASTAT country questionnaire and further downscaled to province level according to the extent of paddy fields (4 130 940 ha in total) reported by the agricultural census 2006 for each province [VN02].

Digital maps of irrigated areas (polygon dataset) [VN03] and irrigation projects (point dataset) [VN04] were used as compiled by the Mekong River Commission. However, these inventories covered only the part of the country that belongs to the Mekong River watershed. In the other part of the country, irrigated area was distributed according to the GlobeCover landcover map [VN05] to areas classified as irrigated or rainfed cropland. These areas fitted well to maps showing the irrigation infrastructure of the country [VN06].

According to the AQUASTAT country profile [VN01], area equipped for irrigation with groundwater is 1 percent of total AEI, and the whole AEI was irrigated in year 2005.

References:

[VN01]: **FAO**. 2012. *AQUASTAT country profile of Viet Nam, version 2010*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/viet_nam/index.stm, 02/04/2012.
[VN02]: **General Statistics Office of Viet Nam**. 2007. Results of the 2006 Rural, Agricultural and Fishery Census. Volume I – General Results. http://www.gso.gov.vn/default_en.aspx?tabid=515&idmid=5&ItemID=8058, 09/03/2010.
[VN03]: **Mekong River Commission Secretariat**. 2003. *People and environment atlas of the Lower Mekong Basin*. CD-Rom. Phnom Penh, MRC.
[VN04]: **Mekong River Commission Secretariat**. 2009. *Irrigation dataset 2009*. http://portal.mrcmekong.org/, 18/04/2012.
[VN05]: **ESA.** 2008. *Regional Globcover Land Cover – Central Asia.* Version 2.2. http://postel.mediasfrance.org/en/DOWNLOAD/, 24/03/2009.
[VN06]: **World Bank**. 1996. *Vietnam - water resources sector review*. East Asia and Pacific Region, Report No. 15041-V. Agriculture and Environment Division, Country Department I.

Yemen

Area equipped for irrigation for year 2004 was estimated at 679 650 ha, consisting of 454 310 ha full/partial control irrigation, 217 541 ha spate irrigation and 7799 ha equipped lowlands [YE01]. Area actually irrigated shows a high year-to-year variability and mainly depends on the availability of irrigation water. The highest area actually irrigated was reported for year 2007 (732 029 ha). To account for the increasing trend in irrigated land, area equipped for irrigation was estimated for each province as the maximum of area actually irrigated reported for period 2005-2009 [YE02]. Total area equipped for irrigation estimated this way was 813 951 ha.

The irrigated areas were digitized using Landsat satellite imagery [YE03], MODIS Vegetation Indices [YE04] and several large-scale irrigation maps ([YE05]; [YE06]; [YE07]). The

approximate position and extent of the major irrigation schemes was detected based on the large-scale maps, and their more precise extent was derived by digitizing vegetated areas from the satellite imagery. The polygons digitized that way were then combined with cropland extracted from the Globcover regional landcover classification for North Africa [YE08] and irrigated area was first assigned to pixels that were covered by both data layers (digitized polygons AND cropland in Globcover) and after, if required, to pixels covered by just one of the two layers (digitized polygons OR cropland in Globcover). In the provinces of Al-Jawf and Mareb irrigated land was in addition assigned to pixels classified in Globcover as "Sparse vegetation (<15 percent)".

Area actually irrigated was computed for each province as the mean of the irrigated areas reported for period 2005-2009 [YE02]. The same time series was used to distinguish the source of irrigation water. Areas irrigated from springs and wells were assumed to represent groundwater irrigation, areas irrigated with water from dams, reservoirs and from floods were assumed to represent surface water irrigation and areas irrigated with water from other sources or water obtained by cars was assumed to represent irrigation with non-conventional water sources. Total area actually irrigated computed that way was 668 504 ha (82 percent of area equipped for irrigation). 66.5 percent of the area was irrigated with groundwater, 31.1 percent with surface water and 2.4 percent with water from non-conventional sources.

References:

[YE01]: **FAO**. 2013. *AQUASTAT country profile of Yemen, version 2008*. FAO, Rome, Italy, http://www.fao.org/nr/water/aquastat/countries_regions/YEM/index.stm, 20/01/2013.

[YE02]: **Central Statistics Office**. 2006-2010. *Statistical yearbook*, volumes 2005-2009, section agriculture. http://cso-yemen.org/content.php?lng=english&cid=131, 20/01/2013.

[YE03]: **Earth Satellite Corporation**. 2004. *Landsat GeoCover (2000/ETM+) Edition Mosaics*, tiles 071-295, 071-296, 071-307, 071-308 and 071-317. Sioux Falls, USA, USGS, http://glcfapp.umiacs.umd.edu:8080.

[YE04]: **NASA, Land Processes Distributed Active Archive Center**. 2004. *MOD13Q1: MODIS/Terra Vegetation Indices 16-Day L3 Global 250m SIN Grid V004*. Enhanced Vegetation Indices (EVI) from 9 June 2000 and 17 January 2001, http://edcimswww.cr.usgs.gov.

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[YE06]: **United States Agency for International Development**. 1993. *Water Resources Action Plan for the Near East*, Figure 3. Washington, DC.

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[YE08]: **POSTEL**. 2008. *GLOBCOVER landcover classification, Version 2.2, North Africa*. Globcover database. http://toyo.mediasfrance.org/?GLOBCOVER, 24/03/2009.

EUROPE

Area equipped for irrigation in version 5 of the Global Map of Irrigation Areas is similar to AEI in version 4 for the European countries with exceptions for Austria, Belarus, Belgium, Croatia, Denmark, Finland, Germany, Kosovo, Montenegro, Russian Federation, Serbia, Switzerland, and United Kingdom. For most of the European countries AEI is based on data collected in national agricultural censuses or farm structure surveys undertaken in the period 1999-2007. The Global Map of Irrigation Areas will be updated for Europe as soon as the data from the agricultural census 2010, undertaken in most of the European countries, become available. One difference to map version 4 is however, that AEI was subdivided according to the source of water and that statistics on area actually irrigated are attached as well. Total area equipped for irrigation in the Global Map of Irrigation for Europe is 24 281 853 ha in map version 5, of which 7 467 198 ha are equipped for irrigation with groundwater. Area actually irrigated is 12 515 264 ha and thus about half of the area equipped for irrigation (Table A13).

TABLE A13
Area equipped for irrigation (AEI) and area actually irrigated (AAI) in Europe in the new version 5 of the Global Map of Irrigation Areas.

Country	AEI in GMIA4 (ha)	AEI in GMIA5, total (ha)	AEI in GMIA5, groundwater (ha)	AEI in GMIA5, surface water (ha)	AEI in GMIA5, non-conventional sources (ha)	AAI in GMIA5 (ha)
Albania	340,000	340,000	1,000	339,000	0	110,712
Andorra	150	150	38	113	0	150
Austria	97,480	116,050	94,602	21,448	0	43,450
Belarus	115,000	114,100	17,115	96,985	0	25,900
Belgium	35,170	23,830	13,864	9,966	0	5,500
Bosnia and Herzegovina	4,630	4,630	1,389	3,241	0	4,630
Bulgaria	545,160	545,160	102,003	443,157	0	68,544
Croatia	5,790	9,275	3,414	5,860	0	9,275
Czech Republic	50,590	50,590	3,337	47,253	0	18,037
Denmark	476,000	448,818	448,818	0	0	204,070
Estonia	1,363	1,363	193	1,170	0	600
Finland	103,800	103,800	15,570	88,230	0	15,000
France (excl. oversea departments)	2,906,081	2,906,081	1,281,673	1,624,408	0	1,693,137
Germany	496,871	515,731	423,479	92,252	0	234,594
Greece	1,544,530	1,544,530	748,535	795,995	0	1,206,017
Hungary	292,147	292,147	63,784	228,363	0	104,415
Iceland	0	0	0	0	0	0
Ireland	1,100	1,100	220	880	0	1,100
Italy	3,892,202	3,892,202	1,285,783	2,606,419	0	2,471,379
Kosovo	77,000	77,000	10,949	66,051	0	39,466
Latvia	1,150	1,150	80	1,070	0	620
Liechtenstein	0	0	0	0	0	0
Lithuania	4,416	4,416	2,331	2,085	0	1,000
Luxembourg	27	27	19	8	0	27
Malta	2,300	2,300	2,287	13	0	2,130
Monaco	0	0	0	0	0	0
Montenegro	2,115	2,115	2,107	8	0	2,115
Netherlands	476,315	476,315	275,899	200,416	0	119,156
Norway	134,396	134,396	8,334	126,062	0	54,970
Poland	134,050	134,050	13,405	120,645	0	63,138
Portugal	792,008	792,008	435,801	356,207	0	374,360
Republic of Moldova	307,000	307,000	0	307,000	0	20,000

Country	AEI in GMIA4 (ha)	AEI in GMIA5, total (ha)	AEI in GMIA5, groundwater (ha)	AEI in GMIA5, surface water (ha)	AEI in GMIA5, non-conventional sources (ha)	AAI in GMIA5 (ha)
Romania	2,149,903	2,149,903	225,801	1,924,102	0	221,106
Russian Federation (incl. Asian part)	4,899,900	2,375,200	475,040	1,900,160	0	938,900
San Marino	0	0	0	0	0	0
Serbia	86,311	86,311	4,605	81,706	0	27,541
Slovakia	225,310	225,310	18,161	207,149	0	64,773
Slovenia	15,643	15,643	1,669	13,974	0	7,121
Spain	3,575,488	3,575,488	1,316,656	2,258,832	0	3,315,594
Sweden	188,470	188,470	50,571	137,899	0	52,150
Switzerland	40,000	55,000	12,100	42,900	0	45,390
The former Yugoslav Republic of Macedonia	127,800	127,800	5,000	122,800	0	79,638
Ukraine	2,395,500	2,395,500	0	2,395,500	0	731,400
United Kingdom	228,950	246,894	101,565	145,329	0	138,159
EUROPE TOTAL	**26,772,116**	**24,281,853**	**7,467,198**	**16,814,655**	**0**	**12,515,264**

For European countries included in the EU Farm Structure Survey 2003 (Austria, Belgium, Bulgaria, Czech Republic, Denmark, France, Greece, Hungary, Italy, Malta, Netherlands, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden) areas equipped for irrigation with groundwater were computed based on areas irrigated with groundwater, surface water and mixed sources reported by EUROSTAT for 134 sub-national or national administrative units (http://epp.eurostat.ec.europa.eu/portal/page/portal/farm_structure_survey/data/ad_hoc_tables). The conversion of the original data categories reported in the farm structure survey to ground- versus surface water supply is reported in Table A14. Area equipped for irrigation with groundwater (AEI_GW) was computed as:

AEI_GW = AEI * AAI_GW / (AAI_GW + AAI_SW).

For the other European countries data sources for the separation of AEI into AEI_GW and AEI_SW are reported in the specific country sections.

TABLE A14

Sources of irrigation water for areas irrigated in year 2003 according to the farm structure survey of the European Union and partitioning into area actually irrigated from groundwater (AAI_GW) and area actually irrigated from surface water (AAI_SW).

FS2003 classification	AAI_GW (% of reported area)	AAI_SW (% of reported area)
Groundwater	100	0
On-farm surface water	0	100
Off-farm surface water	0	100
Off-farm water from water supply networks	0	100
Ground- and surface water	50	50
Groundwater and public network	50	0
Surface water and public network	0	50
Mixed surface water	0	100
Other sources or at least 3 mixed sources	0	0

Albania

The area equipped for irrigation was about 420 000 ha at the beginning of the 1990's [AL01], [AL02] and declined to 340 000 ha around year 2000 [AL03], [AL04]. Area equipped for

irrigation per district as given for the year 1993 (in total 416 977 ha, [AL01]) was scaled so that the country totals meet the value of 340 000 ha reported to be still present.

To distribute irrigated area within the districts, irrigated area was assigned to all polygons classified as cultivated land in the CORINE land cover 2000 database for Europe [AL05] using the priority levels reported in Table A15. The result of this assignment has been in good agreement to other maps showing irrigation infrastructure in Albania ([AL06], [AL07]).

It was reported that irrigation in Albania is from surface water except of 1000 ha land in hilly regions where water from springs is being used [AL08]. Therefore area equipped for irrigation with groundwater was set to 1000 ha. Area actually used for irrigation declined from 316 000 ha in 1991 [AL02] to smaller than 80 000 ha in 1994 because many areas faced an urgent need for rehabilitation [AL03]. Due to intensive rehabilitation works the area actually used for irrigation increased again to 120 000 ha in 1996 and about 250 000 ha in 1998 [AL08]. For this inventory, area actually irrigated per county was computed as average of the AAI reported for the period 2001-2009 [AL09], resulting in a total AAI of 110 712 ha.

TABLE A15
Priorities assigned to land cover types to distribute area equipped for irrigation in administrative units of Albania.

Corine land cover class	Priority assigned in the downscaling procedure
Permanently irrigated land	7
Non-irrigated arable land	6
Fruit trees and berry plantations	6
Olive groves	6
Complex cultivation patterns	6
Pastures	5
Land principally occupied by agriculture with significant areas of natural vegetation	5

References:

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[AL03]: **World Bank**. 2003. *Water resources management in South Eastern Europe. Vol. II: Country water notes and water fact sheets*. World Bank, Washington, http://www.worldbank.org, 29/08/2005.

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[AL05]: **EEA**. 2005. *Corine land cover 2000 - vector by country (CLC2000), version 1*. http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=667, 29/08/2005.

[AL06]: **Toepfer, H**. 1993. *Die Bewässerungslandwirtschaft und Nahrungsmittelproduktion in Albanien.* Irrigation map (Figure 1) on p. 107, In Popp, H. & Rother, K. eds. Die Bewässerungsgebiete im Mittelmeerraum, Passau, Germany, Passavia Universitätsverlag.

[AL07]: **National Environmental Agency**. 1994. *Albanian State of the Environment Report: 1993-1994.* Map: Water reservoir and irrigation areas, http://enrin.grida.no/htmls/albania/soe/htmls/94/html/alba0.htm, 07/07/2006.

[AL08]: **World Bank**. 1999. *Albania - second irrigation rehabilitation project. Project Appraisal Document*. Report no. 19242-ALB, World Bank, Washington, http://www.worldbank.org, 12/08/2009.

[AL09]: **Institute of Statistics**. 2011. *Irrigated area by county in ha*. http://www.instat.gov.al/graphics/doc/tabelat/Treguesit%20Ekonomik/Bujqesia/BUJ%202010/16.xls, 15/10/2011.

Andorra
No sub-national statistics or maps on irrigated areas have been available for Andorra.

150 ha were classified to be permanently irrigated in the 1990-version of the Corine land cover data base for Europe. These areas were extracted and assumed to represent the area equipped for irrigation of Andorra.

Based on the situation in neighbouring administrative units percentage of AEI irrigated with groundwater was estimated at 25 percent. It was assumed that AAI is similar to AEI.

References:

[AN01]: **EEA**. 1999. *Corine land cover 1990 - vector by country (CLC1990), version 1*. http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=188, 29/08/2005.

Austria
Area equipped for irrigation in NUTS3-regions were derived from the EUROSTAT database [AT01] for year 2007 and further downscaled to municipality level by using data on the percentage of irrigated land provided by an online GIS-service [AT02]. Total AEI computed as sum of the areas reported for the NUTS3-regions is 116 050 ha.

Irrigated area was assigned to specific pixels according to the CORINE land cover 2000 database for Europe [AT03]. The highest priority was given to areas classified as non-irrigated arable land, vineyards or complex cultivation patterns. If the extent of these areas was not sufficient, irrigated areas was assigned to areas classified as pastures or land principally occupied by agriculture, with significant areas of natural vegetation.

Area equipped for irrigation with groundwater was computed based on the data collected by the EU farm structure survey 2003 as described before. Area actually irrigated (in total 43450 ha) per NUTS3-region was derived from the EUROSTAT database [AT01]. The data refer to year 2007.

References:

[AT01]: **Statistical Office of the European Communities (EUROSTAT)**. 2011. *Irrigable and irrigated areas*. http://epp.eurostat.ec.europa.eu/portal/page/portal/agri_environmental_indicators/data/database, 28/11/2011.
[AT02]: **Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft**. 2008. Geo-Info. Bewässerte Fläche in Prozent der Gemeindefläche. http://gis.lebensministerium.at/geoinfo/, 03/04/2008.
[AT03]: **EEA**. 2005. *Corine land cover 2000 - vector by country (CLC2000), version 1*. http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=667, 29/08/2005.

Belarus
The area equipped for irrigation reached its maximum in the 1980's at 163 000 ha and declined after to 149 000 ha in 1990, 131 000 ha in 1993 [BY01], 115 100 ha in year 2001 and 114 100 ha in year 2006 [BY02]. Area equipped for irrigation in year 2006 was derived for 6 regions from a statistical yearbook [BY02].

Maps showing the location of irrigation schemes were not available. Since it was reported, that irrigation takes place only in excessively drained areas it was decided to distribute irrigated land to cropland and pastures in lowlands along the major rivers. Additionally irrigated areas were assigned to cultivated land in the Polesye region because it was reported

that most of the drainage work was concentrated in that area. Cropland and pasture areas were derived from the GLC2000 data base for Northern Eurasia [BY03]. Cells classified as humid grassland, cropland or cropland / grassland were extracted from this land cover data set if located on river valley bottoms.

Irrigation water is provided mainly by retention tanks. About 77 percent of the area is reported to be irrigated from these reservoirs. Other water sources are canals and groundwater [BY01]. Based on this indicative information percentage of AEI irrigated with groundwater was set to 15 percent (17 250 ha). Because of organizational, economic and technical reasons the irrigation schemes are not operating at full capacity. It can be assumed that the area actually used for irrigation is much lower now compared to the situation in 1990 because irrigation water use declined strongly from 63 Mio m³ in 1985 and 67.3 Mio m³ in 1990 to 5 Mio m³ in 2000 and 11.7 Mio m³ in 2003 [BY04]. Based on the reported ratio of irrigation water extractions in years 1990 and 2003 AAI in year 2003 was estimated at 25 900 ha.

References:

[BY01]: **FAO**. 2012. *AQUASTAT country profile of Belarus, version 1997*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/belarus/index.stm, 02/04/2012.

[BY02]: **National Statistical Committee of the Republic of Belarus.** 2011. *Environmental protection in the Republic of Belarus*. National Statistical Committee of the Republic of Belarus, Minsk, Belarus, 237 pp.

[BY03]: **Bartalev, S.A., Belward, A.S., Erchov, D.V., Isaev, A.S., Bartholomé, E., Gond, V., Vogt, P., Achard, F., Zubkov, A.M., Mollicone, D., Yu Savin, I., Fritz, S., Repina, G., Hartley, A.** 2003. The land cover map for Northern Eurasia for the year 2000. GLC2000 database, European Commision Joint Research Centre, http://www-gem.jrc.it/glc2000.

[BY04]: **Ministry of Natural Resources and Environmental Protection**. 2003. *Environmental conditions in the Republic of Belarus*. http://www.nd.minpriroda.by/eng/index.htm, 12/07/2006.

Belgium

Area equipped for irrigation and area actually irrigated for 11 regions was derived from the statistics of the farm structure survey 2005 [BE01], [BE02]. Total area equipped for irrigation is 23 830 ha, of which 21 710 ha is for irrigated outdoor crops and 2120 ha for crops in greenhouses.

Maps showing the location of irrigation schemes were not available. Area equipped for irrigation was distributed to cultivated land [BE03] in regions of coarse soil [BE04] using priorities in the distribution process as described in Table A16.

Area equipped for irrigation with groundwater was computed based on the data collected by the EU farm structure survey 2003 as described before.

TABLE A16

Priorities used to assign irrigated area to cultivated areas on coarse soil in Belgium.

Attribute in Corine land cover 2000 data base	Attributes in soil map	Priority
Non-irrigated arable land (211) or complex cultivation patterns (242)	SLTXCL = 1 and SLTXCL2 = 1	6
Non-irrigated arable land (211) or complex cultivation patterns (242)	SLTXCL = 1 and SLTXCL2 > 1	5
Fruit trees and berry plantations (222) or pastures (231) or land principally occupied by agriculture, with significant areas of natural vegetation (243)	SLTXCL = 1 and SLTXCL2 = 1	5
Non-irrigated arable land (211) or complex cultivation patterns (242) or fruit trees and berry plantations (222)		4

*: SLTXCL represents the soil texture class of the main soil type, while SLTXCL2 is the soil texture class of an associated soil; a soil texture class of 1 is assigned to soils having less than 18 percent clay content and more than 65 percent sand content.

References:

[BE01]: **Statistical Office of the European Communities (EUROSTAT)**. 2011. *Irrigable and irrigated areas*. http://epp.eurostat.ec.europa.eu/portal/page/portal/agri_environmental_indicators/data/database, 28/11/2011.

[BE02]: **Statistical Office of the European Communities (EUROSTAT)**. 2010. *Land use*. http://epp.eurostat.ec.europa.eu/portal/page/portal/agriculture/data/database, 15/07/2010.

[BE03]: **EEA**. 2005. *Corine land cover 2000 - vector by country (CLC2000), version 1*. http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=667, 29/08/2005.

[BE04]: **The Commission of the European Communities, Directorate General for Agriculture, Coordination of Agricultural Research**. 1985. *Soil Map of the European Communities at 1:1 000 000*. The Office for Official Publications of the European Communities, ISBN 92-825-5427-9, L-2985 Luxembourg, 124 pages, http://www.grid.unep.ch/data/, 07/07/2006.

Bosnia and Herzegovina

Irrigation potential for Bosnia Herzegovina was estimated at 74 000 ha, but only 4630 ha are equipped for irrigation [BA01]. The irrigated area of the country is concentrated in three irrigation systems:

- Ljubuški and Ljubuški Polje (2800 ha),
- Trebinje and Trebinjsko Polje (650 ha), and
- Dubrava Plateau [BA02].

The boundaries of the irrigation systems were digitized from a map published in [BA03]. Irrigated area was assigned to all areas within the digitized polygons that were classified in the Corine 2000 land cover database for Europe [BA04] as non-irrigated arable land (211), fruit trees and berry plantations (222), complex cultivation patterns (242) or land principally occupied by agriculture, with significant areas of natural vegetation (243).

Most of the larger public irrigation schemes in Bosnia and Herzegovina extract water from the Neretva River or its main tributaries, while small scale irrigation is often practised using groundwater (springs, wells, sub-surface streams in the Karst system). The actual extent of irrigation and therefore also the fraction of irrigation areas using groundwater is uncertain because of missing information on the extent of informal irrigation schemes and because a significant part of the irrigation infrastructure was destroyed in the last war [BA03]. Percentage of irrigated area from groundwater sources was estimated at 30 percent based on the description of the irrigation infrastructure in [BA02].

References:

[BA01]: **Civil Society Promotion Center**. 2002. *Environment in Bosnia and Herzegovina 2002*. http://enrin.grida.no/htmls/bosnia/bosnia2002/index.html, 07/07/2006.

[BA02]: **World Bank**. 2002. *Bosnia and Herzegovina Small Scale Commercial Agricultural Development Project. Environmental assessment.* http://www-wds.worldbank.org/, 12/08/2009.

[BA03]: **World Bank**. 2003. *Bosnia and Herzegovina Small Scale Commercial Agricultural Development Project. Project appraisal document.* Report No: 25519-BiH, http://www-wds.worldbank.org/, 12/08/2009.

[BA04]: **EEA**. 2005. *Corine land cover 2000 - vector by country (CLC2000), version 1*. http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=667, 29/08/2005.

Bulgaria

The area equipped for irrigation was 1 288 000 ha in 1990 [BG01] but declined later to 673 000 ha in 1995 [BG02] and 545 160 ha in 2003 [BG03]. Even stronger was the decline in the area actually used for irrigation. While in 1985 about 1 014 000 ha of cultivated land was irrigated the area actually irrigated declined to 842 000 ha in 1989 [BG01], to about 100 000 ha in the period 1992-1996 [BG02] and to about 40 000 ha nowadays [BG04]. Large parts of the irrigation infrastructure constructed before 1990 deteriorated because of the break up of large farms and the lack of finance for restructuring irrigation systems to meet the needs of small farmers [BG05]. The restructuring of the irrigation sector makes it difficult to estimate the area equipped for irrigation. The equipment at the former pumping stations is missing almost everywhere and a significant part of the canals is destroyed [BG04]. Thus it depends on the definitions used whether areas are still classified as equipped for irrigation or not and one can find different numbers for the extent of irrigated areas in the statistics. EUROSTAT for example reported for 2003 an irrigable area of 124 490 ha and an area actually irrigated of 79 370 ha [BG06]. In 2002 the hydraulic infrastructure for 537 558 ha irrigated land in 235 irrigation systems was managed by the Irrigation Systems Co. (ISC) and 3351 ha in five systems by the Hydro-melioratzii Ltd. Sevlievo (HMS). Both are trade companies. In contrast 4251 ha were managed by newly created irrigation associations [BG03]. Area equipped for irrigation per branch of the ISC was derived from [BG03].

The outlines of the major irrigation areas of the country were digitized from an irrigation map published in [BG01] to distribute irrigated areas within the branches of the ISC. Irrigated area was assigned to all polygons of the Corine land cover 2000 data base [BG07] that were located within the digitized irrigation areas and that were classified as non-irrigated arable land (211), rice fields (213), vineyards (221), fruit trees and berry plantations (222) or complex cultivation patterns (242) using priority levels shown in Table A17.

Area actually irrigated for 5 regions was computed as average of the AAI reported in the EU farm structure surveys 2003, 2005 and 2007 [BG06]. Total AAI computed that way was 68 544 ha.

TABLE A17

Priorities used to assign irrigated area to the areas classified as cultivated in the CORINE land cover 2000 data base for Bulgaria.

Attribute	Priority
Rice fields	7
Non-irrigated arable land	6
Fruit trees and berry plantations	6
Vineyards	6
Complex cultivation patterns	6

References:

[BG01]: **FAO**. 1991. *Bulgaria. Irrigation subsector review*. FAO Investment Centre, Report No: 109/91 CP-BUL 2, Rome, Italy.

[BG02]: **Öko Inc. Budapest**. 2001. *Agricultural water management policies in Bulgaria, Hungary, Romania and Slovakia*. Final report. Budapest, Hungary, 35 pp.

[BG03]: **Ministry of Agriculture and Forestry**. 2004. *Rural development project. Study on irrigation tariffs and subsidy*. Sofia, Bulgaria, 63 pp., http://www.mzgar.government.bg/, 07/07/2006.

[BG04]: **Chehlarova-Simeonova, S., Yusuf, S., Florov, V. and Ninova, M.** 2006. *Country report from Bulgaria*. In: Dirksen, W. and Huppert, W. (ed.). Irrigation sector reform in Central and Eastern European countries. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn, Germany, 41-102.

[BG05]: **World Bank**. 2003. *Water resources management in South Eastern Europe. Vol. II - Country water notes and water fact sheets.* Washington, United States, http://www-wds.worldbank.org/, 07/07/2006.
[BG06]: **Statistical Office of the European Communities (EUROSTAT)**. 2011. *Irrigable and irrigated areas*. http://epp.eurostat.ec.europa.eu/portal/page/portal/agri_environmental_indicators/data/database, 28/11/2011.
[BG07]: **EEA**. 2005. *Corine land cover 2000 - vector by country (CLC2000), version 1*. http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=667, 29/08/2005.

Croatia

Sub-national irrigation statistics as compiled by the Agricultural Census 2003 were available for the area actually irrigated during season 2002-2003 and were summing up to 9275 ha, of which 5000 ha were used by agricultural households and 4275 ha by business entities [HR01]. It was assumed that AEI is similar to the irrigated areas reported by the agricultural census report at the county level. Irrigated area at municipality level has been available for agricultural households only. Therefore it was assumed that the share of municipalities on the irrigated area of the counties was equal for agricultural households and business entities.

Irrigated area was distributed within the municipalities by assigning area equipped for irrigation to cultivated land as classified by the Corine 2000 land cover data base for Europe [HR02] by using the priorities shown in Table A18. The highest priority was given to polygons classified as permanently irrigated land (212) while olive groves (223) and pastures (231) got the lowest priority.

The number of farms irrigated from groundwater, surface water and from water supply networks was reported for each county and per farm size class by the agricultural census report 2003 [HR01]. Area irrigated from groundwater was computed for each farm size class as AEI * N_GW / (N_GW + N_SW) where N_GW was the number of farms irrigated from groundwater and N_SW was the number of farms irrigated from surface water. Next, the sum of area irrigated from groundwater of all farm size classes was computed for each county. AEI irrigated with groundwater computed this way was 3414 ha.

TABLE A18
Priorities used to assign irrigated area to the areas classified as cultivated in the CORINE land cover 2000 data base for Croatia.

Attribute	Priority
Permanently irrigated land	7
Non-irrigated arable land	6
Fruit trees and berry plantations	6
Vineyards	6
Complex cultivation patterns	6
Land principally occupied by agriculture, with significant areas of natural vegetation	5
Olive groves	4
Pastures	4

References:

[HR01]: **CROSTAT**. 2006. Agricultural census 2003. Republic of Croatia - Central Bureau of Statistics (CROSTAT), http://www.dzs.hr/default_e.htm, 17/08/2009.
[HR02]: **EEA**. 2005. *Corine land cover 2000 - vector by country (CLC2000), version 1*. http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=667, 29/08/2005.

Czech Republic

During the last century irrigation infrastructure was built on about 155 000 ha of agricultural land. Area equipped for irrigation was at its maximum in the period 1995-1997 at 132 401 ha [CZ01]. Area actually irrigated was largest in 1988 (99 115 ha) and declined later to about 48 000 ha at the beginning of the 1990s, about 35 000 ha in the mid 90s and 16 238 ha in 1997 [CZ02]. Irrigation is nowadays only being used for crops that cannot be grown without irrigation or for those for which irrigation generates high added value (vegetables, hop-fields, orchards, vineyards and potatoes). EUROSTAT reported areas actually irrigated of 16 870 ha in 2003 and 17 320 ha in 2005 [CZ03]. The low figures of area actually irrigated in the last ten years indicate that a large part of the former irrigation infrastructure seems to be dead and no longer useable. Therefore area equipped for irrigation was estimated for eight regions by choosing the maximum of the irrigable areas as reported by EUROSTAT for the years 2003 and 2005 [CZ03]. Area equipped for irrigation per region estimated that way is summing up to 50 590 ha.

The main irrigation areas of the country were digitized from an irrigation map. The map showed areas in operation, areas under construction and planned irrigation areas [CZ04]. Additionally a large irrigation area was digitized in the surrounding of Znojmo in South Moravia [CZ05]. Irrigated area was then assigned to cultivated land extracted from the Corine 2000 land cover data base for Europe [CZ06] using the priorities shown in Table A19. In the regions of Jihozápad and Střední Morava irrigated area was assigned to all areas classified as vineyards (221), fruit trees and berry plantations (222) or complex cultivation patterns (242) because none of the digitized irrigation areas was located within these regions.

Area equipped for irrigation with groundwater was computed based on the data collected by the EU farm structure survey 2003 as described before. Area actually irrigated was computed for each region as average of AAI reported by the EU farm structure surveys 2003, 2005 and 2007 [CZ03]. AAI per region estimated that way is summing up to 18 037 ha.

TABLE A19

Priorities used to assign irrigated area to cultivated areas on in the Czech Republic.

Attribute in Corine land cover 2000 data base	Status of digitized irrigation areas	Priority
Non-irrigated arable land (211) or vineyards (221) or fruit trees and berry plantations (222) or complex cultivation patterns (242)	"operating" or "under construction"	7
Vineyards (221) or fruit trees and berry plantations (222) or complex cultivation patterns (242)	"planned"	7
Non-irrigated arable land (211)	"planned"	6
Vineyards (221) or fruit trees and berry plantations (222) or complex cultivation patterns (242)	-	5

References:

[CZ01]: **Štastná, M., Miškovský, J., Cermák, J., Doležal, F., Zavadil, J. & Spitz, P.** 2006. *Country report from Czech Republic*. In: Dirksen, W. and Huppert, W. (ed.). Irrigation sector reform in Central and Eastern European countries. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn, Germany, 103-118.

[CZ02]: **Miskovsky, J.** 2002. *Privatisation of irrigation systems in the Czech Republic*. EWRG letter 12, 3-6.

[CZ03]: **Statistical Office of the European Communities (EUROSTAT)**. 2011. *Irrigable and irrigated areas*. http://epp.eurostat.ec.europa.eu/portal/page/portal/agri_environmental_indicators/data/database, 28/11/2011.

[CZ04]: **Framji, K.K., Garg, B.C. & Luthra, S.D.L.** 1981. *Irrigation and drainage in the world.* Third edition. Vol. I, p. 304. New Delhi, ICID.

[CZ05]: **Ministry of Agriculture**. 2004. *General information about water management in the Czech Republic*. Prague, Czech Republic, 14 pp., http://www.mze.cz/, 19/07/2006.
[CZ06]: **EEA**. 2005. *Corine land cover 2000 - vector by country (CLC2000), version 1*. http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=667, 29/08/2005.

Denmark

AEI and AAI for 12 regions were derived from the EU farm structure survey 2003 [DK01]. Irrigated areas per region are summing up to 448 818 ha (AEI) and 204 070 ha (AAI).

Maps showing the location of irrigation areas in Denmark were not available but it was reported that irrigation is mainly used in horticulture or to grow semi-intensive or intensive field crops like maize, potatoes and sugar beets on coarse textured or shallow soils ([DK02], [DK03]). Irrigated area was therefore assigned to all regions of coarse soil texture [DK04] classified as non-irrigated arable land (211), fruit trees and berry plantations (222) or complex cultivation patterns (242) in the Corine 2000 land cover data base for Europe [DK05] by using the priorities shown in Table A20.

According to the data released by the EU farm structure survey 2003 all irrigation is from groundwater.

TABLE A20
Priorities used to assign irrigated area to cultivated areas on coarse textured soil in Denmark.

Attribute in Corine land cover 2000 data base	Attributes in soil map*	Priority
Non-irrigated arable land (211) or fruit trees and berry plantations (222) or complex cultivation patterns (242)	SLTXCL = 1 and SLTXCL2 = 1	5
Non-irrigated arable land (211) or fruit trees and berry plantations (222) or complex cultivation patterns (242)	SLTXCL = 1 and SLTXCL2 > 1 or SLTXCL > 1 and SLTXCL2 = 1	4
Non-irrigated arable land (211) or fruit trees and berry plantations (222) or complex cultivation patterns (242)	SLTXCL = 2 and SLTXCL2 > 1	3

*: SLTXCL represents the soil texture class of the main soil type, while SLTXCL2 is the soil texture class of an associated soil; a soil texture class of 1 is assigned to soils having less than 18 percent clay content and more than 65 percent sand content.

References:

[DK01]: **Statistical Office of the European Communities (EUROSTAT)**. 2011. *Irrigable and irrigated areas*. http://epp.eurostat.ec.europa.eu/portal/page/portal/agri_environmental_indicators/data/database, 28/11/2011.
[DK02]: **Baldock, D., Caraveli, H., Dwyer, J., Einschütz, S., Petersen, J.E., Sumpsi-Vinas, J., Varela-Ortega, C.** 2000. *The environmental impacts of irrigation in the European Union*. A report to the Environment Directorate of the European Commission, 147 pp., http://ec.europa.eu/environment/agriculture/, 07/07/2006.
[DK03]: **Danish Environmental Protection Agency**. 2004. *Nature & Environment 2003 – Theme: Water in Denmark*. http://www.mst.dk/homepage/default.asp?Sub=http://www.mst.dk/udgiv/Publications/2004/87-7614-3805/html/helepubl_eng.htm#kap01_eng, 07/07/2006.
[DK04]: **The Commission of the European Communities, Directorate General for Agriculture, Coordination of Agricultural Research**. 1985. *Soil Map of the European Communities at 1:1 000 000*. The Office for Official Publications of the European Communities, ISBN 92-825-5427-9, L-2985 Luxembourg, 124 pages, http://www.grid.unep.ch/data/, 07/07/2006.
[DK05]: **EEA**. 2005. *Corine land cover 2000 - vector by country (CLC2000), version 1*. http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=667, 29/08/2005.

Estonia

Area equipped for irrigation reached its maximum by the end of the 1970s (14 000 ha), but was reduced to 3680 ha in 1995 due to the liquidation of the kolkhoz and sovkhoz [EE01].

Area equipped for irrigation per county was available for year 2005 [EE02], the areas sum up to 1362.7 ha.

Maps showing the location of irrigation areas in Estonia were not available, but it was reported that irrigation is mainly used to grow vegetables or to water pastures [EE01]. While the irrigation of pastures was practiced traditionally, the irrigation of early potatoes is mentioned explicitly in a more recent report [EE03]. It was therefore decided to assign 80 percent of the area still equipped for irrigation to polygons classified as non-irrigated arable land (211) or complex cultivation patterns (242) in the Corine 2000 land cover data base for Europe [EE04] and to assign the remaining irrigated area to polygons classified as pastures (231) in the same data base.

Based on the ratio between groundwater abstractions for agriculture, forestry and fishery and total water abstractions for agriculture, forestry and fishery in period 2003-2007 [LV06] area equipped for irrigation with groundwater was estimated at 193 ha (14 percent of total AEI). Area actually irrigated around year 2000 was reported to be 600 ha [EE06].

References:

[EE01]: **FAO**. 2012. *AQUASTAT country profile of Estonia, version 1997*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/estonia/index.stm, 02/04/2012.

[EE02]: *Area equipped for irrigation per county on 01/01/2005,* data provided by Mati Tonismae, Chairman of ICID National Committee of Estonia (ESTICID) and Head of the Bureau of Infrastructure, Ministry of Agriculture on 21/02/2006.

[EE03]: **Kucera, L. & Genovese, G. (ed.)**. 2004. *Crop monographies on Central European countries – MOCA Study*. Joint Research Centre of the European Commission, Directorate General, Institute for the Protection and Security of the Citizen, Agriculture & Fisheries Unit, Ispra, Italy, http://agrifish.jrc.it/marsstat/Crop_Yield_Forecasting/MOCA/INDEX.HTM, 07/07/2006.

[EE04]: **EEA**. 2005. *Corine land cover 2000 - vector by country (CLC2000), version 1*. http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=667, 29/08/2005.

[EE05]: **Statistical Office of the European Communities (EUROSTAT)**. 2011. *Annual water abstraction by source and by sector*. http://epp.eurostat.ec.europa.eu/portal/page/portal/environment/data/database, 28/11/2011.

[EE06]: **Baldock, D., Caraveli, H., Dwyer, J., Einschütz, S., Petersen, J.E., Sumpsi-Vinas, J. & Varela-Ortega, C.** 2000. *The environmental impacts of irrigation in the European Union*. A report to the Environment Directorate of the European Commission, 147 pp., http://ec.europa.eu/environment/agriculture/, 07/07/2006.

Finland

Area equipped for irrigation for 20 regions (103 800 ha in total) was derived from the EU farm structure survey 2003 [FI01].

Maps showing the location of irrigation areas in Finland were not available. Therefore area equipped for irrigation was assigned to all areas classified as non-irrigated arable land (211) in the Corine 2000 land cover database for Europe [FI02].

In Finland, irrigation water is extracted in most cases from lakes. Groundwater extraction occurres mainly in vegetable production because of the higher water quality of groundwater [FI03], but statistics on the involved areas were not available. Based on the qualitative information in this aforementioned report and considering the situation in neighbouring Sweden, percentage of irrigated area from groundwater sources was estimated at 15 percent. The area actually irrigated is however much lower than the equipped area, in dry summers about 20 000 – 40 000 ha are irrigated [FI04]. The main irrigated crops are vegetables,

potatoes and beets ([FI04], [FI05]). Based on this information AAI was estimated at 15 000 ha.

References:

[FI01]: **Statistical Office of the European Communities (EUROSTAT)**. 2011. *Irrigable and irrigated areas*. http://epp.eurostat.ec.europa.eu/portal/page/portal/agri_environmental_indicators/data/database, 28/11/2011.

[FI02]: **EEA**. 2005. *Corine land cover 2000 - vector by country (CLC2000), version 1*. http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=667, 29/08/2005.

[FI03]: **Pajula, H. and Triipponen, J.-P.** 2003. *Selvitys Suomen kastelutilanteesta: esimerkkialueena Varsinais-Suomi. (A survey of the irrigation in Finland – case study Southwestern Finland)*. The Finnish Environment 629. Finnish Environment Institute, Helsinki, Finland, http://www.ymparisto.fi/default.asp?contentid=33041, 18/08/2009.

[FI04]: **Baldock, D., Caraveli, H., Dwyer, J., Einschütz, S., Petersen, J.E., Sumpsi-Vinas, J. & Varela-Ortega, C**. 2000. *The environmental impacts of irrigation in the European Union.* A report to the Environment Directorate of the European Commission, 147 pp., http://ec.europa.eu/environment/agriculture/, 07/07/2006.

[FI05]: **Sierla, J.** 2006. *Water resources management and agriculture in Finland*. Summary report available at the web-page of the Finnish National Committee of the ICID (FINCID), http://www.salaojakeskus.fi/fincid/indexeng.htm, 07/07/2006.

France
(French Guyana, Guadeloupe, Martinique and Réunion are reported separately)

The irrigable area of the country increased steadily from 2 099 700 ha in 1990 to 2 510 410 ha in 1995 and 2 723 700 ha in 2003. The area actually irrigated was lower but increased also from 1 484 840 ha in 1990 to 1 629 580 ha in 1995 and 1 938 730 ha in 2003 [FR01]. According to the agricultural census 2000 the main irrigated crops were maize (56 percent of the irrigated area), vegetables and potatoes (12 percent of irrigated area) and fruits and vines (9 percent of the irrigated area) [FR02]. Area equipped for irrigation was estimated by selecting the maximum of the irrigable area as reported by the EIDER data base by department for the years 1997, 2000 and 2003 [FR03]. For the year 2003 data were available for only 46 of the 96 departments which may lead to an underestimation of the area equipped for irrigation in the remaining 50 departments. Area equipped for irrigation by region and department estimated that way is summing up to 2 906 081 ha.

Area equipped for irrigation was distributed within the departments by combining cultivated areas as derived from the Corine 2000 land cover data base for Europe [FR04] and a map published in [FR02] showing the percentage of cultivated land that is irrigated by canton. It was assumed that the density of area equipped for irrigation within the departments is relative to the density of area actually irrigated computed that way. To assure that irrigation is mainly concentrated on arable land, the priority levels shown in Table A21 were used. The irrigation map for France compiled that way was found to be in good agreement to irrigation maps published in the literature ([FR05], [FR06]).

Area equipped for irrigation with groundwater was computed based on the data collected by the EU farm structure survey 2003 as described before. Area actually irrigated per province was computed as average of AAI reported by the farm structure surveys 2003, 2005, and 2007 [FR01]. Total AAI computed that way was summing up to 1 693 137 ha.

TABLE A21
Priorities used to assign irrigated area to the areas classified as cultivated in the CORINE land cover 2000 data base for France.

Attribute	Priority
Permanently irrigated land	7
Rice fields	7
Non-irrigated arable land	6
Fruit trees and berry plantations	6
Complex cultivation patterns	6
Vineyards	5
Olive groves	5
Pastures	5
Land principally occupied by agriculture, with significant areas of natural vegetation	5

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Germany

Surveys of the German Sprinkler Association undertaken in the years 1995 and 2001 indicate that about 500 000 ha were equipped for sprinkler irrigation in Germany around year 2000 ([DE01], [DE02]). An area of about 5 000 ha is under micro irrigation (mainly drip irrigation in vineyards). In the north-eastern part of the country there are about 600 000 ha of equipped lowlands. Combined drainage / subsurface irrigation facilities were installed there to manage peat soils and groundwater near sandy sites. Surface irrigation methods are not used anymore [DE03]. Irrigation is mainly practiced on arable land and in most irrigation areas only specific crops in a crop rotation are irrigated (e.g. potatoes, sugar beets, maize, and vegetables). Therefore the area actually irrigated was only 236 797 ha in 1998 and 220 907 ha in 2002. Arable crops covered about 79 percent of the irrigation area, horticulture 17 percent and perennial crops about 4 percent ([DE04], [DE05]). Sub-national statistics on area equipped for irrigation were compiled from different sources. The main source of information was the survey of the German Sprinkler Association undertaken in 2001 that provided figures for the 16 federal states [DE02]. For the federal state of Niedersachsen, where about 47 percent of the irrigated area is concentrated, statistics per county were provided by the local branch of the Sprinkler Association [DE06] while statistics for Sachsen-Anhalt, also on the county level, were derived from the literature [DE07]. The figures for the federal state of Hessen were replaced by statistics taken from a recently published report [DE08]. Total area equipped for irrigation was 515 731 ha. Irrigation in equipped lowlands were neglected because it was reported, that operation and maintenance of the subsurface irrigation systems were drastically reduced during the transformation process of irrigated agriculture in Eastern Germany. Thus the water use statistics also do not account for these systems. There are initiatives to reactivate the systems of ditches, control structures, weirs and pumping stations because under the

climatic conditions there is a high requirement for water retention and impounded water irrigation on cultivated grassland in north-eastern Germany. However, the focus is more on the protection of the peat soils and wetlands than on increasing agricultural production [DE03]. AEI reported for the federal states of Bayern, Brandenburg, Hessen, Nordrhein-Westfalen, and Schleswig-Holstein was then downscaled to NUTS2-regions or districts in relation to the share of area actually irrigated provided by several publications for year 2002 [DE09-DE13].

Irrigation areas within the sub-national units were located and digitized using maps and information taken from the literature ([DE08], [DE14]-[DE19]). Irrigated area was assigned to cropland derived from the Corine 2000 land cover data base for Europe [DE20] located within the digitized polygons. However, for some regions irrigation maps were not available (e.g. Saarland). Therefore, irrigated area was also assigned to arable land on coarse soils [DE21].

Area equipped for irrigation with groundwater (AEI_GW) per NUTS2-region or district was computed as AEI_GW = AEI * IWU_GW / (IWU_GW + IWU_SW) by using statistics on irrigation water use from groundwater (IWU_GW) or irrigation water use from surface water (IWU_SW) reported in several publications of the statistical offices of the federal states ([DE09]-[DE13], [DE22]). Area actually irrigated in year 2002 was derived from the same publications.

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Greece

The area reported to be irrigable increased in Greece from 1 130 570 ha in 1990 to 1 235 300 ha in 1995 and 1 521 600 ha in 2003. The area actually irrigated also increased from 932 980 ha in 1990 to 1 142 180 ha in 1995 and 1 294 400 ha in 2003 [GR01]. Area equipped for irrigation was computed by selecting the maximum of the irrigable area as reported by the EUROSTAT for 13 regions and for the years 1997, 2000 and 2003 [GR01]. The island of Crete was further subdivided in four districts because irrigation statistics could be obtained from the literature [GR02]. Area equipped for irrigation by region computed that way adds up to 1 544 530 ha.

Irrigated area was assigned first to all areas classified as "Permanently irrigated land" (212) or "Rice fields" (213) by the Corine 2000 land cover database for Europe [GR03]. 658 386 ha were distributed in total that way. Additionally other irrigation areas were digitized from an irrigation map [GR04] or from a land use map published in an atlas [GR05]. Cultivated land located within the digitized polygons was extracted from the Corine land cover data base and 432 250 ha of irrigated land were assigned to these areas. Finally, the remaining fraction of the area equipped for irrigation was assigned to cultivated land located outside the digitized polygons by using the priorities shown in Table A22. In this process it was assumed that the irrigation density in polygons of priority 4 is only 10 percent of the irrigation density in polygons of priority 5. Polygons of priority 4 represent pastures, marginal areas and olive groves and thus areas that are usually not irrigated in Greece. An exception was made for the

island of Crete. It was reported that more than 40 percent of the olive groves are irrigated there today [GR06]. Therefore polygons classified as olive groves and located on Crete got the higher priority level 5.

Area equipped for irrigation with groundwater was computed based on the data collected by the EU farm structure survey 2003 as described before. Area actually irrigated per province was computed as average of AAI reported by the farm structure surveys 1997, 2000, and 2003 [GR01]. Total AAI computed that way was summing up to 1 206 017 ha.

TABLE A22

Priorities used to assign irrigated area to the areas located outside the digitized irrigation areas and classified as cultivated in the CORINE land cover 2000 data base for Greece.

Attribute	Priority
Non-irrigated arable land	5
Fruit trees and berry plantations	5
Annual crops associated with permanent crops	5
Complex cultivation patterns	5
Vineyards	5
Olive groves*	4
Pastures	4
Land principally occupied by agriculture, with significant areas of natural vegetation	4

*: Olives groves got priority 5 if located in Crete.

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Hungary

In Hungary the area equipped for irrigation reached its maximum in 1974 at 451 000 ha when the barrage at Kisköre and a dam in Békés were put into operation [HU01]. The area still equipped for irrigation is lower today but the statistics differ significantly dependent on the reference year and the source of information. The irrigable area of the country as reported by EUROSTAT or the Central Statistics Office was 308 110 ha in 2000 [HU02] and about 242 170 ha in 2003 [HU02], [HU03], while statistics of the National Water Authority indicate an area equipped for irrigation of 235 500 ha in 2000 and 208 400 ha in 2003 [HU01]. According to the latter statistics the area equipped for irrigation declined each year within the period 1998 (264 300 ha) to 2004 (159 100 ha). Differences also exist in the statistics referring to the area actually irrigated. EUROSTAT reported an area actually irrigated of 67 100 ha in 2000 and 148 690 ha in 2003 [HU02]. In contrast, the National Water Authority reported actual irrigation areas of 125 300 ha in 2000 and 115 200 ha in 2003 [HU01]. Because of the given

uncertainties area equipped for irrigation was estimated for this study by selecting for each county the maximum of the areas reported as irrigable (Central Statistics Office, year 2003) or equipped for irrigation (National Water Authority, years 2001, 2002 and 2004). The total area equipped for irrigation estimated that way is summing up to 292 147 ha.

Polygons, showing the irrigation system of Hungary, were digitized from an irrigation map published in an atlas [HU04] and combined to polygons of cultivated land as extracted from the Corine 2000 land cover database for Europe [HU05] by using the priority levels shown in Table A23.

Area equipped for irrigation with groundwater was computed based on the data collected by the EU farm structure survey 2003 as described before. Area actually irrigated per county was computed as average of AAI reported for the period 2003-2009 [HU06]. Total AAI computed that way was summing up to 104 415 ha.

TABLE A23
Priorities used to assign irrigated area to cultivated areas in Hungary.

Attribute in Corine land cover 2000 data base	Location within polygons of the digitized irrigation areas	Priority
Rice fields (213)	Yes or No	7
Non-irrigated arable land (211) or vineyards (221) or fruit trees and berry plantations (222) or complex cultivation patterns (242)	Yes	6
Pastures (231) or land principally occupied by agriculture, with significant areas of natural vegetation (243)	Yes	5
Non-irrigated arable land (211) or vineyards (221) or fruit trees and berry plantations (222) or complex cultivation patterns (242)	No	4

References:

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[HU06]: **Hungarian Central Statistical Office**. 2011. *Data on irrigated land area*. http://statinfo.ksh.hu/Statinfo/QueryServlet?ha=MN1B05, 15/03/2011.

Iceland

No data on irrigation in Iceland were available. However, there exists some vegetable production on Iceland, e.g. cucumbers and tomatoes [IS01]. The total harvested vegetable area was 77 ha in 2003 [IS02]. Because of the climatic conditions on Iceland it can be assumed that most of this production is coming from greenhouses what also would indicate that there might be some irrigation. For this study it was nevertheless assumed that there is no irrigation in Iceland.

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Ireland

The irrigated area in Ireland is about 1100 ha and consists of about 500 ha early potatoes, 500 ha vegetables and 100 ha strawberries in plastic tunnels. Most of the irrigated area is located in the southern, eastern and south-eastern regions of the country [IE01]. No sub-national statistics on irrigated area have been available for Ireland. Therefore the potato growing area of the counties located in the south, east or south-east was extracted from the Agricultural Census 2000 [IE02] and it was assumed that the irrigated area is proportional to the potato growing area (in total 2122 ha).

Area equipped for irrigation was equally distributed over all polygons classified as non-irrigated arable land (211) or complex cultivation patterns (242) in the Corine 2000 land cover database for Europe [IE03].

Statistics related to irrigated areas and sources of irrigation water were not available. Based on data for neighbouring West England and Wales, percentage of irrigated area from groundwater sources was estimated at 20 percent.

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Italy

According to EUROSTAT the irrigable area of Italy was 3 854 910 ha in 2000 and 3 977 210 ha in 2003, while the area actually irrigated was 2 453 120 ha in 2000 and 2 732 730 ha in 2003 [IT01]. The results of the 5th agricultural census, undertaken in growing season 2000-2001 and reported for the 8101 communities are similar. The irrigable area is summing up to 3 892 202 ha, while the area actually used for irrigation is summing up to 2 471 379 ha [IT02]. It was assumed, that the irrigable area by community as reported by the agricultural census also represents the area equipped for irrigation.

Area equipped for irrigation was distributed within the communities to cultivated areas as extracted from the Corine 2000 land cover database for Europe [IT03] by using the priority levels shown in Table A24. The resulting irrigation map for Italy was found to agree well with irrigation maps published in the literature ([IT04]–[IT06]).

Area equipped for irrigation with groundwater was computed based on the data collected by the EU farm structure survey 2003 as described before. Area actually irrigated was derived from the database of the agricultural census 2000 [IT02].

TABLE A24
Priorities used to assign irrigated area to areas classified as cultivated in the CORINE land cover 2000 data base for Italy.

Attribute	Priority
Permanently irrigated land (212)	7
Rice fields (213)	7
Non-irrigated arable land (211)	6
Fruit trees and berry plantations (222)	6
Annual crops associated with permanent crops (241)	6
Complex cultivation patterns (242)	6
Vineyards (221)*	5
Olive groves (223)	5
Pastures (231)	5
Land principally occupied by agriculture, with significant areas of natural vegetation (243)	5

*: Priority level 6 was assigned to vineyard areas if located in the regions of Molise, Puglia, Sicilia, Trento, Alto Adige or Valle d'Aosta .

References:

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Kosovo

Under the former Federal Republic of Yugoslavia about 68 000 ha were equipped for irrigation in the Kosovo area [KV01]. The area equipped for irrigation dropped to 23 000 ha in 1999 due to the devastation of war and the lack of maintenance. Thanks to donor contribution about 51 000 ha were under irrigation again in 2002 [KV02] and the actual extent of the irrigation schemes was given at 77 000 ha [KV01]. Area actually irrigated as derived from the agricultural household survey 2004 by municipality [KV03] was scaled to meet the figures for the total area equipped for irrigation in the entire region (77 000 ha).

Area equipped for irrigation was assigned to polygons extracted from the Corine 2000 land cover database for Europe [KV04] that were classified as non-irrigated arable land (211), vineyards (221), fruit trees and berry plantations (222), or complex cultivation patterns (242).

Statistics on the source of irrigation water were not available for the Kosovo territory. However, large irrigation water extractions from surface water sources (rivers and reservoirs) are reported while because of the aquifer conditions groundwater use is limited to the western part of the country [KV05]. Other statistics indicate that small scale private irrigation is nowadays very important in Kosovo ([KV06], [KV07]) and that the rural water supply in parts of the country is based on groundwater extractions [KV08]. Based on this indicative information percentage of irrigated area from groundwater sources was estimated at 5 percent

for the eastern part of the country and at 25 percent for the western part. Area actually irrigated in 7 regions was computed as average of AAI in period 2005-2007 [KV09]. Total AAI computed that way was 39 466 ha.

References:

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Latvia

Area equipped for irrigation was about 20 000 ha in 1995, all of it sprinkler irrigation [LV01]. However, the restructuring of the agricultural sector caused a strong decline of the area equipped for irrigation. According to EUROSTAT the irrigable area was 560 ha in 2000, 1150 ha in 2003 and 790 ha in 2005 [LV02]. Areas equipped with sprinkler irrigation infrastructure were reported by district for the year 2001 and were summing up to 569 ha [LV03]. The sprinkler irrigation areas by district were scaled so that the country totals were equal to the maximum irrigable area as reported by EUROSTAT (1150 ha).

The main irrigated crops are vegetables, potatoes, sugar beets and strawberries [LV01], [LV04]. Since irrigation maps were not available for Latvia, irrigated area was assigned to polygons as extracted from the Corine 2000 land cover database for Europe [LV05] classified as non-irrigated arable land (211), fruit trees and berry plantations (222) or complex cultivation patterns (242).

Statistics on the source of irrigation water were not available for Latvia. Based on the ratio between groundwater abstractions for agriculture, forestry and fishery and total water abstractions for agriculture, forestry and fishery in period 2003-2007 [LV06] area equipped for irrigation with groundwater was estimated at 80 ha (7 percent of total AEI).

References:

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Liechtenstein

Reports, maps or statistical data indicating that irrigation would exist in Liechtenstein were not available. Therefore it was assumed that there is no irrigation.

Lithuania

Area equipped for irrigation was 42 700 ha in 1990, the largest part of the irrigation infrastructure (29 900 ha) was located on meadows and pastures [LT01]. As private owners started working on small plots there was no need anymore for large scale irrigation infrastructure. Therefore area equipped for irrigation declined to 9247 ha in 1995 [LT01], 8122 ha in 1998 [LT02] and 4416.3 ha in 2005 [LT03]. 3920.9 ha of the area equipped for irrigation are located on artificial drained land [LT03]. Area equipped for irrigation by county and municipality was derived from an inventory related to year 2005 [LT03].

Today the main irrigated crops are potatoes and vegetables [LT04]. Since irrigation maps were not available for Lithuania, irrigated area was assigned to polygons as extracted from the Corine 2000 land cover database for Europe [LT05] classified as non-irrigated arable land (211) or complex cultivation patterns (242).

Based on the ratio between groundwater abstractions for irrigation and total water abstractions for irrigation in period 2003-2005 [LV06] area equipped for irrigation with groundwater was estimated at 2331 ha (53 percent of total AEI). [LT06]. Area actually irrigated was set to 1000 ha according to the EU farm structure survey 2007 [LT07].

References:

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Luxembourg

In Luxembourg only some small scale vegetable production is irrigated [LU01], but irrigation statistics were not available. 36 ha vegetable production was reported for Luxembourg and year 2002 [LU02]. It was assumed that 75 percent of the vegetable production is irrigated, which results in an estimate of 27 ha for the area equipped for irrigation.

Irrigation maps were not available for Luxembourg. Instead of it, area equipped for irrigation was assigned to polygons extracted from the Corine 2000 land cover database for Europe [LU03] classified as non-irrigated arable land (211) or complex cultivation patterns (242) that were located within polygons indicating coarse soil (sltxtcl = 1) as extracted from a European soil map [LU04].

Percentage of irrigated area from groundwater sources was estimated at 70 percent based on the statistics for neighbouring Belgian provinces.

References:

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Malta

Area equipped for irrigation was 2300 ha in 2003, while the area actually used for irrigation was 2130 ha in the same year [MT01]. Sub-national irrigation statistics on the community level collected in the year 2001 reported an area equipped for irrigation of 1509 ha [MT02]. The area equipped for irrigation by community was scaled so that the country totals are equal to the value reported for the year 2003 (2300 ha).

To distribute area equipped for irrigation within the communities, irrigated area was assigned to polygons extracted from the Corine 2000 land cover data base for Europe [MT03] classified as non-irrigated arable land (211), permanently irrigated land (212), vineyards (221), pastures (231), complex cultivation patterns (242) or land principally occupied by agriculture, with significant areas of natural vegetation (243).

Area equipped for irrigation with groundwater (2287 ha) was computed based on the data collected by the EU farm structure survey 2003 as described before.

References:

[MT01]: **Statistical Office of the European Communities (EUROSTAT)**. 2011. *Irrigable and irrigated areas*. http://epp.eurostat.ec.europa.eu/portal/page/portal/agri_environmental_indicators/data/database, 28/11/2011.

[MT02]: **National Statistics Office**. 2004. *Agriculture and fisheries 2002*. Valletta, Malta, 175 pp., http://www.nso.gov.mt, 07/07/2006.

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Monaco

It was assumed that irrigated agriculture does not exist in this urban centre.

Montenegro

No statistics on area equipped for irrigation were available. However, the maximum of the area actually irrigated during the period 2001 - 2005 was reported at 2115 ha for year 2005 [ME01]. It was assumed that this area also represents the area equipped for irrigation. No subnational statistics were available.

Since irrigation maps were not available for Montenegro, area equipped for irrigation was assigned to polygons extracted from the Corine 2000 land cover database for Europe [RS03] that were classified as non-irrigated arable land (211), vineyards (221), fruit trees and berry plantations (222), or complex cultivation patterns (242).

Average irrigation water use from groundwater within the period 2005-2007 was 7.3 Million m^3 yr^{-1} while irrigation water extraction from surface water was only 25 Thousand m^3 yr^{-1} [ME03]. Based on the ratio between irrigation water uses from the different water sources, area equipped for irrigation with groundwater was estimated at 2108 ha.

References:

[ME01]: **Statistical Office of the Republic of Montenegro**. 2006. *Statistical Yearbook 2006*. MONSTAT, Podgorica, Montenegro, 346 pp.

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Netherlands

Area equipped for irrigation was available at the municipality level [NL01] and was summing up to 475 098 ha. However, for 19 out of the 544 municipalities the database had no data. After replacing these no-data-values by data using the reported irrigation densities in neighbouring municipalities total area equipped for irrigation was summing up to 476 315 ha.

The main irrigated crops in the Netherlands are grass, maize, potatoes and vegetables [NL02]. Irrigated area was therefore assigned to polygons extracted from the Corine 2000 land cover database for Europe [NL03] classified as non-irrigated arable land (211), pastures (231), complex cultivation patterns (242) or land principally occupied by agriculture, with significant areas of natural vegetation (243).

Area equipped for irrigation with groundwater was computed for 4 regions based on the data collected by the EU farm structure survey 2003 as described before. Area actually irrigated is varying from year to year depending on the specific climate in the reference year. In the wet growing season 1998/1999 area actually irrigated was only 123 300 ha while it was 308 700 ha in the dry growing season 1996/1997 [NL02]. Area actually irrigated per NUTS2-region was computed therefore as average of AAI reported by the EU farm structure surveys 2003, 2005 and 2007 [NL04]. Total AAI computed that way is summing up to 119 156 ha.

References:

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[NL02]: **Hoogeveen, M.W., van Bommel, K.H.M. & Cotteleer, G.** 2003. *Beregening in land- en tuinbouw*. Rapport voor de Droogtestudie Nederland. Rapport 3.03.02, LEI, Den Haag, Netherlands, 64 pp., http://www.lei.wur.nl/nl/publicaties+en+producten/leipublicaties/?n=3.03.02, 02/08/2006.

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Norway

Area equipped for irrigation was increasing in Norway from 68 815 ha in 1979 to 90 670 ha in 1989 and 134 396 ha in 1999 [NO01]. Irrigation is mainly practiced on soils of low or moderate water holding capacity in South-East Norway in locations east of the mountains trapping rain water. However, in some isolated valleys in the inland the yearly amount of precipitation is down to 320 mm. Here agriculture (cereals/grass) is not possible without irrigation. The main irrigated crops are berries, vegetables, cereals, potatoes and grass [NO02]. Area equipped for irrigation by county is shown in the table below.

An inventory of soil properties on agricultural land [NO03] was used to distribute area equipped for irrigation within the counties. The inventory does not cover entire Norway but the largest part of the areas used for agricultural production. Among many other soil properties the inventory provides the water holding capacity of the topsoil (upper 60 cm) in four classes. Irrigated area was assigned to all soils of low water holding capacity (<50 mm) and to soils of moderate water holding capacity (50 – 90 mm). In total 77 845 ha of irrigated area were assigned to those soil regions. The remaining part of area equipped for irrigation was assigned to cultivated areas in regions not covered by the soil inventory and to soils of higher water holding capacity. Polygons for the cultivated land were extracted from a digital data set also available from the Norwegian Institute of Land Inventory [NO04]. This data set had a lower resolution but covered the entire country.

The percentage of AEI irrigated with groundwater was estimated by using the number of holdings irrigating by using ground- or surface water as reported for each county by the agricultural census 1999 [NO01]. Area actually irrigated per county was derived from the report of the farm structure survey 2007 as provided by EUROSTAT [NO05].

References:

[NO01]: **Statistics Norway**. 2003. *Census of agriculture 1999*. Report No. NOS C 746, Oslo - Kongsvinger, Norway, 202 pp., http://www.ssb.no/english/subjects/10/04/10/nos_jt1999_en/, 07/07/2006.

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[NO03]: **Norwegian Institute of Land Inventory (NIJOS)**. 2006. *Jordsmonndatabasen, Vanlagringsevne per commune*. Maps in GIS-format, http://www.nijos.no/index.asp?topExpand=&subExpand=&menuid=1000523&strUrl=1002320i&context=14, 03/08/2006.
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Poland

The extent of irrigated land reached its maximum in Poland in 1975 (408 700 ha) and declined later to 301 500 ha in 1990, 201 100 ha in 1995 and 83 292 ha in 2003. Sub-surface irrigation of permanent grasslands in wetlands and inland valley bottoms in combined drainage / irrigation schemes is dominant in Poland. The area of ameliorated grasslands is about 1 931 000 ha and about 25 percent of the drained grasslands are equipped with hydraulic structures that would in general allow to irrigate them. However, in 2004 only 89 000 ha of grasslands were classified as irrigable. The corresponding figures for arable land listed only 5300 ha, mainly by micro-irrigation [PL01]. In contrast, the statistics published by EUROSTAT indicate that the extent of both, irrigable and actually irrigated area started recently to increase again. The irrigable area of Poland was reported at 98 420 ha in 2003 and 124 200 ha in 2005 while the area actually irrigated was 46 910 ha in 2003 and 70 450 ha in 2005 [PL02]. Because of the given uncertainties area equipped for irrigation was estimated for this study by selecting for each province the maximum of the areas reported as irrigable for the years 2003 and 2005. Area equipped for irrigation computed that way adds up to 134 050 ha.

To distribute irrigated areas within the provinces, pasture areas were extracted from the Corine 2000 land cover database for Europe [PL03]. Additionally the major irrigation areas of the country were digitized from irrigation maps [PL04], [PL05]. Then irrigated area was assigned to all pasture polygons within the digitized irrigation areas or to pasture polygons that were located along the major rivers of the country.

90 percent of Poland's irrigation area is irrigated with surface water and 10 percent with groundwater [PL01]. Area actually irrigated per district was computed as average of AAI reported by the EU farm structure surveys 2003, 2005 and 2007 [PL02]. Total AAI computed that way adds up to 63 138 ha.

References:

[PL01]: **Mioduszewski, W., Labedzki, L., Kuzniar, A., and Lipinski, J.** 2006. *Polish report*. In: Dirksen, W. and Huppert, W. (ed.). Irrigation sector reform in Central and Eastern European countries. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn, Germany, 329-383.
[PL02]: **Statistical Office of the European Communities (EUROSTAT)**. 2011. *Irrigable and irrigated areas*. http://epp.eurostat.ec.europa.eu/portal/page/portal/agri_environmental_indicators/data/database, 28/11/2011.
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[PL05]: **Achtnich, W.** 1980. *Bewässerungslandbau*. Map on p. 26, Ulmer, Stuttgart, Germany.

Portugal

According to the data reported by EUROSTAT irrigated area in Portugal was decreasing during the last 15 years. While area equipped for irrigation was 877 690 ha in 1990, it decreased to 796 540 ha in 1995 and 791 990 ha in 2000. For the year 2003 the reported irrigable area was even much lower at 674 800 ha. The same trend was reported for the year actually irrigated, which was 631 120 ha in 1990 but only 248 040 ha in 2003 [PT01]. The agricultural census undertaken in 1999 reported an area equipped for irrigation of 792 008 ha and an area actually used for irrigation of 606 213 ha [PT02]. These census data were also used in this study because the area equipped for irrigation was reported down to 306 NUTS III units.

In order to distribute irrigated areas within the municipalities, irrigation areas were extracted from a digital land use map at the scale 1 : 250 000 [PT03] and from the Corine 2000 land cover database for Europe [PT04]. The large-scale irrigation areas shown on an irrigation map of the country [PT05] were represented very well that way. 421 805 ha irrigated areas were assigned in total to polygons extracted from the two digital data sets. The remaining irrigated area was assigned to polygons also extracted from the Corine 2000 land cover database for Europe [PT04] but classified as rainfed agriculture by using the priority levels shown in Table A25. Since the Corine 2000 database did not cover the island of Madeira, cultivated land was digitized from satellite imagery [PT06] and irrigated area was assigned to the digitized polygons.

Area equipped for irrigation with groundwater was computed for 7 regions based on the data collected by the EU farm structure survey 2003 as described before.

TABLE A25

Priorities used to assign irrigated area to areas classified as rainfed agriculture in the CORINE land cover 2000 data base for Portugal.

Attribute	Priority
Non-irrigated arable land (211)	5
Fruit trees and berry plantations (222)	5
Annual crops associated with permanent crops (241)	5
Complex cultivation patterns (242)	5
Vineyards (221)*	4
Olive groves (223)	4
Pastures (231)	4
Land principally occupied by agriculture, with significant areas of natural vegetation (243)	4

References:

[PT01]: **Statistical Office of the European Communities (EUROSTAT)**. 2011. *Irrigable and irrigated areas*. http://epp.eurostat.ec.europa.eu/portal/page/portal/agri_environmental_indicators/data/database, 28/11/2011.

[PT02]: **Instituto Nacional de Estatistica**. 2003. *Recenseamento Geral da Agricultura 1999. Principais Resultados por Região Agrária*. http://www.ine.pt/prodserv/Rga/publicacaopdf_ra.htm, 25/08/2005.

[PT03]: **Instituto Geográfico Português**. 2001. *Carta de Ocupação de solo de 1990*. http://www.igeo.pt/IGEO/portugues/Frameset-egeo.htm, 08/08/2005.

[PT04]: **EEA**. 2005. *Corine land cover 2000 - vector by country (CLC2000), version 1*. http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=667, 29/08/2005.

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Republic of Moldova

Area equipped for irrigation was 312 000 ha in 1994 [MD01] but declined later to 302 100 ha in 2000 and 280 800 ha in 2002 [MD02]. In this study the value 307 000 ha is used as area equipped for irrigation. The figure refers to 1999 [MD03].

The irrigation schemes of the country were digitized from an irrigation map [MD04] and the area equipped for irrigation was equally distributed over the digitized polygons.

Large parts of the irrigation infrastructure are abandoned or out of use. AAI in years 1993-1995 was 49 percent - 67 percent of the AEI [MD05] and the reported agricultural water use (AWU) in year 1992 was 775 Million m^3 [MD01]. In contrast, AWU in year 2008 was only 37 Million m^3 [MD06]. Therefore we estimated that the AAI in year 2008 was only about 20 000 ha. It was reported that, because of the low quality of available groundwater resources, all irrigation is from surface water [MD05].

References:

[MD01]: **FAO**. 2012. *AQUASTAT country profile of the Republic of Moldova, version 1997*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/moldova_rep/index.stm, 02/04/2012.

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[MD03]: **FAO**. 2011. *FAOSTAT*. http://faostat.fao.org/, 13/02/2006.

[MD04]: **Catrinescu, V., Calasnic, A. & Melian, R.** 1999. *Irrigation in Moldova*. In: European Regional Working Group (ERWG) of the ICID. EWRG letter 7, 1-4.

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Romania

The total agricultural land reclaimed for irrigation reached its maximum in 1996 at 3 210 000 ha and declined later to 3 176 000 ha in 2003 [RO01]. However, from 1991 onwards a large part of the irrigation infrastructure was not used anymore. The minimum extent of the actually used irrigation areas was reported for the period 1998-2000 when less than 10 percent of the reclaimed irrigation area was irrigated [RO02]. At this time a program started to establish water user's associations and to transfer the on-farm irrigation infrastructure to them. Additionally an irrigation rehabilitation program, supported by the World Bank, started in regions of high crop water requirements. As a consequence of these activities the area actually used for irrigation was increasing again. Nevertheless it is very unlikely that all the former irrigation areas will be re-activated within the next years. A study carried out in 1994 with the support of the World Bank for example clearly indicated that irrigation is not economic in the higher terraces, even if agriculture redevelops, and should be discontinued so as not to waste further resources [RO02]. This, and the fact that a large part of the irrigation infrastructure has not been used for a long time shows that it is not useful to consider all the reclaimed irrigation area still as equipped for irrigation. EUROSTAT reported the irrigable area for the year 2003 at 1 510 820 ha [RO03], which is about half of the area developed in former times. These figures might refer to the so called 'area declared prepared for irrigation', which was 2 121 238 ha in 1999, 1 502 642 ha in 2000, 900 678 ha in 2001 and 1 222 000 ha in 2002 [RO02]. For this study area equipped for irrigation was taken out of a table published in [RO01] listing the total area of schemes in counties where water user's associations are established (as per

31/12/2004). The statistics were given for 24 counties covering by far the largest part of the former irrigation zones and were summing up to 2 021 911 ha. Area equipped for irrigation for the other counties was estimated based on a map published in the same report showing the former reclaimed irrigation areas. The total area equipped for irrigation computed that way for the 17 counties missing in the statistics was 127 992 ha which gives a total sum of 2 149 903 ha for the whole country.

Area equipped for irrigation was assigned to polygons extracted from the Corine 2000 land cover database for Europe [RO04] that were located within the digitized irrigation areas and that were classified as non-irrigated arable land (211), permanently irrigated land (212), rice fields (213), vineyards (221), fruit trees and berry plantations (222), pastures (231), complex cultivation patterns (242) or land principally occupied by agriculture, with significant areas of natural vegetation (243).

Area equipped for irrigation with groundwater was computed for 8 regions based on the data collected by the EU farm structure survey 2003 as described before. Area actually irrigated per NUTS2-region was computed as average of AAI reported by the EU farm structure surveys 2003, 2005 and 2007 [RO03]. Total AAI computed that way adds up to 221 106 ha.

References:

[RO01]: **Nicolaescu, I., Buhociu, L., Condruz, R., Suciu, G.-I., Paraschiv, D. & Boeru, M.** 2006. *Country report from Romania*. In: Dirksen, W. and Huppert, W. (ed.). Irrigation sector reform in Central and Eastern European countries. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn, Germany, 385-462.

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Russian Federation

Area equipped for irrigation was 6 124 000 ha in year 1990 and declined to 5 158 000 ha in year 1994 [RU01] and 2 375 200 ha in year 2006 [RU02]. Area equipped for irrigation for the 87 provinces of the Russian Federation was derived from the report of the agricultural census 2006 [RU02].

The irrigated areas and arable land were derived from a land-use map [RU03] and from an agricultural map [RU04], both provided by the International Institute for Applied Systems Analysis. In the Asian and more northern parts of Russia, only a few areas are classified as irrigated. Therefore, irrigated areas were also distributed to other agricultural areas using the priorities as documented in Table A26. Irrigated area was first distributed only to cells with a priority of 7, then to cells with a priority of 6, and so on until the sum of the distributed irrigated area was equal to the irrigated area of the specific region as derived from the statistics.

Area actually irrigated was 4 095 000 ha in year 1994 [RU01] but declined to 938 900 ha in year 2006 [RU02]. Consequently, agricultural water use was 15.3 km^3 yr^{-1} in 1994 [RU01], but only 8.8 km^3 yr^{-1} in year 2006 [RU05]. The dramatic restructuring of the irrigation sector results in serious difficulties to estimate the percentage of AEI irrigated with groundwater. In 1990, most of the land under irrigation was commanded by reservoirs and open canals

conveyed the water to the irrigation schemes. However, it was also reported, that projects planned for the period 1998-2003 were mostly based on extraction of groundwater for irrigation [RU01]. According to another report the percentage of surface water use is 90 percent for industrial water use, 92 percent for domestic water use but only 64 percent for agricultural water use [RU06]. Based on these statistics and considering the ongoing transformation of the irrigation sector area equipped for irrigation with groundwater was estimated at 20 percent of total AEI.

TABLE A26

Priorities assigned to specific land uses to distribute irrigated areas within provinces in the Russian Federation.

Dataset	Attribute information	Priority
RU03	Irrigated cropland	7
RU03	Irrigated cropland (more than 50%) combined with multiyear plantation	7
RU03	Irrigated meadows	7
RU03	Irrigated multiyear plantation	7
RU03	Irrigated multiyear plantation (more than 50%) combined with irrigated cropland	7
RU03	Cropland	6
RU03	Cropland (more than 50%) combined with forest	6
RU03	Cropland (more than 50%) combined with improved forage land, forest and bushes	6
RU03	Cropland (more than 50%) combined with multiyear plantation	6
RU03	Cropland (more than 50%) combined with natural and improved forage land	6
RU03	Cropland (more than 50%) combined with natural forage land	6
RU03	Cropland (more than 50%) combined with natural forage land and forest	6
RU03	Desert and semi-desert combined with cropland (up to 20%)	6
RU03	Improved forage land combined with cropland (up to 20%)	6
RU03	Multiyear plantation	6
RU03	Multiyear plantation (more than 50%) combined with cropland	6
RU03	Forest combined with cropland (up to 20%) and natural meadow forage land	5
RU03	Forest combined with natural forage land and cropland (up to 20%)	5
RU03	Meadow and meadow-steppe combined with cropland (up to 30%) and forest	5
RU03	Meadow and meadow-steppe combined with cropland (up to 30%), forest and bogs	5
RU03	Meadow and meadow-steppe combined with cropland (up to 30%), forest and solonchaks	5
RU03	Meadows combined with improved meadows, forest and cropland (up to 30%)	5
RU03	Natural forest forage land combined with cropland (up to 20%)	5
RU03	Natural meadow forage land combined with cropland (up to 20%) and forest	5
RU03	Park forest and bushes combined with cropland (up to 20%)	5
RU03	Park forest and bushes combined with cropland (up to 20%) and bogs	5
RU03	Sparse forest and open woodland combined with cropland (up to 20%)	5
RU03	Steppe combined with cropland (up to 20%)	5
RU04	Little used in agriculture	4

References:

[RU01]: **FAO**. 2012. *AQUASTAT country profile of the Russian Federation, version 1997*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/russian_fed/index.stm, 02/04/2012.

[RU02]: **Federal State Statistics Service**. 2008a. *Results of all-Russia agricultural census 2006. Vol. III: Soil resources.* Federal State Statistics Service, Moscow, Russia, 311 pp. (in Russian).

[RU03]: **Stolbovoi, V. & McCallum, I.** 2002. *Land resources of Russia*. Map 'Land Use'. Version 1.1. CD-ROM. Laxenburg, Austria, IIASA, http://www.iiasa.ac.at, 29/07/2004.

[RU04]: **Stolbovoi, V. & McCallum, I.** 2002. *Land resources of Russia*. Map 'Agriculture'. Version 1.1. CD-ROM. Laxenburg, Austria, IIASA, http://www.iiasa.ac.at, 29/07/2004.

[RU05]: **Federal State Statistics Service**. 2008b. *Environment protection in Russia, 2008*. Federal State Statistics Service, Moscow, Russia, 253 pp. (in Russian).

[RU06]: **Kireycheva, L.V., Glazunova, I.V. & Belova, I.V.** 2006. *Country report from Russia*. In: Dirksen, W. and Huppert, W. (ed.). Irrigation sector reform in Central and Eastern European countries. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn, Germany, 463-524.

San Marino
It was assumed that irrigated agriculture does not occur in San Marino.

Serbia
Under the former Federal Republic of Yugoslavia, about 120 000 ha of agricultural land were equipped for irrigation in 288 schemes in Serbia. However, only about 35 000 ha of schemes are fully operational and 47 000 ha are partially functional. Among other, this is caused by the shortage of markets, redistribution of the Kombinats, adverse farmer financial positions, deterioration in the physical systems, land ownership problems, legal changes and institutional weakness [RS01]. Area equipped for irrigation by region was assumed to be represented by the maximum of the area intended to be used for irrigation in the period 2001-2005 [RS02]. The total area was summing up to 86 311 ha.

Area equipped for irrigation was assigned to polygons extracted from the Corine 2000 land cover database for Europe [RS03] that were classified as non-irrigated arable land (211), vineyards (221), fruit trees and berry plantations (222), or complex cultivation patterns (242).

Total area actually irrigated and related water abstractions of ground- and surface water was available for the years 2003-2007 for the regions of Central Serbia and Vojvodina [RS04]. Since irrigated areas and corresponding water abstractions varied significantly from year to year, area actually irrigated and percentage area irrigated from groundwater was computed based on average in this 5 year period. The area actually used for irrigation in Serbia computed that way was 27 541 ha.

References:
[RS01]: **World Bank**. 2005. *Serbia irrigation and drainage rehabilitation project. Project appraisal document*. Report No: 32379-YF, http://www-wds.worldbank.org/, 02/07/2006.
[RS02]: **The Agriculture Inspection of the Republic of Serbia**. unknown. *A survey of the arable agriculture land in the Republic of Serbia intended for irrigation (for the period 2001-2005)*. Table A1.1 in: Ministry for the Protection of the Natural Resources and Environment. 2001. State of the Environment in 2000 and priorities in 2001+ for Serbia. http://enrin.grida.no/htmls/yugo/serb/index.htm, 05/08/2006.
[RS03]: **EEA**. 2007. *Corine land cover 2000 - vector by country (CLC2000), update for Serbia and Montenegro*. http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=667, 03/04/2007.
[RS04]: **Statistical Office of the Republic of Serbia**. 2008. *Statistical yearbook of Serbia, 2008*. Statistical Office of the Republic of Serbia, Belgrade, Serbia, http://webrzs.statserb.sr.gov.yu/axd/en/god.htm, 26/08/2009.

Slovakia
Irrigation infrastructure was constructed on 308 200 ha of agricultural land [SK01], but area equipped for irrigation declined to 225 310 ha in year 2001 [SK02] which means that parts of the former infrastructure cannot be used anymore. Area equipped for irrigation per region was derived from the database of the farm structure census 2001 [SK02].

The main irrigation areas of the country were digitized from an irrigation map. The map showed areas in operation, areas under construction and planned irrigation areas of the former Czechoslovakia [SK03]. Irrigated area was then assigned to cultivated land extracted from the Corine 2000 land cover data base for Europe [SK04] using the priorities shown in Table A27. In the regions of Zilina and Presov irrigated area was assigned to all areas classified as vineyards (221), fruit trees and berry plantations (222) or complex cultivation patterns (242) because none of the digitized irrigation areas was located within these regions.

Area equipped for irrigation with groundwater was computed for 4 regions based on the data collected by the EU farm structure survey 2003 as described before. Area actually irrigated was computed for 8 regions as average of AAI reported by the farm structure surveys 2001, 2005 and 2007 [SK05]. AAI per region computed that way added up to 64 773 ha.

TABLE A27
Priorities used to assign irrigated area to cultivated areas in Slovakia.

Attribute in Corine land cover 2000 data base	Status of digitized irrigation areas	Priority
Non-irrigated arable land (211) or vineyards (221) or fruit trees and berry plantations (222) or complex cultivation patterns (242)	"operating" or "under construction"	7
Non-irrigated arable land (211) or vineyards (221) or fruit trees and berry plantations (222) or complex cultivation patterns (242)	"planned"	6
Vineyards (221) or fruit trees and berry plantations (222) or complex cultivation patterns (242)	-	5

References:

[SK01]: **Slovak National Committee of ICID**. unknown. *Slovak Republic*. ICID country profile http://icid.org/index_e.html, 07/07/2003.

[SK02]: **Statistical Office of the Slovak Republic**. 2002. *Farm structure census 2001*. http://www.statistics.sk/webdata/english/index2_a.htm, 06/08/2006.

[SK03]: **Framji, K.K., Garg, B.C. & Luthra, S.D.L.** 1981. *Irrigation and drainage in the world*. Third edition. Vol. I, p. 304. New Delhi, ICID.

[SK04]: **EEA**. 2005. *Corine land cover 2000 - vector by country (CLC2000), version 1*. http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=667, 29/08/2005.

[SK05]: **Statistical Office of the European Communities (EUROSTAT)**. 2011. *Irrigable and irrigated areas*. http://epp.eurostat.ec.europa.eu/portal/page/portal/agri_environmental_indicators/data/database, 28/11/2011.

Slovenia

The area equipped for irrigation was 6500 ha in 1995, most of it located in the Savinja valley, Podravje region and Vipava valley [SI01]. After a severe drought (1992-1993) a National Irrigation Program was prepared and based on a feasibility study undertaken by the World Bank (1997-1999) the development of an additional irrigation area of 10 000 ha was suggested [SI02]. The total area equipped for irrigation is now 15 643 ha in Slovenia [SI03]. It is necessary to draw attention to the fact that the irrigated area of the country is underestimated in the official statistical yearbook [SI04] and in the statistics reported by EUROSTAT [SI05] as well. The reason maybe that most of the irrigation facilities are of very small extent and many of them operate without any authorization for water withdrawal [SI02].

No updated sub-national irrigation statistics have been available, but, instead of it, a rather detailed map showing the location and extent of the single irrigation areas [SI06]. Area equipped for irrigation was distributed equally over the polygons digitized from this map.

Area equipped for irrigation with groundwater was computed based on the data collected by the EU farm structure survey 2003 as described before. Area actually irrigated (7121 ha) was computed based on the ratio between actually irrigated area and equipped area reported for years 2003-2007 in a pilot study undertaken to prepare the agricultural census 2010 [SI07].

References:

[SI01]: **World Bank**. 1997. *Slovenia – Irrigation project. Working paper 3: Water resources and irrigation in Slovenia*. Report available in the AQUASTAT library.

[SI02]: **Maticic, B. & Steinman, F.** 2006. *Country report from Slovenia*. In: Dirksen, W. and Huppert, W. (ed.). Irrigation sector reform in Central and Eastern European countries. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn, Germany, 525-606.
[SI03]: **Maticic, B.** (President of Slovenian National Committee on Irrigation and Drainage), personal communication.
[SI04]: **Statistical Office of the Republic of Slovenia**. 2006. *Statistical Yearbook of the Republic of Slovenia 2005*. http://www.stat.si/letopis/index_letopis_en.asp, 06/08/2006.
[SI05]: **Statistical Office of the European Communities (EUROSTAT)**. 2011. *Irrigable and irrigated areas*. http://epp.eurostat.ec.europa.eu/portal/page/portal/agri_environmental_indicators/data/database, 28/11/2011.
[SI06]: **Unknown**. *Irrigation areas in Slovenia*. Map, provided by Prof. Dr. Maticic (President of Slovenian National Committee on Irrigation and Drainage) on 13/04/2006 showing the location and extent of the Slovenian irrigation schemes.
[SI07]: **Pintar, M. & Maver, D.** 2009. *Pilot studies on estimating the volume of water used for irrigation. Final Report*. Table A6: Irrigated areas in Slovenia, Survey on water for irrigation (Environmental statistics). Statistical Office of the Republic of Slovenia, http://www.stat.si/eng/PrikaziDatoteko.aspx?id=3566, 04/04/2011.

Spain

Area equipped for irrigation was 2 540 310 ha in 1990 and increased then to 2 891 050 ha in 1995, 3 478 050 ha in 2000 and 3 828 110 ha in 2003. A similar trend was observed for the area actually irrigated that was reported at 2 433 700 ha in 1990, 2 609 920 ha in 1995, 3 235 510 ha in 2000 and 3 437 370 ha in 2003 [ES01]. Sub-national statistics were derived from the Agricultural Census 1999 for the 326 municipalities [ES02]. The total area equipped for irrigation as reported by the census in 1999 was 3 575 494 ha, while the area actually irrigated was 3 315 600 ha. However, the sum of area equipped for irrigation as reported for the single municipalities, which is similar to the area incorporated in the global irrigation map, was 3 575 488 ha. The difference of 6 ha compared to the value reported at the national scale may reflect rounding errors and was thus neglected.

Four data sets were combined to distribute irrigated area within the municipalities. First, irrigated areas were extracted from two digital data sets covering Andalusia and the Ebro river drainage basin ([ES03], [ES04]). Polygons extracted from these data sets got the highest priority of 8 in the distribution process because both data sets are regional products associated by a lot of additional information collected at the ground (e.g. type of irrigation, water sources etc.). The second highest priority level of 7 was assigned to irrigation areas additionally extracted from irrigation maps covering entire Spain [ES05]. Priority level of 6 was assigned to areas classified as permanently irrigated land (212) or rice fields (213) in the Corine 2000 land cover database for Europe [ES06], but not present in the data sets [ES04] or [ES05]. Finally irrigated area was also assigned to 77 908 ha agricultural land classified as rainfed agriculture in the Corine database, because the area equipped for irrigation reported by the census statistics was still larger in the related 52 municipalities than the total irrigated area assigned to the irrigation schemes before.

Area actually irrigated for 60 provinces and regions was derived from the database of the Agricultural census 1999 [ES02] while area equipped for irrigation with groundwater was computed for the 19 states by using the data EU farm structure survey 2003 as described before.

References:

[ES01]: **Statistical Office of the European Communities (EUROSTAT)**. 2011. *Irrigable and irrigated areas*. http://epp.eurostat.ec.europa.eu/portal/page/portal/agri_environmental_indicators/data/database, 28/11/2011.

[ES02]: **Instituto Nacional de Estadística**. 2002. *Censo Agrario 1999*. Online data base, http://www.ine.es/inebase/index.html, 11/04/2006.
[ES03]: **Consejeria de Agricultura y Pesca**. 2005. *Inventario y caracterización de los regadios de Andalucia. Actualización 2002.* Junta de Andalucia, CD-ROM, maps online: http://www.juntadeandalucia.es/agriculturaypesca/, 15/04/2006 .
[ES04]: **Confederación Hidrográfica del Ebro, Oficina de Planificación Hidrológica**. 2004. *Superficies regadío 2000*. http://www.oph.chebro.es/ContenidoCartoRegadios.htm, 08/08/2005.
[ES05]: **Ministerio de Agricultura, Pesca e Alimentación**. 2006. *Programa de Vigilancia Ambiental del Plan Nacional de Regadios.* Mapa 3 - Perímetro de los regadíos existentes. http://www.mapa.es/es/desarrollo/pags/vigilanciaambiental/mapas.htm, 06/08/2006.
[ES06]: **EEA**. 2005. *Corine land cover 2000 - vector by country (CLC2000), version 1*. http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=667, 29/08/2005.

Sweden

Area equipped for irrigation for 8 regions was derived from the statistics of the farm structure survey 2003. AEI reported for the regions added up to 188 470 [SE01]. Since these 8 regions are still pretty large and statistics on area equipped for irrigation were not available at higher resolution, statistics on irrigation water consumption [SE02] were used to downscale the irrigated area statistics to counties and municipalities. It is very likely that this procedure introduced an unknown error since irrigation water use per unit area is varying. However, it helped to identify the main zones of irrigation infrastructure development.

Irrigation maps were not available for Sweden. Instead of it area equipped for irrigation was assigned to polygons extracted from the Corine 2000 land cover database for Europe [SE03] using the priorities shown in Table A28.

Area equipped for irrigation with groundwater was computed for 8 regions based on the data collected by the EU farm structure survey 2003 as described before. Area actually irrigated for the same regions was computed as average of the AAI reported in the farm structure surveys 2003, 2005 and 2007 [SE01]. AAI computed this way added up to 52 150 ha.

TABLE A28
Priorities used to assign irrigated area to polygons derived from the CORINE land cover 2000 data base for Sweden.

Attribute	Priority
Non-irrigated arable land (211)	5
Fruit trees and berry plantations (222)	5
Complex cultivation patterns (242)	5
Pastures (231)	4
Land principally occupied by agriculture, with significant areas of natural vegetation (243)	4

References:

[SE01]: **Statistical Office of the European Communities (EUROSTAT)**. 2011. *Irrigable and irrigated areas*. http://epp.eurostat.ec.europa.eu/portal/page/portal/agri_environmental_indicators/data/database, 28/11/2011.
[SE02]: **Statistiska centralbyrån**. 1999. *Vattenuttag och vattenanvändningen i Sverige 1995*. Report No: Mi 27 SM 9901, Stockholm, Sweden, 67 pp.
[SE03]: **EEA**. 2005. *Corine land cover 2000 - vector by country (CLC2000), version 1*. http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=667, 29/08/2005.

Switzerland

Information about the extent of irrigated areas in Switzerland is very scarce. Total area equipped for irrigation is estimated at 55 000 ha, of which 43 000 ha are regulary irrigated while 12 000 ha are irrigated in dry years only. Area equipped for irrigation and area actually irrigated for 19 cantons were estimated from the statistics contained in a report of the irrigation survey 2006 [CH01]. For the cantons containing the largest irrigated areas, statistics were reported by the survey, while for other cantons irrigated areas were computed based on reported water uses. To estimate areas actually irrigated it was assumed that the areas, which are irrigated in dry years only, receive irrigation in 1 out of in 5 years.

Irrigation is mainly practiced in some parts of the canton Valais along the Rhone river where annual precipitation is less than 600 mm. 29 500 ha of irrigated land is located in this region. The outlines of the corresponding irrigation area and some additional irrigation areas in other parts of Switzerland were digitized from irrigation maps ([CH02], [CH03]). Regions of high irrigation water requirements indicated on maps in [CH04] were digitized as well. Area equipped for irrigation was then assigned to polygons extracted from the Corine 2000 land cover database [CH05] classified as agricultural land (classes 211 – 243) and located inside the polygons digitized before. The total extent of agricultural land in the Canton of Valais according to the Corine 2000 land cover database was smaller than the area considered to be equipped for irrigation. Therefore the difference of 4630 ha was assigned to areas classfied as natural grasslands (CLC class 321) and located in the neighbourhoud of agricultural land.

Based on the statistics provided by the irrigation survey 2006 [CH01] area equipped for irrigation with groundwater was estimated at 12 100 ha.

References:

[CH01]: **Weber, M. & Schild, A.** 2007. *Stand der Bewässerung in der Schweiz. Bericht zur Umfrage 2006*. Bundesamt für Landwirtschaft, Abteilung Strukturverbesserungen, Bern, Switzerland, http://www.blw.admin.ch/dokumentation/00018/00112/00504/index.html?lang=de, 27/08/2009.

[CH02]: **Framji, K.K., Garg, B.C. & Luthra, S.D.L.** 1981. *Irrigation and drainage in the world. Third edition.* Vol. III, p. 1306. New Delhi, ICID.

[CH03]: **Göpfert, R.** 2007. Ermittlung der Bewässerungsbedürftigkeit landwirtschaftlicher Nutzflächen im Kanton Graubünden. Bündener Bauernverband, Chur, Switzerland, http://www.gr.ch/DE/institutionen/verwaltung/dvs/alg/dokumentation/meliorationen/Dokumentliste%20Meliorationen/Bericht_Bewaesserung.pdf, 12/07/2010.

[CH04]: **Fuhrer, J. & Jasper**, K. 2009. Bewässerungsbedürftigkeit in der Schweiz: Schlussbericht. Forschungsanstalt Agroscope Reckenholz-Tänikon (ART), http://www.agroscope.admin.ch/publikationen/einzelpublikation/index.html?lang=en&aid=26435&pid=26883, 18/01/2010.

[CH05]: **EEA**. 2011. *Corine Land Cover 2000 seamless vector data - version 15 (08/2011)*. http://www.eea.europa.eu/data-and-maps/data/ds_resolveuid/e4618505e7d92a741dfdd9cbe8a05adc, 20/05/2012.

The former Yugoslav Republic of Macedonia

Area under irrigation in The Former Yugoslav Republic of Macedonia is 163 700 ha of which sprinkler systems cover about 100 000 ha and surface irrigation methods 63 700 ha. However, most of the systems are in poor condition. Additionally parts of this area has been lost to urbanization, other parts never received water. It is reported, that 32 percent of the irrigation distribution system is completely out of use, 22 percent faces serious deterioration, 19 percent moderate deterioration and only 27 percent is fully serviceable. Thus, the actual extent of area equipped for irrigation is about 127 800 ha [MK01]. No sub-national irrigation statistics have been available.

41 Irrigation areas located in the country were digitized from an irrigation map [MK02]. The area equipped for irrigation was reported for the 8 largest schemes (in total 104 449 ha). The corresponding area equipped for irrigation was assigned to agricultural land as extracted from the Corine 2000 land cover database for Europe [MK03] located within the digitized polygons. Polygons were extracted from the Corine database if classified as non-irrigated arable land (211), permanently irrigated land (212), rice fields (213), vineyards (221), fruit trees and berry plantations (222), pastures (231), annual crops associated with permanent crops (241), complex cultivation patterns (242) or land principally occupied by agriculture, with significant areas of natural vegetation (243).

The total AEI irrigated with groundwater is estimated at about 5000 ha [MK01], while total AAI in year 2007 was 79 638 ha [MK04].

References:

[MK01]: **Vukelic, Z., Jankovic, J.T. & Kondinski, I.** 2006. *Country report from Macedonia*. In: Dirksen, W. and Huppert, W. (ed.). Irrigation sector reform in Central and Eastern European countries. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn, Germany, 251-328.

[MK02]: **Ministry of Agriculture, Forestry and Water Supply**. 2005. Irrigation systems. http://www.water.org.mk/plavo/currentstructures/Irrigation.htm, 26/04/2005.

[MK03]: **EEA**. 2005. *Corine land cover 2000 - vector by country (CLC2000), version 1*. http://dataservice.eea.europa.eu/dataservice/metadetails.asp?id=667, 29/08/2005.

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Ukraine

Until 1992 irrigation infrastructure was installed on a total area of 2 624 000 ha. The highest construction rates of irrigation systems was registered between 1965 and 1985. After 1992 the construction of new irrigation systems was virtually stopped and several of the existing schemes went out of operation. While the area actually irrigated was still 2 291 600 ha in 1990, it decreased to 1 845 100 ha in 1995, 1 402 700 ha in 1998 and only 543 300 ha in 2001. In 2002 area actually irrigated was 730 100 ha and in 2003 it was 731 400 ha [UA01]. The reported lack of government funds to provide for proper operation and maintenance of the irrigation canals (total length 59 300 km), pumping stations (in total 13 700) and other hydro-technical constructions (in total 475 000) indicates that the area actually irrigated will, at least in the near future, very likely not reach the extent observed in the beginning of the 1990s again. Sub-national irrigation statistics were available for the year 1985 and were summing up to 2 395 500 ha [UA02]. This is very close to recent figures. It was reported that actually existing main and secondary level irrigation systems can provide watering on an area of 2 448 000 ha [UA03]. It was therefore decided to use the figures reported for the year 1985 without any changes.

The irrigation schemes of the country were digitized from irrigation maps published in [UA03] and area equipped for irrigation was assigned to these digitized polygons.

The whole area equipped for irrigation is irrigated with water extracted from surface water sources ([UA01], [UA04]). Area actually irrigated was set to 731 400 ha as indicated for year 2003 [UA01].

References:

[UA01]: **Kovalenko, P., Zhovtonog, O., Filipenko, L., Kruchenyk, V. & Michailov, J.** 2006. *Country report from Ukraine*. In: Dirksen, W. and Huppert, W. (ed.). Irrigation sector reform in Central and Eastern European countries. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn, Germany, 607-667.

[UA02]: **Unknown**. *Irrigated area per region in 1985*. Data table available in the AQUASTAT library.
[UA03]: **Zhovtonog, O.** 2005. *History of irrigation in Ukraine - bridge from the past to future developments*. In: Integrated Land and Water Resources Management in History, Special Edition 2, Siegburg, Germany, 205-218.
[UA04]: **FAO**. 2012. *AQUASTAT country profile of Ukraine, version 1997*. FAO, Rome, http://www.fao.org/nr/water/aquastat/countries_regions/ukraine/index.stm, 02/04/2012.

United Kingdom

Irrigable area for the United Kingdom was reported at 267 110 ha for the year 1997 and 228 950 ha for the year 2003 [GB01]. The area actually irrigated for the territory of England, where the majority of the total area equipped for irrigation is located, was 155 650 ha in the more dry year 1995 and 147 270 ha in the more wet year 2001 [GB02]. Area equipped for irrigation reported for 10 regions was derived from the statistics of the farm structure survey 2003. AEI for Scotland was set to 17 944 ha according to information on the extent of irrigated potatoes [GB03] and vegetables [GB04]. The main irrigated crops in UK are potatoes and vegetables, which account together for about 79 percent of the total irrigated area [GB02]. About 47 percent of the potato growing area and about 23 percent of the vegetable growing area in UK was irrigated in 2001 [GB05]. Irrigated area per county was estimated by combining harvested crop area derived from the statistics [GB06] and crop specific ratios of irrigated crop area versus total crop area. These ratios were reported for 8 regions for the year 2001 [GB05]. The irrigated areas computed that way for the specific crops were summed up and the irrigated areas by county were scaled so that the total irrigated area by region was equal to the values reported for the area equipped for irrigation for the year 2003. The resulting irrigation densities by county were found to be in good agreement to the spatial distribution of irrigation water demand [GB05] and to densities of points of agricultural water abstractions [GB07].

Area equipped for irrigation was distributed within the counties by assigning irrigated area to polygons extracted from the Corine 2000 land cover database for Europe [GB08] classified as non-irrigated arable land (211), fruit trees and berry plantations (222) or complex cultivation patterns (242).

Irrigation water extraction by source of water was available for 8 regions covering the territory of England and Wales [GB09]. The data are related to year 2005. It was assumed that for each region the percentage of AEI irrigated with groundwater was similar to the percentage of irrigation water use extracted from groundwater. In Scotland irrigation is mainly practised for potatoes, vegetables, grass and soft fruits [GB04]. Detailed statistics related to irrigated areas and sources of irrigation water were not available, but case studies for specific watersheds show that irrigation water is extracted from rivers, reservoirs and boreholes [GB03]. Based on the survey data in [GB03] percentage of irrigated area from groundwater sources was estimated at 20 percent for Scotland.

References:

[GB01]: **Statistical Office of the European Communities (EUROSTAT)**. 2011. *Irrigable and irrigated areas*. http://epp.eurostat.ec.europa.eu/portal/page/portal/agri_environmental_indicators/data/database, 28/11/2011.
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[GB05]: **Morris, J., Weatherhead, E.K., Knox, J.W., Vasilieou, K., de Vries, T.T., Freeman, D., Leiva, F.R. & Twite, C.** 2004. *Sustainability of European irrigated agriculture under Water Directive and Agenda (WADI). Summary country report: England and Wales.* Institute of Water and Environment, Cranfield University, Silsoe, UK, http://www.silsoe.cranfield.ac.uk/iwe/projects/wadi/, 07/08/2006.

[GB06]: **Department for Environment, Food and Rural Affairs (DEFRA)**. 2003. *June Agricultural Census Data – 2001*. http://www.defra.gov.uk/esg/work_htm/publications/cs/farmstats_web/Publications/complete_pubs.htm#info, 07/08/2006.

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[GB09]: **Weatherhead, E.K.** 2007. *Survey of irrigation of outdoor crops in 2005 – England and Wales*. Cranfield University, Cranfield, UK, http://www.cranfield.ac.uk/sas/pdf/survey%20of%20irrigation%20of%20outdoor%20crops%20in%202005%20,%20england%20and%20wales-%20revised.pdf, 31/08/2009.

OCEANIA

The year update of the global irrigation map to version 5 was the second update for Oceania. In addition to the separation of area equipped for irrigation according to the source of water, the following countries and territories have been updated due to new available spatial information: Australia, Fiji Islands, New Zealand and Northern Mariana Islands (USA). Total area equipped for irrigation in Oceania increased strongly due to this update from 2 637 835 ha in map version 4 to 4 692 730 ha in version 5 (Table A29). The major reason for this increase was the adjustment of the data in Australia and New Zealand with the objective to distinguish AEI from AAI. In the national statistics only AAI was reported and in version 4 of the Global Map of Irrigation Areas it was assumed that AEI was equal to AEI.

TABLE A29
Area equipped for irrigation (AEI) and area actually irrigated (AAI) in Oceania in the new version 5 of the Global Map of Irrigation Areas compared to area AEI in the previous version 4.

Country	AEI in GMIA4 (ha)	AEI in GMIA5, total (ha)	AEI in GMIA5, groundwater (ha)	AEI in GMIA5, surface water (ha)	AEI in GMIA5, non-conventional sources (ha)	AAI in GMIA5 (ha)
American Samoa (USA)	0	0	0	0	0	0
Australia	2,056,580	4,068,965	940,612	3,054,360	73,993	2,558,121
Cook Islands	0	0	0	0	0	0
Fiji Islands	3,000	4,000	400	3,600	0	4,000
Guam (USA)	312	312	237	76	0	229
Kiribati	0	0	0	0	0	0
Marshall Islands	0	0	0	0	0	0
Micronesia (Federated States of)	0	0	0	0	0	0
Nauru	0	0	0	0	0	0
New Zealand	577,882	619,294	195,175	424,119	0	509,031
Niue	0	0	0	0	0	0
Northern Mariana Islands (USA)	60	159	123	36	0	138
Palau	0	0	0	0	0	0
Samoa	0	0	0	0	0	0
Solomon Islands	0	0	0	0	0	0
Tokelau	0	0	0	0	0	0
Tonga	0	0	0	0	0	0
Tuvalu	0	0	0	0	0	0
Vanuatu	0	0	0	0	0	0
OCEANIA TOTAL	**2,637,835**	**4,692,730**	**1,136,546**	**3,482,191**	**73,993**	**3,071,518**

American Samoa (USA)

The most recent agricultural census report did not indicate any use of irrigation in American Samoa [AS01]. Because of the humid climate conditions there is likely no requirement for irrigation in agriculture.

References:

[AS01]: **NASS**. 2005. *American Samoa*. 2003 Census of Agriculture, Volume 1, Geographic Area Series, Part 55, National Agricultural Statistics Service (NASS), US Department of Agriculture, http://www.agcensus.usda.gov/Publications/2002/index.asp, 12/08/2009.

Australia

Area equipped for irrigation is not reported in the Australian agricultural or water use statistics. Therefore area equipped for irrigation was estimated based on two independent data sets: area actually irrigated reported by the water use statistics of the Australian Bureau of Statistics [AU01] and irrigated land derived from a remote sensing based land use map of Australia [AU02]. Only a fraction of the area equipped for irrigation is receiving irrigation and the extent of the areas actually irrigated varies significantly from year to year. Area actually irrigated was 2 546 318 ha in season 2005/2006 but declined to 1 760 758 ha in season 2008/2009, mainly as the consequence of a severe drought [AU03]. We used here the statistics related to season 2005/2006 because the area actually irrigated reported for this season represents the maximum within the period 2002-2010. Furthermore, the report related to this season provided statistics for states, statistical divisions, statistical subdivisions and local government areas while statistics related to other years were limited to states or statistical divisions. However, for many local government areas and statistical subdivisions data were suppressed in the census reports to preserve confidentiality which required a combination of the statistics reported for the different administrative levels and aggregation of the "nodata" areas into larger units. Since area actually irrigated was reported in units of 1000 ha we preferred to compute this area based on the variables "Irrigation volumes applied" and "Irrigation volumes applied per ha" which were reported at higher precision. This resulted in a final data set of area actually irrigated for 691 administrative units and a total area actually irrigated of 2 558 221 ha. Area equipped for irrigation was then computed for the 691 units by combining these statistics to the sum of irrigated land in the Australian land use map [AU02] and by selecting the maximum of both data sources for each of the 691 units. This resulted in a total area equipped for irrigation of 4 068 965 ha.

Areas equipped for irrigation were assigned to specific cells within the sub-national units by combining three data sets by using the priorities documented below. The highest priority was given to areas derived from the Australian land use map [AU02] belonging to the following classes: 3.3.5 Sugar, 3.3.6 Cotton, 3.4.1 Tree fruits, 3.4.4 Vine fruits, 3.5.4 Vegetables & herbs, 4.2.0 Irrigated modified pastures, 4.3.0 Irrigated cropping, 4.3.1 Irrigated cereals, 4.3.3 Irrigated hay & silage, 4.3.4 Irrigated oil seeds, 4.3.5 Irrigated sugar, 4.3.6 Irrigated cotton, 4.3.8 Irrigated legumes, 4.4.0 Irrigated perennial horticulture, 4.4.1 Irrigated tree fruits, 4.4.3 Irrigated tree nuts, 4.4.4 Irrigated vine fruits, 4.5.4 Irrigated vegetables & herbs, 5.4.1 Shadehouses, 5.4.3 Glasshouses (hydroponic). Then, with the next priority, we considered areas classified by the MODIS land cover [AU04] as cropland or cropland/natural vegetation mosaic (priority 7) or grasslands (priority 6) and located inside polygons showing the extent of major irrigation areas in Australia [AU05]. Finally, if required, area equipped for irrigation was also assigned to grid cells belonging to these MODIS land cover classes and located outside the extent of the major irrigation areas. Irrigated area was first distributed only to cells having priority 8, then to cells having priority 7 and so on until the sum of the distributed irrigated area was equal to the irrigated area reported for the related subnational administrative unit.

The distinction of area equipped for irrigation in areas irrigated with groundwater, surface water or with non-conventional water sources was based on the water use statistics for season 2006/2006 [AU01] that reported water uses from "surface water", "groundwater", "town or country reticulated mains supply", "recycled or re-used water from off farm sources" and "others". We assumed that the fraction of groundwater in "town or country reticulated mains supply" is similar to the ratio between "groundwater" and the sum of "surface water" and "groundwater" while "recycled or re-used water from off farm sources" and "others" were assumed to represent non-conventional water sources. The ratio of areas equipped for

irrigation from the different sources of water was assumed to be similar to the ratio of the irrigation water use volumes reported in the water use census.

TABLE A30
Criteria and priorities used to assign areas equipped for irrigation to specific cells within the sub-national units in Australia.

Input data	priority
National land-use classification [AU02]	8
Modis land use classification class 12 and 14 [AU04] inside of polygons, showing irrigated areas [AU05]	7
Modis land use classification class 10 [AU04] inside of polygons, showing irrigated areas [AU05]	6
Modis land use classification class 12 and 14 [AU04] outside of polygons, showing irrigated areas [AU05]	6
Modis land use classification class 10 [AU04] outside of polygons, showing irrigated areas [AU05]	5

References:

[AU01]: **ABS, 2008.** Water use on Australian farms, 2005-06. Australian Bureau of Statistics (ABS), cat. no. 4618.0, http://www.abs.gov.au/AUSSTATS/abs@.nsf/allprimarymainfeatures/902502BE6F61594CCA2574B100160196?opendocument, 06/06/2011.

[AU02]: **BRS, 2010.** 2001/2002 Land Use of Australia, Version 3. National Land and Water Resources Audit, Bureau of Rural Sciences (BRS), Commonwealth of Australia, http://adl.brs.gov.au/mapserv/landuse/index.cfm?fa=app.loaddata&tab=loaddata, 07/06/2010.

[AU03]: **ABS, 2011.** Water use on Australian farms, 2009-10. Australian Bureau of Statistics (ABS), cat. no. 4618.0, http://www.abs.gov.au/AUSSTATS/abs@.nsf/allprimarymainfeatures/A5A4DA2DF9F997A0CA2571AD007DDFD4?opendocument, 06/06/2011.

[AU04]: **Modis Land Cover Group, 2009.** Modis Global Land Cover. Department of Geography and Environment, Boston University. ftp://crsftp.bu.edu/modis/MOD12Q1_data/, 07/06/2010.

[AU05]: **BRS, 2001.** Australian Irrigation Areas Version 1a. National Land and Water Resources Audit, compiled by Bureau of Rural Sciences (BRS) from data supplied by Agriculture WA, Queensland Department of Natural Resources and Mines, Murray-Darling Basin Commission, NSW Department of Land and Water Conservation and Tasmanian Department of Primary Industries, Water and Environment. BRS, Commonwealth of Australia, 2001a. http://adl.brs.gov.au/anrdl/metadata_files/pa_aia__r9ab__00211a02.xml, 07/06/2010.

Fiji Islands

Area equipped for irrigation is 4000 ha of which 3000 ha of irrigated land is used for rice production and 1000 ha for production of upland crops [FJ01]. The figures refer to year 2003. No sub-national statistics on areas equipped for irrigation were available.

About 366 ha of irrigated land was assigned to locations reported to be irrigated in several reports [FJ01-FJ04]. The remaining area equipped for irrigation was assigned to cropland areas as derived from the MODIS land cover classification [FJ05].

Groundwater extractions are reported to be small but increasing [FJ02]. Based on this information percentage of irrigated area from groundwater sources was estimated at 10 percent.

References:

[FJ01]: **Pacific Regional Environment Programme**. 2003. Pacific regional consultation on water in small island countries - country brief Fiji Islands. Pacific Regional Environment Programme, http://www.sprep.org/publication/pein_fiji.asp, 18/08/2009.

[FJ02] **U.S. Global Change Research Information Office**. 1997. Final report for Fiji's United States country studies climate change program. http://www.gcrio.org/CSP/pdf/fiji_inven_vuladap.pdf, 06/06/2011.

[FJ03] **UN Department of Economic and Social Affairs**. 2009. Agriculture Fiji. UN Department of Economic and Social Affairs, Division for Sustainable Development, http://www.un.org/esa/agenda21/natlinfo/countr/fiji/agriculture.pdf, 08/06/2010.
[FJ04] **Pacific Islands Legal Information Institute**. 1985. Irrigation Act. http://www.paclii.org/fj/legis/consol_act/ia131/, 27/07/2010.
[FJ05]: **Modis Land Cover Group, 2009.** Modis Global Land Cover. Department of Geography and Environment, Boston University. ftp://crsftp.bu.edu/modis/MOD12Q1_data/, 07/06/2010.

Guam (United States of America)

Area equipped for irrigation (772 acres or 312 hectares) was estimated as the maximum of the area actually irrigated reported in the reports of the agricultural censuses 2007 [GU01] and 2002 [GU02].

Since no direct or indirect information about the spatial distribution of irrigation was available for Guam, irrigated area was distributed according to a global land cover data set [GU03] to all areas classified as: “Dryland Cropland and Pasture”, “Irrigated Cropland and Pasture”, “Cropland/Grassland Mosaic”, “Cropland/Woodland Mosaic”, “Grassland”, “Shrubland”, “Mixed Shrubland/Grassland”, “Savanna”, “Herbaceous Wetland” or “Wooded Wetland”.

Area actually irrigated was 565 acres (229 ha) in year 2007 [GU02]. By far the most of the irrigating farms used water from public utilities as major source for irrigation (89 of 96 farms in total) while 5 farms used surface water sources. Based on the assumption of 80 percent share of groundwater in water from public utilities area equipped for irrigation with groundwater was estimated at 237 ha (76 percent of total area equipped for irrigation).

References:

[GU01]: **NASS**. 2009. *Guam island data*. 2007 Census of Agriculture, Volume 1, Geographic Area Series, Part 53, National Agricultural Statistics Service (NASS), US Department of Agriculture, http://www.agcensus.usda.gov/Publications/2007/index.asp, accessed 01/02/2011.
[GU02]: **NASS**. 2004. *Guam*. 2002 Census of Agriculture, Volume 1, Geographic Area Series, Part 53, National Agricultural Statistics Service (NASS), US Department of Agriculture, http://www.agcensus.usda.gov/Publications/2002/index.asp, accessed 12/08/2009.
[GU03]: **United States Geological Survey (USGS)**. 2002. *Global Land Cover Characteristics database Version 2.0*, http://lpdaac.usgs.gov/glcc/glcc.asp, 11/04/2005.

New Zealand

Area equipped for irrigation at the territorial authority level was derived from the statistics of the agricultural census 2007 [NZ01]. Total area equipped for irrigation was 619 294 ha, of which 522 168 ha was located on the South Island 97 126 ha on the North Island.

Area equipped for irrigation was assigned to areas derived from a local land use data set developed by the Ministry of Environment [NZ02] classified there as short-rotation cropland, vineyard, orchard and other perennial crops or high producing exotic grassland.

Area actually irrigated was not reported by the agricultural census 2007. Therefore area equipped for irrigation according to the 2007 census was multiplied for each territorial authority by the ratio between area actually irrigated and area equipped for irrigation reported by the agricultural census 2002 [NZ03] to estimate area actually irrigated in year 2007. This resulted in an estimated total area actually irrigated in year 2007 of 509 031 ha. Irrigation water use from surface and groundwater sources was available for regional councils [NZ04]. The percentage of equipped for irrigation with groundwater was assumed to be similar to the percentage of irrigation water use from groundwater reported for each region. Area equipped

for irrigation with groundwater computed that way was 195 175 ha while area equipped for irrigation with surface water was 424 119 ha.

References:

[NZ01]: **Statistics New Zealand**. 2009. 2007 Agricultural Census tables. Statistics New Zealand, http://stats.govt.nz/browse_for_stats/industry_sectors/agriculture-horticulture-forestry/2007-agricultural-census-tables/land-treatments.aspx, 09/06/2009.

[NZ02]: **Ministry for the Environment**. 2009. The New Zealand Land Cover Database. Ministry for the Environment, Wellington, New Zealand, http://www.mfe.govt.nz/issues/land/land-cover-dbase/, 08/07/2009.

[NZ03]: **Statistics New Zealand**. 2004. 2002 Agricultural Census tables. Statistics New Zealand, http://stats.govt.nz/browse_for_stats/industry_sectors/agriculture-horticulture-forestry/2002-agricultural-census-tables/land-treatments.aspx, 09/06/2009.

[NZ04]: **Lincoln Environmental**. 2000. Information on water allocation in New Zealand. Report No 4375/1, prepared for the Ministry for the Environment, Lincoln Environmental, http://www.mfe.govt.nz/publications/water/water-allocation-apr00.html, 24/08/2009.

Northern Mariana Islands (United States of America)

Area equipped for irrigation was estimated as the maximum of the area actually irrigated reported per municipality in the reports of the agricultural censuses 2007 [MP01] and 2002 [MP02]. Total area equipped for irrigation computed that way was 392 acres (159 ha).

Since no direct or indirect information about the spatial distribution of irrigation within the municipalities was available, irrigated area was distributed according to a global land cover data set [MP03] to all areas classified as: “Dryland Cropland and Pasture”, “Irrigated Cropland and Pasture”, “Cropland/Grassland Mosaic”, “Cropland/Woodland Mosaic”, “Grassland”, “Shrubland”, “Mixed Shrubland/Grassland”, “Savanna”, “Herbaceous Wetland” or “Wooded Wetland”.

Area actually irrigated was 341 acres (138 ha) in year 2007 [MP01]. 126 farms used public utilities as water supplier for irrigation, 27 farms used wells or cisterns and 8 farms used water extracted from rivers or streams [MP01]. Percentage area equipped for irrigation with groundwater was computed based on the number of farms reporting the different water sources and by assuming that the share of groundwater in the public supply system is 80 percent.

References:

[MP01]: **NASS**. 2009. *Northern Mariana Islands commonwealth and island data*. 2007 Census of Agriculture, Volume 1, Geographic Area Series, Part 56, National Agricultural Statistics Service (NASS), US Department of Agriculture, http://www.agcensus.usda.gov/Publications/2007/index.asp, 01/02/2011.

[MP02]: **NASS**. 2004. *Commonwealth of the Northern Mariana Islands*. 2002 Census of Agriculture, Volume 1, Geographic Area Series, Part 56, National Agricultural Statistics Service (NASS), US Department of Agriculture, http://www.agcensus.usda.gov/Publications/2002/index.asp, 12/08/2009.

[MP03]: **United States Geological Survey (USGS)**. 2002. *Global Land Cover Characteristics database Version 2.0*, http://lpdaac.usgs.gov/glcc/glcc.asp, 11/04/2005.

Appendix B

Additional tables with country specific data

TABLE B1

Comparison of area equipped for irrigation (AEI) in version 5 of the Global Map of Irrigation Areas, the AQUASTAT main country data base and the FAOSTAT database. Data for the most recent reference year were extracted from the AQUASTAT main country data base while FAOSTAT data refer to the mean of area equipped for irrigation in the period 2000 - 2008. Data were extracted on 01.10.2013. Data for countries and territories without irrigation are not shown.

Country	GMIA 5		AQUASTAT		FAOSTAT
	AEI (ha)	Reference year	AEI (ha)	Reference year	AEI (mean 2000-2008, ha)
Afghanistan	3,199,070	1993	3,208,000	2002	3,206,222
Albania	340,000	2000	188,400	2006	351,944
Algeria	569,418	2001	569,400	2001	569,222
Andorra	150	1990	n.a.	n.a.	0
Angola	80,000	2005	85,530	2005	84,389
Antigua and Barbuda	130	1997	130	1997	103
Argentina	1,767,784	2002	2,357,000	2011	1,595,556
Armenia	273,530	2006	273,500	2006	274,000
Australia	4,068,965	2006	2,546,000	2006	2,524,000
Austria	116,050	2007	117,000	2007	104,222
Azerbaijan	1,426,000	2003	1,425,000	2010	1,430,389
Bahrain	4,060	2001	4,015	2000	4,000
Bangladesh	5,049,400	2007	5,050,000	2008	4,738,278
Barbados	1,000	1989	5,435	1989	5,000
Belarus	114,100	2001	115,000	2003	117,222
Belgium	23,830	2005	23,350	2007	26,000
Belize	3,548	2005	3,000	1997	3,778
Benin	12,258	2002	23,040	2008	11,778
Bhutan	27,685	2007	31,910	2010	27,333
Bolivia (Plurinational State of)	128,240	1999	128,200	1999	146,222
Bosnia and Herzegovina	4,630	2002	3,000	2000	3,000
Botswana	1,439	2002	1,439	2002	1,471
Brazil	4,463,691	2006	5,400,000	2011	4,227,889
Brunei Darussalam	1,000	1995	1,000	1995	1,000
Bulgaria	545,160	2002	104,600	2007	276,176
Burkina Faso	25,000	2001	25,000	2001	26,222
Burundi	21,430	2000	21,430	2000	22,667
Cambodia	506,775	2009	353,600	2006	318,067
Cameroon	25,654	2000	25,650	2000	27,333
Canada	1,218,345	2006	869,900	2004	827,444
Cape Verde	2,780	1997	3,476	2004	3,250
Central African Republic	135	1987	135	1987	1,000
Chad	30,273	2002	30,270	2002	29,333
Chile	1,936,402	1997	1,199,000	1991	1,900,000
China	62,392,392	2004	62,938,000	2006	60,432,333
Colombia	900,000	1998	1,087,000	2011	933,333
Comoros	130	1987	130	1987	130
Congo	2,000	2003	2,000	1993	2,000
Costa Rica	103,084	1997	103,100	1997	108,000
Cote d'Ivoire	72,750	1994	72,750	1994	73,000
Croatia	9,275	2003	3,627	2010	9,867
Cuba	870,319	1997	870,300	1997	870,000
Cyprus	55,456	2003	45,790	2007	44,367

Country	GMIA 5		AQUASTAT		FAOSTAT
	AEI (ha)	Reference year	AEI (ha)	Reference year	AEI (mean 2000-2008, ha)
Czech Republic	50,590	2004	38,530	2007	41,667
Democratic People's Republic of Korea	1,460,000	1995	1,460,000	1995	1,460,000
Democratic Republic of the Congo	10,500	1995	10,500	1995	11,000
Denmark	448,818	2003	435,400	2007	445,333
Djibouti	1,012	1999	1,012	1999	1,000
Dominican Republic	306,442	2010	306,500	2009	286,111
Ecuador	853,332	2000	853,400	2000	886,667
Egypt	3,422,178	2002	3,422,000	2002	3,458,111
El Salvador	52,452	2005	44,990	1997	45,000
Eritrea	21,590	1993	21,590	1993	21,000
Estonia	1,363	2005	458	2010	4,000
Ethiopia	290,729	2001	289,600	2001	290,000
Fiji	4,000	1998	3,000	1998	3,000
Finland	103,800	2003	68,580	2010	87,189
France	2,906,081	2000	2,642,000	2007	2,660,889
French Guyana (France)	5,931	2007	5,931	2007	5,600
Gabon	4,450	1987	4,450	1987	4,000
Gambia	2,149	1999	5,000	2011	2,167
Georgia	432,790	2006	432,800	2007	437,444
Germany	515,731	2001	515,700	2006	503,300
Ghana	59,000	2000	30,900	2000	32,333
Greece	1,544,530	2000	1,555,000	2007	1,502,742
Grenada	219	2000	219	1997	689
Guadeloupe (France)	6,635	2007	6,635	2007	6,856
Guam (USA)	312	2007	n.a.	n.a.	271
Guatemala	142,499	2004	312,100	2003	280,000
Guinea	94,914	2001	94,920	2001	95,000
Guinea Bissau	22,558	1996	22,560	1996	25,000
Guyana	150,134	1991	150,100	1991	150,000
Haiti	91,502	1991	97,000	2009	95,667
Honduras	81,631	2005	87,850	2007	83,667
Hungary	292,147	2002	140,900	2007	186,961
India	61,907,846	2001	66,334,000	2008	63,792,444
Indonesia	6,722,299	2005	6,722,000	2005	6,320,367
Iran (Islamic Republic of)	8,847,818	2010	8,700,000	2009	8,407,889
Iraq	3,525,000	1990	3,525,000	1990	3,525,000
Ireland	1,100	2000	1,100	1998	0
Israel	183,407	2000	225,000	2004	219,556
Italy	3,892,202	2001	3,951,000	2007	3,941,500
Jamaica	26,650	1997	25,220	1997	25,000
Japan	2,834,956	2010	2,500,000	2010	2,576,000
Jordan	83,450	2007	78,860	2004	80,673
Kazakhstan	2,482,500	2006	2,066,000	2010	1,969,778
Kenya	103,203	2003	103,200	2003	97,778
Kosovo	77,000	2003	n.a.	n.a.	
Kuwait	10,142	2006	8,600	2007	7,844
Kyrgyzstan	1,045,131	2005	1,021,000	2005	1,035,189
Lao People's Democratic Republic	309,657	2002	310,000	2005	304,778
Latvia	1,150	2003	830	2007	889

Country	GMIA 5		AQUASTAT		FAOSTAT
	AEI (ha)	Reference year	AEI (ha)	Reference year	AEI (mean 2000-2008, ha)
Lebanon	104,010	1999	104,000	1998	90,000
Lesotho	2,638	1999	2,637	1999	3,000
Liberia	2,100	1987	2,100	1987	3,000
Libya	470,000	2000	470,000	2000	470,000
Lithuania	4,416	2005	1,340	2007	4,844
Luxembourg	27	2002	0	n.a.	0
Madagascar	1,086,291	2000	1,086,000	2000	1,086,000
Malawi	56,390	2002	73,500	2006	65,833
Malaysia	362,687	1994	380,000	2009	365,000
Mali	235,791	2000	235,800	2000	236,000
Malta	2,300	2003	3,200	2007	2,489
Martinique (France)	6,170	2007	6,170	2007	6,556
Mauritania	45,012	1994	45,010	2004	45,000
Mauritius	21,543	2009	21,220	2002	21,000
Mexico	6,817,240	2007	6,460,000	2009	6,316,667
Mongolia	84,300	1993	84,300	1993	84,000
Montenegro	2,115	2005	2,412	2010	2,200
Morocco	1,484,160	2004	1,485,000	2004	1,453,000
Mozambique	118,120	2001	118,100	2001	117,667
Myanmar	2,110,000	2004	2,110,000	2004	2,089,778
Namibia	7,573	2002	7,573	2002	7,889
Nepal	1,168,349	2002	1,168,000	2002	1,164,333
Netherlands	476,315	2005	457,200	2007	424,444
New Zealand	619,294	2007	619,300	2007	500,000
Nicaragua	94,240	2001	94,240	2001	61,000
Niger	73,663	2005	73,660	2005	73,444
Nigeria	293,117	2004	293,200	2004	292,000
Norway	134,396	1999	114,900	2007	121,811
Occupied Palestinian Territory	23,484	2006	24,000	2003	22,889
Oman	58,850	2004	58,850	2004	59,333
Pakistan	16,725,843	2004	19,990,000	2008	18,740,000
Panama	34,626	1997	34,620	1997	43,000
Paraguay	67,000	1998	136,200	2012	67,000
Peru	1,729,069	1994	1,196,000	1998	1,196,000
Philippines	1,879,084	2006	1,879,000	2006	1,413,183
Poland	134,050	2004	115,700	2007	106,322
Portugal	792,008	1999	583,700	2007	658,222
Puerto Rico (USA)	36,997	2007	22,040	2005	22,000
Qatar	12,935	2001	12,940	2001	12,989
Republic of Korea	806,475	2009	880,400	2002	866,222
Republic of Moldova	307,000	1999	228,300	2011	249,489
Reunion (France)	8,811	2007	8.811	2007	8,056
Romania	2,149,903	2004	615,300	2007	3,159,333
Russian Federation	2,375,200	2006	4,346,000	2008	4,538,111
Rwanda	8,500	2000	9,625	2007	9,133
Saint Kitts and Nevis	18	1997	18	1997	150
Saint Lucia	3,321	2007	3,000	2007	3,000
Saint Vincent and the Grenadines	0	n.a.	0	n.a.	1,000
Sao Tome and Principe	9,700	1991	9,700	1991	10,000
Saudi Arabia	1,348,696	2007	1,620,000	2004	1,731,000
Senegal	119,680	2002	119,700	2002	117,556

Country	GMIA 5		AQUASTAT		FAOSTAT
	AEI (ha)	Reference year	AEI (ha)	Reference year	AEI (mean 2000-2008, ha)
Serbia	86,311	2003	91,960	2011	96,000
Seychelles	260	2003	260	2003	300
Sierra Leone	29,360	1992	29,360	1992	30,000
Slovakia	225,310	2001	172,000	2007	180,889
Slovenia	15,643	2001	7,604	2010	5,778
Somalia	200,000	2003	200,000	2003	200,000
South Africa	1,498,000	2000	1,670,000	2012	1,513,778
Spain	3,575,488	1999	3,470,000	2011	3,794,222
Sri Lanka	600,730	2010	570,000	2006	570,000
Sudan and South Sudan	1,863,000	2000	1,890,000	2010	1,874,889
Suriname	51,180	1998	51,180	1998	54,278
Swaziland	49,843	2000	49,850	2000	50,000
Sweden	188,470	2003	159,700	2007	164,111
Switzerland	55,000	2006	55,000	2007	41,444
Syrian Arab Republic	1,489,000	2006	1,341,000	2010	1,354,778
Tajikistan	742,051	2008	742,100	2009	726,111
Thailand	6,414,880	2007	6,415,000	2007	6,052,444
The former Yugoslav Republic of Macedonia	127,800	2005	127,800	2004	107,556
Timor-Leste	33,698	2005	34,650	2002	34,444
Togo	7,300	1996	7,300	1996	7,000
Trinidad and Tobago	3,600	1997	3,600	1997	6,333
Tunisia	455,070	2006	397,000	2003	411,889
Turkey	5,215,144	2000	5,340,000	2012	5,137,222
Turkmenistan	1,990,800	2006	1,991,000	2006	1,947,889
Uganda	9,150	1998	14,420	2010	11,389
Ukraine	2,395,500	1985	2,175,000	2010	2,236,333
United Arab Emirates	230,841	2003	92,000	2010	224,556
United Kingdom	246,894	2003	228,000	2005	212,222
United Republic of Tanzania	189,047	2002	184,300	2002	180,000
United States of America	28,375,752	2007	26,644,000	2007	26,816,297
United States Virgin Islands (USA)	185	2007	n.a.	n.a.	171
Uruguay	243,419	2000	181,000	1998	209,444
Uzbekistan	4,198,000	2005	4,198,000	2005	4,199,111
Venezuela (Bolivarian Republic of)	759,524	2008	1,055,000	2008	842,778
Viet Nam	4,585,500	2005	4,585,000	2005	4,215,000
Yemen	813,951	2009	680,100	2004	611,111
Zambia	155,912	2002	155,900	2002	152,333
Zimbabwe	173,513	1999	173,500	1999	174,000
TOTAL	**307,635,659**		**310,541,892**		**303,371,813**