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Development and validation of the global map of irrigation areas

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Abstract. A new version of a digital global map of irrigation areas was developed by combining irrigation statistics for 10 825 sub-national statistical units and geo-spatial information on the location and extent of irrigation schemes. The map shows the percentage of each 5 arc minute by 5 arc minute cell that was equipped for irrigation around the year 2000. It is thus an important data set for global studies related to water and land use. This paper describes the data set and the mapping methodology and gives, for the first time, an estimate of the map quality at the scale of countries, world regions and the globe. Two indicators of map quality were developed for this purpose, and the map was compared to irrigated areas as derived from two remote sensing based global land cover inventories.

1 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Agriculture is by far the largest water-use sector, accounting for about 70 percent of all water withdrawn worldwide from rivers and aquifers for agricultural, domestic and industrial purposes (Shiklomanov, 2000). In many developing countries more than 90 percent of the water withdrawals are for irrigation (FAO AQUASTAT-database, http://www.fao.org/ag/agl/aglw/aquastat/main/index.stm, 2005). In arid regions, irrigation is the prerequisite for crop production. In semi-arid and humid areas, irrigation serves to increase yields, to attenuate the effects of droughts or, in the case of rice production, to minimize weed growth. Average yields are generally higher under irrigated conditions as compared to rainfed agriculture (Bruinsma, 2003). In the United States, for example, average crop yields of irrigated farms exceeded, in 2003, the corresponding yields of dryland farms by 15% for soybeans, 30% for maize, 99% for barley, and by 118% for wheat (Veneman et al., 2004). Although globally only 18% of the cultivated area is irrigated (FAO, 2005a), 40% of the global food production comes from irrigated agriculture (UNCSD, 1997). Both the water scarcity caused by using large amounts of water in irrigated agriculture and the importance of irrigation for crop production and food security induced several studies to quantify the different elements of the global water balance in space and time (e.g. Vörösmarty et al., 2000; Oki et al., 2001; Alcamo et al., 2003; FAO, 2005b). Others focused on the importance of irrigated food production in general (Wood et al., 2000; Faures et al., 2002), on the impact of irrigated agriculture on global (or regional) climate (De Rosnay et al., 2003; Boucher et al., 2004) or on the impact of climate change and climate variability on global irrigation water requirements (Döll, 2002).

All these studies depend on data on the distribution and extent of irrigated areas in the world. The first digital global map (or rather data set) of irrigated areas was published in 1999 (Döll and Siebert, 2000). It showed the areal fraction of 0.5 arc degrees by 0.5 arc degree grid cells that was equipped for irrigation in the 1990s. Since then, the map has been updated several times and the map resolution has increased to 5 arc minutes by 5 arc minutes. A new mapping methodology was developed (Siebert and Döll, 2001) and this methodology was applied to all countries by using information collected in the framework of FAO's AQUASTAT program (http://www.fao.org/ag/agl/aglw/aquastat/main/index.stm). A documentation of the source data used in these updates as well as the most recent version of the Global Map of Irrigation Areas is available at the web page of the mapping project (http://www.fao.org/ag/agl/aglw/aquastat/irrigationmap/index.stm).

In this paper we present the most recent version 3.0 of the Global Map of Irrigation Areas, which shows the fraction of 5 arc minutes by 5 arc minutes cells that was equipped for irrigation around the year 2000. To our knowledge, this is the only global data set of irrigated areas that is not primarily

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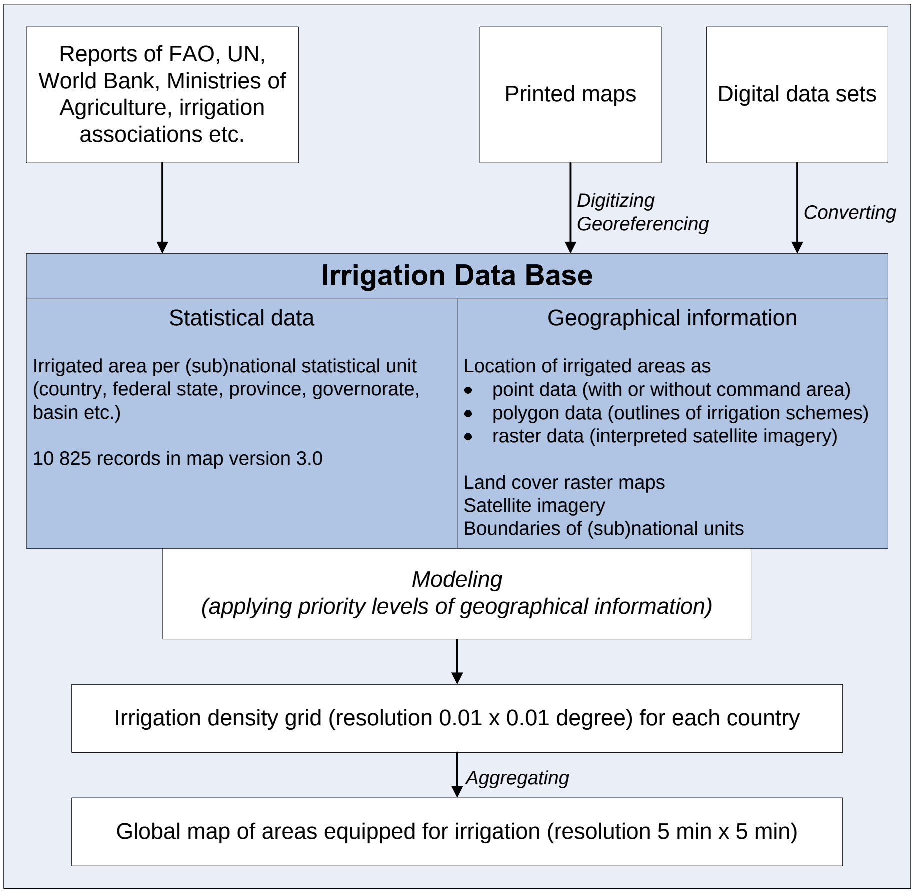

Fig. 1. Scheme of mapping methodology used to develop the Global Map of Irrigation Areas.

based on remote sensing information. We describe the mapping methodology (Sect. 2) and then we present the mapping results (Sect. 3). The focus of this paper is on an assessment of the map quality which is based on two indicators of map quality and a comparison to irrigated areas as identified in global and continental land cover maps that are based on remote sensing (Sect. 4). Finally, we draw conclusions with respect to the recommended use of the data set (Sect. 5).

2 Data and methods

The global map of irrigation areas 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 (Fig. 1). In the following, we provide a concise description of the mapping methodology. A detailed description is given in Siebert and Döll (2001).

Irrigation statistics for 10 825 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, were used to develop the most recent map version 3 (Fig. 2). For most of the countries, these statistics refer to the area equipped for irrigation. Due to several reasons (e.g. crop rotation, water shortages, 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. Statistics for the year closest to 2000 were used if statistics for more than one year have been available. For countries, where the irrigation statistics reported by the FAO AQUASTAT database were assumed to be more representative, the collected sub-national 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.

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.

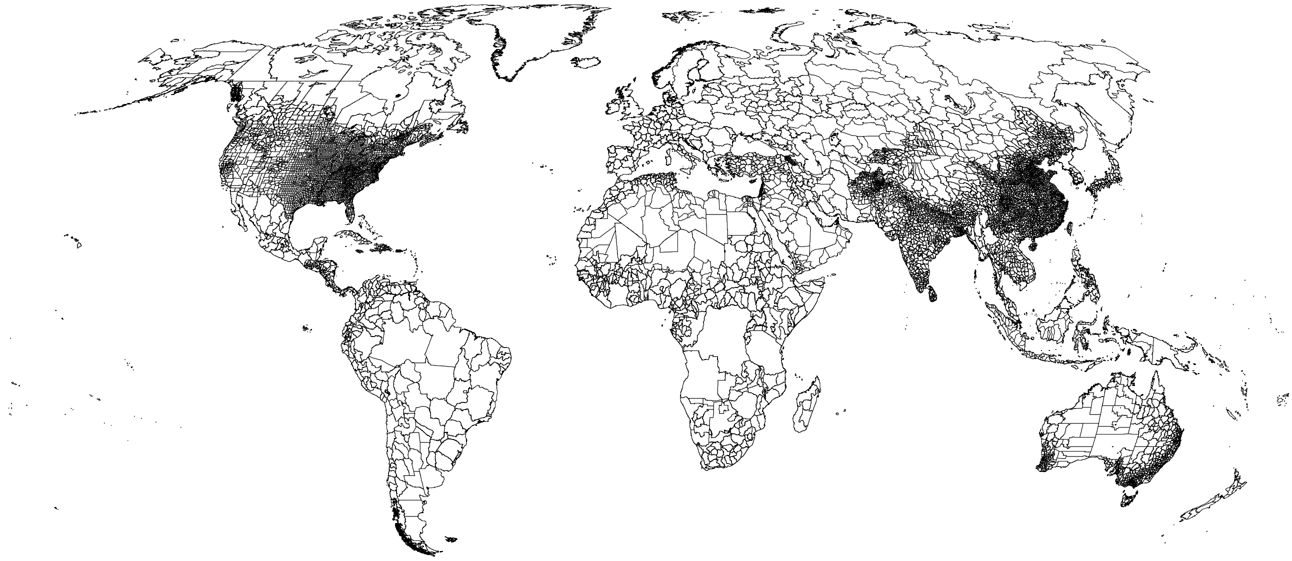

Fig. 2. Location and extent of the 10 825 sub-national units with information on area equipped for irrigation (or areas actually irrigated) that was used to develop the Global Map of Irrigation Areas Version 3 (Robinson projection).

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 a global land cover data set (USGS, 2000) 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”.

3 Results

The total area equipped for irrigation in map version 3 of the Global Map of Irrigation Areas is 273.7 Mio ha (Table 1). About 69% of the total irrigated area is located in Asia, 17% in America, 9% in Europe, 4% in Africa and 1% in Oceania. The largest values of irrigated area on the country level are those for India (57.3 Mio ha), China (53.8 Mio ha) and the United States (27.9 Mio ha) (Table A1). More than 20% of the cultivated area are equipped for irrigation in the following world regions: South Asia (37.6%), Central Asia (34.9%), Near East (30.6%) and Northern Africa (20.5%). In Western Africa the cultivated areas are almost completely rainfed (Table 1).

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

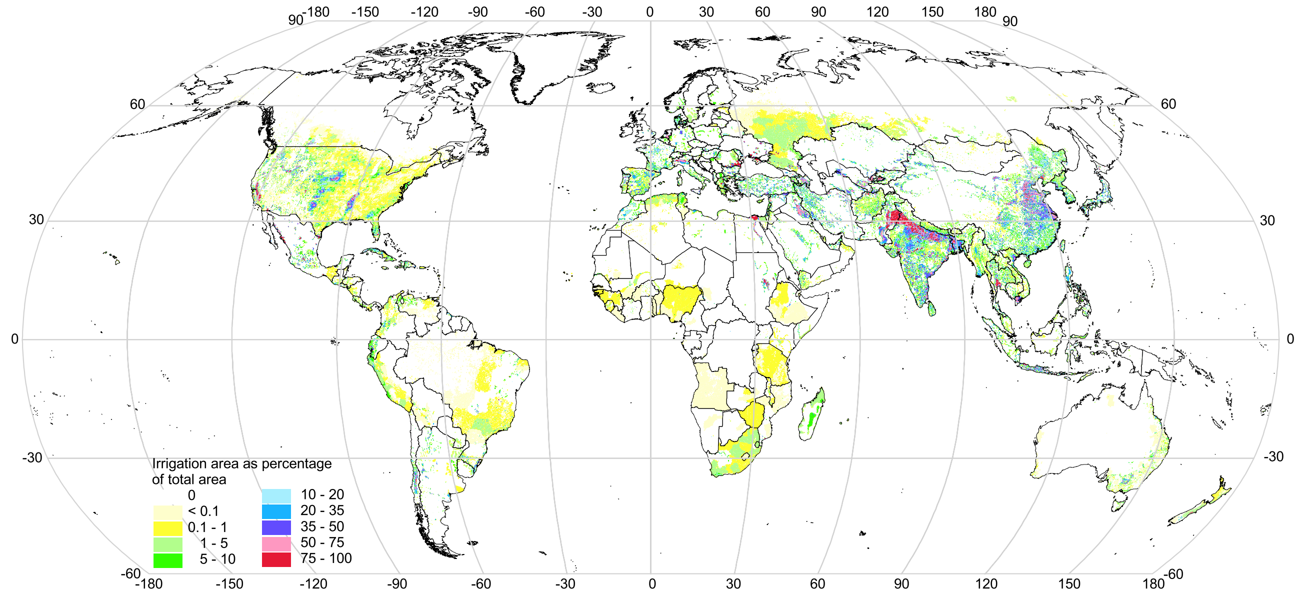

Fig. 3. Global Map of Irrigation Areas Version 3: Percentage of 5-min grid cell area that was equipped for irrigation around the year 2000 (Robinson projection).

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 (Fig. 3).

4 Assessment of map quality

A common method to assess the quality of a macro-scale data set is to compare it with independent smaller-scale information at selected locations and then to draw conclusions with respect to the quality at these locations and in general. Here, however, all data on irrigated areas known to the authors (at appropriate scales) were used to compile the map itself and could thus not be used for a quality assessment. Besides, any generalization would not be possible, as the map quality is different in each individual sub-national unit depending on the data sources used in the specific case. Instead, to assess the quality of the Global Map of Irrigation Areas, two indicators were computed that take into account the geospatial information density (Sect. 4.1), and the map was compared to the irrigated areas of two global land cover inventories that are based on remote sensing (Sect. 4.2).

4.1 Indicators of map quality

Because of the mapping methodology (see Sect. 2), the quality of the mapping product is strongly influenced by the density and reliability of the used information. Thus the map quality differs from country to country and even within countries.

Two country-specific indicators were developed to quantify the density of information used as input data sources: indicator A (*IND_A*) represents the density of the used sub-national irrigation statistics while indicator B (*IND_B*) represents the density of the available geospatial records on position and extent of irrigated areas. Marks derived from the two indicators were combined to obtain a mark for the overall map quality for each country (Table A1).

While the density of information could be assessed, it was in general not possible to estimate the reliability of the data sources. Some local studies show that there may be large differences between census-based sub-national irrigation statistics and the extent of areas equipped for irrigation observed in reality. Döll and Hauschild (2002), for example, presented best guess estimates of local experts for area equipped for irrigation in the two semi-arid Brazilian states of Piauí and Ceará that were 28% (Piauí) and 45% (Ceará) lower than the corresponding results of the Brazilian agricultural census. The reliability of geo-spatial data on location and extent of irrigation schemes may be also uncertain. It is well known, for example, that many of the former irrigation schemes in Eastern Europe and the former Soviet Union do not exist anymore. But lack of information made it impossible to verify the available data on the global scale systematically. However, the overall map quality mark was downgraded for a country when it was found that sub-national statistics coming from different sources disagreed, when statistics were found to be incomplete or when geo-spatial information was found to be out of date.

Table 1. Number of countries (n_{cnt}), area equipped for irrigation ($area_{\text{irri}}$), percentage of cultivated area equipped for irrigation ($irri_{\text{perc}}$), average area of the sub-national units ($area_{\text{admav}}$) and average area of the sub-national units weighted by irrigation density ($area_{\text{admw}}$) for the entire world and 19 world regions.

Region	n_{cnt}	$area_{\text{irri}}$ (ha)	$irri_{\text{perc}}$ (%)	$area_{\text{admav}}$ (ha)	$area_{\text{admw}}$ (ha) (*IND_A*)
North America	2	28 698 918	12.4	512 287	243 101
Central America	32	7 859 309	18.3	971 195	938 242
South America	14	10 102 130	8.1	9 065 021	2 744 775
Northern Africa	5	5 804 793	20.5	3 860 121	448 374
Western Africa	24	1 005 495	1.1	4 939 529	2 520 777
Eastern Africa	13	3 546 276	7.5	4 404 625	1 918 066
Southern Africa	11	1 880 337	4.6	7 445 113	3 408 977
Western Europe	15	2 131 807	6.9	7 387 722	4 385 796
Eastern Europe	18	7 556 000	8.1	11 745 784	13 696 554
Southern Europe	9	10 022 456	18.0	2 222 626	2 635 819
Russian Federation	1	4 878 000	3.9	19 234 888	5 028 884
Near East	16	18 839 608	30.6	2 075 844	834 586
Central Asia	9	14 854 955	34.9	1 045 886	323 565
East Asia	7	59 875 193	19.4	457 947	161 378
South Asia	7	77 236 998	37.6	523 047	395 817
South-East Asia	11	16 793 335	17.7	1 603 949	681 205
Oceania	26	2 637 835	4.7	623 907	147 544
World	221	273 723 445	16.3	1 241 912	330 249

4.1.1 Indicator for the density of sub-national irrigation statistics (*IND_A*)

A possible indicator for the density of sub-national irrigation statistics is the arithmetic mean of the size of the sub-national units. However, there are some countries where irrigation is concentrated in some small sub-national units while in other very large sub-national units of the same country there is no or very little irrigation. One of these countries is Canada, with a lot of irrigation in some small census divisions in southern Alberta and no irrigation at all in several very large census divisions in the northern part. To avoid that large sub-national units without significant irrigation have a negative impact on the indicator, the size of each sub-national statistical unit is weighted by the irrigation density in the sub-national unit relative to the irrigation density in the entire region (country, world region or global), and

$$IND\_A_{\text{reg}} = \frac{area_{\text{reg}}}{\sum\limits_{\text{adm}=1}^{n} (irridens_{\text{adm}}/irridens_{\text{reg}})} \quad (1)$$

with

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

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

Simplifying Eq. (1) results in

$$IND\_A_{\text{reg}} = \frac{irarea_{\text{reg}}}{\sum\limits_{\text{adm}=1}^{n} irridens_{\text{adm}}} \quad (3)$$

where $irarea_{\text{reg}}$ is the total irrigated area in region *reg* (ha).

IND_A would be equal the arithmetic mean of the size of sub-national units in a region if the irrigation density would be the same in all sub-national units of the region. If all irrigated area would be concentrated in only one sub-national unit, *IND_A* would be equal to the size of this sub-national unit. *IND_A* would be lower than the arithmetic mean of the size of the sub-national units if the irrigation density is higher in small sub-national units than in the larger sub-national units.

A comparison of the arithmetic mean of the size of sub-national units ($area_{\text{admav}}$) and *IND_A* on the country level (Table A1) or per region (Table 1) shows that *IND_A* is smaller in most cases. This indicates that the density of irrigation statistics is higher in areas where irrigation is important (areas of high irrigation density). However, there are also exceptional cases, e.g. the countries of Azerbaijan, Cameroon, Fiji (Table A1) or the regions of Eastern and Southern Europe (Table 1).

Table 2. Assignment of marks dependent on the quantities of the map quality indicators for the weighted average size of sub-national statistical units (*IND_A*) and the percentage of irrigated area assigned to grid cells by using geospatial records on position and extent of known irrigation schemes (*IND_B*).

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

4.1.2 Indicator for the density of geo-spatial records (*IND_B*)

The second indicator (*IND_B*) was developed to give an estimate on the density of geospatial information used to assign irrigated area 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 projects.

4.1.3 Mark for the overall map quality at the country level

Depending on the computed indicator values, the marks excellent, very good, good, fair, poor or very poor were given to each country for both of the indicators *IND_A* and *IND_B* (Table 2). 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. Thus, in general, the mark for the overall map quality was set to the better of the two marks given according to *IND_A* and *IND_B* (Table A1). If, for example, the location and extent of almost all irrigation projects in a country is known then the overall quality of the map should be excellent independently from the mark given according to the weighted size of sub-national units. On the other hand, if the size of the sub-national 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 excellent even if there are no geo-spatial records on the position of irrigation schemes within the sub-national units available.

In 64 out of 211 countries, however, the mark for the overall map quality was downgraded because there were doubts regarding the reliability of the used information (Table A1). One example is Cyprus. Based on the average weighted size of the sub-national units of 81 702 ha the mark for *IND_A* is excellent. The mark given according to *IND_B* is good, because an inventory of public irrigation schemes was available. The overall quality mark is set to good and not to excellent, because of lack of information for the Turkish part of the island. Another example is China, where the marks according to both of the indicators are very good. However, the overall map quality is estimated as good only, because there are doubts regarding the quality of information published in the statistical yearbooks (Heilig, 1999) and due to inconsistencies between irrigated areas derived from a land use atlas and the statistics published in the corresponding statistical yearbook. There are 27 countries where the overall map quality is estimated as very good but also 9 countries with a very poor map quality (all of the latter are located in Africa or Europe).

4.1.4 Mark for the overall map quality at the global level and in world regions

Marks for the overall mapping quality in world regions or at global scale were computed by combining the marks for the overall quality of the map at country level and the irrigated area in the corresponding countries (Table A1) as:

$$m_{\text{reg}} = \frac{irarea_{\text{v\_good}} + 2 \times irarea_{\text{good}} + 3 \times irarea_{\text{fair}} + 4 \times irarea_{\text{poor}} + 5 \times irarea_{\text{v\_poor}}}{irarea_{\text{reg}}} \quad (4)$$

where m_{reg} is the overall quality of irrigation map in region *reg*, $irarea_{\text{v\_good}}$, $irarea_{\text{good}}$, $irarea_{\text{fair}}$, $irarea_{\text{poor}}$ and $irarea_{\text{v\_poor}}$ represent the irrigated area of all countries in a region *reg* with very good, good, fair, poor or very poor map quality (ha) and $irarea_{\text{reg}}$ is the irrigated area in region *reg* (ha).

At the level of world regions, map quality in North America (overall mark 1.03), Oceania (1.44), Central Asia (1.63), South-East Asia (1.87) and South Asia (1.94) is best. Western Africa (3.39), Southern Africa (3.85), Western Europe (3.97) and the Russian Federation (4.00) have the worst map quality. At the global scale, the overall map quality is good (2.05). About 50 Mio ha of areas equipped for irrigation are located in countries where map quality is estimated to be very good, 171 Mio ha in countries with good map quality, 43 Mio ha in countries with fair map quality, 9 Mio ha in countries with poor map quality and 0.7 Mio ha in countries with very poor map quality. Consequently about 81% of the total irrigated area of the world is located in countries where the map quality is assessed to be very good or good (Table 3).

More than 20% of the cultivated area is equipped for irrigation in Northern Africa, Near East, Central Asia and South Asia (Table 1). The overall map quality mark in these regions is best in Central Asia (1.63) and worst in Northern Africa (2.38) (Table 3). The overall map quality mark for these four regions is 1.96. 93% of the total irrigated area in this region is located in countries where map quality is assessed to be very good or good. Therefore it can be stated that the map quality is better than average for regions where irrigation is important.

The weighted arithmetic mean of the size of sub-national units at the global scale is 330 249 ha. This is close to the size of one 0.5 degree grid cell at the equator. This indicates,

Table 3. Sum of area equipped for irrigation in countries with very good ($irarea_{v\_good}$), good ($irarea_{good}$), fair ($irarea_{fair}$), poor ($irarea_{poor}$) and very poor ($irarea_{v\_poor}$) map quality and resulting final mark for map quality for the entire world and 19 world regions.

Region	$irarea_{v\_good}$ (ha)	$irarea_{good}$ (ha)	$irarea_{fair}$ (ha)	$irarea_{poor}$ (ha)	$irarea_{v\_poor}$ (ha)	Final mark
North America	27 913 872	785 046	0	0	0	1.03
Central America	65 608	539 542	7 251 160	3000	0	2.92
South America	0	2 231 334	7 752 616	118 180	0	2.79
Northern Africa	0	3 606 150	2 198 643	0	0	2.38
Western Africa	0	113 799	405 546	466 935	19 215	3.39
Eastern Africa	17 630	1 981 720	1 158 017	360 785	28 124	2.55
Southern Africa	0	150 857	47 781	1 606 699	75 000	3.85
Western Europe	0	0	602 120	989 687	540 000	3.97
Eastern Europe	340 000	307 000	6 618 000	282 000	9000	2.91
Southern Europe	0	3 900 456	6 122 000	0	0	2.61
Russian Federation	0	0	0	4 878 000	0	4.00
Near East	403 645	14 834 051	3 601 912	0	0	2.17
Central Asia	7 708 097	4 991 658	2 155 200	0	0	1.63
East Asia	525 528	57 832 365	1 517 300	0	0	2.02
South Asia	4 958 127	72 278 871	0	0	0	1.94
South-East Asia	5 565 415	7 821 600	3 406 320	0	0	1.87
Oceania	2 056 580	372	580 882	0	0	1.44
World	49 554 503	171 374 820	43 417 497	8 705 286	671 339	2.05

that the use of the map can be recommended in general for global or regional studies at this resolution. The overall quality of the map at the global scale (2.05) indicates, that the use of the map can also be recommended for global studies performed on the map resolution of 5 arc minutes. For studies performed on the country or regional scale, we recommend the use of the Global Map of Irrigation Areas only if the overall map quality was estimated as very good (Table A1) or better than 2.5 (Table 3).

4.2 Comparison to global land cover data sets

To further assess the quality of the Global Map of Irrigation Areas, it was compared to results of global land cover classifications based on remote sensing which distinguish in their classification irrigated and rainfed agriculture at the global scale (Global Land Cover Characterization GLCC, USGS, 2000) or at least for some world regions (Global Land Cover 2000 database GLC2000, European Commission, Joint Research Centre, 2003). Both data sets have a resolution of 1 km by 1 km. Please note that they were not developed with the focus on mapping irrigated areas, and that the land cover class irrigated agriculture is only one of many others.

GLCC was derived from 1-km Advanced Very High Resolution Radiometer (AVHRR) 10-day composites spanning a 12-month period (April 1992–March 1993). In addition, other key geographic data such as digital elevation data, ecoregions interpretations, and country or regional-level vegetation and land cover maps have been used in the classification. The methodology used to develop GLCC is described in Loveland et al. (2000). Dataset and documentation are available at http://lpdaac.usgs.gov/glcc/glcc.asp.

GLC2000 was developed by using 14 months of daily 1-km resolution satellite data acquired over the whole globe by the VEGETATION instrument on-board the SPOT 4 satellite and delivered as multi-channel daily mosaics. The monitoring period was from 1 November 1999 to 31 December 2000. Irrigated and rainfed agriculture was distinguished in the regional products for Africa, Europe, South Asia and South-East Asia only. Dataset and documentation are available at http://www-gvm.jrc.it/glc2000/defaultGLC2000.htm.

The area classified as irrigated in these data sets was summarized for each country and compared to the corresponding irrigation statistics as used for the Global Map of Irrigation Areas (Table A1). The two remote sensing based data sets detected the area that was actually irrigated during the monitoring period while the statistics used to develop the Global Map of Irrigation Areas depict, for most countries, the area equipped for irrigation, which includes all areas having irrigation infrastructure. Therefore it can be expected that the irrigated areas of the remote sensing products are somewhat smaller than the values of the irrigation statistics. However, the result of the comparison shows that there is hardly any agreement between the statistical data and the irrigated areas of GLCC and GLC2000 even on the country level. The difference between irrigated areas from the statistics and from remote sensing was smaller than 20% for only seven countries in the case of GLCC, and for only three countries in the case of GLC2000. Additionally there is also hardly any agreement between the two land cover data sets (Table A1). Certainly, census based statistics may have a high degree of

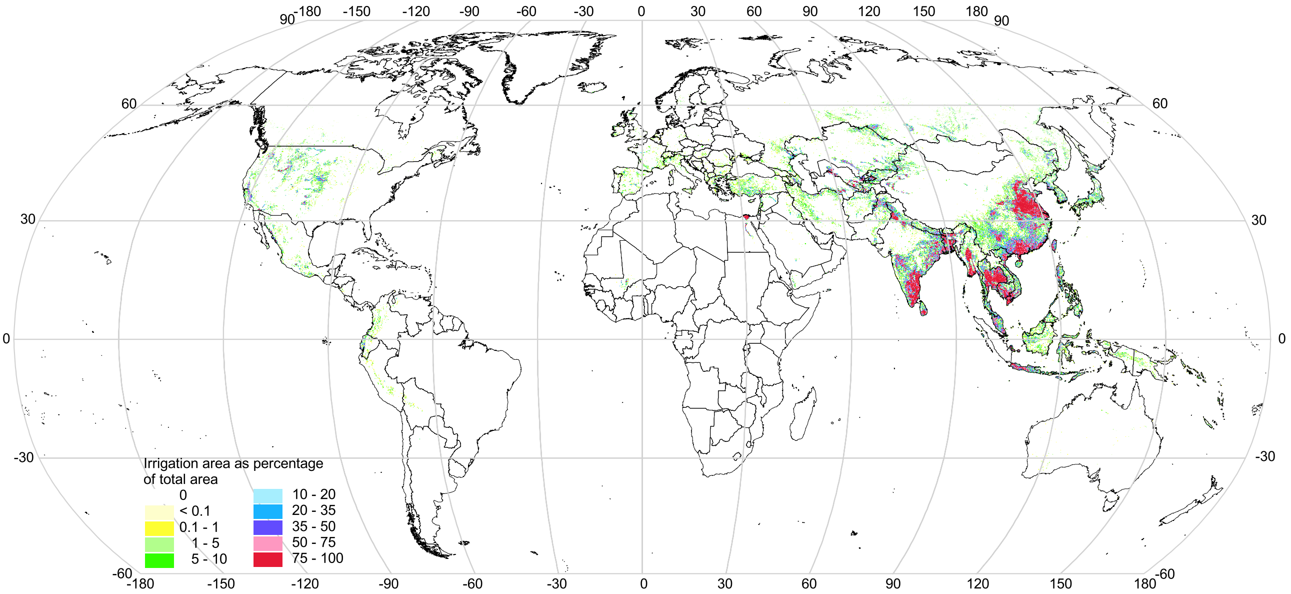

Fig. 4. Percentage of 5-min grid cell area that was classified as irrigated agriculture in the GLCC (in Robinson projection).

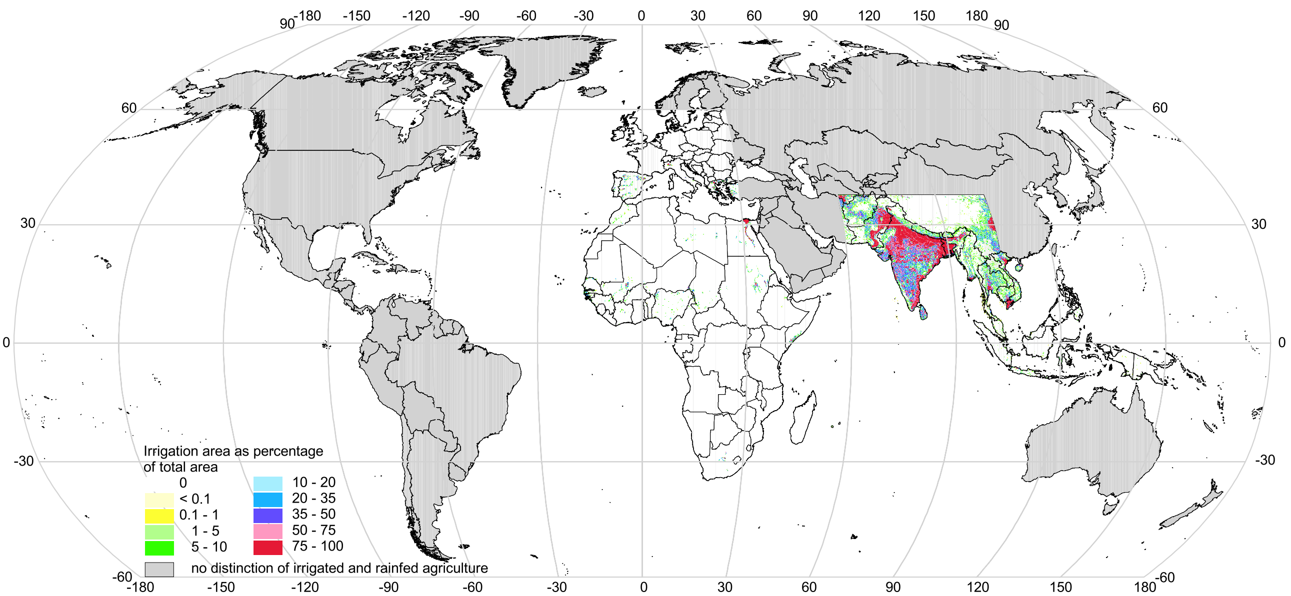

Fig. 5. Percentage of 5-min grid cell area that was classified as irrigated agriculture in the GLC2000 data set (Robinson projection).

uncertainty, depending often on the importance of irrigation for a country. However, the large discrepancies in most countries do indicate that the estimates of the extent of irrigated areas as derived from the land cover classification are not very reliable.

A second comparison was performed at the scale of 5 arc minutes. The cells of the two land cover classifications were aggregated to the 5 arc minutes resolution, and the percentage of each 5 min cell that is irrigated was computed (Figs. 4 and 5). The comparison of the Global Map of Irrigation Areas (Fig. 3) to GLCC shows that the best agreement exists in Egypt, Western China and North America (although the many irrigation areas along the Mississippi and the scattered small scale irrigation in the Eastern US are missing in GLCC). In all other regions there are large discrepancies. For example most of the important irrigation areas in the Ganges and Indus basins are missing in GLCC. Instead, large parts in South-East India appear to be irrigated. Most of the irrigation schemes in Africa, Europe, South America, Australia and on the Arabian Peninsula are missing in GLCC, while other areas in Myanmar, Thailand and Eastern China are irrigated very densely. The agreement between the Global Map of Irrigation Areas and GLC2000 is good for the Nile basin and parts of South Asia (Myanmar, Thailand, Vietnam, upper Indus and upper Ganges basins). In all the other regions there are large discrepancies. The irrigated areas in many parts of Africa, Europe and South-East Asia are missing in GLC2000, while irrigation density in India is mostly very high. Not only with respect to the country values but also with respect to the spatial distribution of irrigated areas within countries, there is also very little agreement between the two land cover classifications themselves (Figs. 4 and 5).

There are several reasons why the remote sensing based global land cover inventories failed to classify irrigated areas in many regions. First of all, the methodology used in the land cover classifications leads to the detection of the main land cover type for each grid cell, which would be irrigated agriculture if irrigation density is more than 50%, and something else if irrigation density is lower. Therefore, the land cover classification maps tend to overestimate irrigation density in the main irrigation areas as compared to the Global Map of Irrigation Areas, and on the other hand many of the smaller irrigation areas are missing. Second, a successful detection of irrigated areas in more humid regions requires a lot of background knowledge on cropping practices, weather, soil conditions and agricultural management, which is not available on the global scale at the required resolution. The results of the land cover classifications are better in arid regions if the irrigation schemes are large enough. The irrigated areas along the Nile River or at the fringe of the Taklamakan desert in Western China are detected very well while many of the oases on the Arabian Peninsula or in Northern Africa are classified as scrubland or grassland because they are much smaller than the resolution of the used satellite imagery.

Please remember that the methodology used in the land cover classification was not developed with the focus on irrigated areas. A methodology for remote sensing based global irrigation mapping was developed by researchers at the International Water Management Institute (IWMI). The methodology is actually being used in an ongoing global irrigation mapping project (see http://www.iwmidsp.org/iwmi/info/research.asp).

5 Conclusions

The quality of the Global Map of Irrigation Areas, which was compiled by combining sub-national irrigation statistics for 10 825 statistical units with geo-spatial information on the location and extent of irrigation schemes, differs strongly between countries and world regions, depending on the density and reliability of the used data sources. The overall map quality of version 3 of the global irrigation map is estimated as good. Improvements of the irrigation map are in particular necessary for the continents of Africa and Europe and for the Russian Federation.

The quality of the map allows to recommend the use of the data set for global studies or for studies focusing on the world regions of North America, Northern Africa, Near East, Central Asia, East Asia, South Asia, South-East Asia or Oceania. Additionally the map quality was estimated as very good for 27 countries so that the use of the Global Irrigation Map for studies performed for these countries can also be recommended if there is a lack of similar country specific data sets and if the map resolution of 5 arc minutes is sufficient.

The comparison to two global land cover inventories indicates that these data sets should not be used to extract irrigated areas. The main advantage of the Global Map of Irrigation Areas is that the total area equipped for irrigation in any of the sub-national units is equal to the irrigated area as reported by census-based statistics. This is important for many applications of the map, e.g. for the calculation of irrigation water use. The mapping methodology allows to easily incorporate new information and thus to benefit from advancements made by national census and mapping authorities.

Appendix

Table A1. Assessment of map quality for countries. Number of sub-national units (n_{adm}), area equipped for irrigation ($area_{\mathrm{irri}}$), average area of the sub-national units ($area_{\mathrm{admav}}$), average area of the sub-national units weighted by irrigation density (*IND_A*), map quality based on indicators A and B (considering the weighted average size of sub-national units and the availability of geospatial records to distribute irrigated areas within sub-national units, respectively), overall map quality, and irrigated area in the Global Land Cover Characterization (USGS, 2000) data set GLCC, and irrigated area in the Global Land Cover 2000 data set GLC2000 (European Commission, Joint Research Centre, 2003) (GLC2000), for all countries where irrigation was reported.

Country	Region	n_{adm}	$area_{\mathrm{irr}}$ (ha)	$area_{\mathrm{admav}}$ (ha)	*IND_A* (ha)	Map quality			Irrigated area in other datasets (ha)	
						Based on indicator A	Based on indicator B	**overall**	GLCC	GLC2000
Afghanistan	Central Asia	329	3 199 070	195 012	100 129	very good	good	**very good**	1 556 249	6 251 633
Albania	Eastern Europe	1	340 000	2 869 803	2 869 803	poor	very good	**very good**	19 055	0
Algeria	Northern Africa	48	555 500	4 832 921	356 678	good	poor	**fair**	0	1385
Andorra	Southern Europe	1	150	46 040	46 040	excellent	good	**good**	1075	0
Angola	Southern Africa	1	75 000	125 157 722	125 157 722	very poor	very poor	**very poor**	0	0
Antigua and Barbuda	Central America	1	130	54 524	54 524	excellent	very poor	**good**	0	n.a.
Argentina	South America	24	1 437 275	11 580 985	10 013 677	very poor	good	**fair**	1554	n.a.
Armenia	Central Asia	39	286 027	75 942	53 342	excellent	good	**very good**	14 107	n.a.
Australia	Oceania	1322	2 056 580	582 328	116 419	very good	good	**very good**	26 270	n.a.
Austria	Western Europe	1	46 000	8 363 819	8 363 819	very poor	fair	**fair**	5883	0
Azerbaijan	Central Asia	7	1 453 318	1 231 120	2 078 392	poor	good	**good**	712 368	n.a.
Bahrain	Near East	9	4060	6925	3774	excellent	very good	**very good**	0	n.a.
Bangladesh	South Asia	64	3 751 045	213 733	202 300	very good	good	**very good**	7 466 244	10 339 672
Barbados	Central America	1	1000	44 964	44 964	excellent	good	**very good**	0	n.a.
Belarus	Eastern Europe	1	115 000	17 650 795	17 650 795	very poor	poor	**poor**	419	n.a.
Belgium	Western Europe	1	40 000	3 046 628	3 046 628	very poor	poor	**poor**	6761	0
Belize	Central America	1	3000	2 229 079	2 229 079	poor	fair	**poor**	0	n.a.
Benin	Western Africa	6	10 236	1 933 320	966 604	fair	good	**fair**	0	15 121
Bhutan	South Asia	20	38 734	198 897	159 021	very good	very good	**very good**	63 698	214 268
Bolivia	South America	10	128 240	10 877 707	6 741 935	very poor	good	**fair**	31 583	n.a.
Bosnia Herzegovina	Eastern Europe	1	2000	5 034 643	5 034 643	very poor	very poor	**very poor**	3158	0
Botswana	Southern Africa	6	1381	9 659 377	712 669	fair	fair	**fair**	0	0
Brazil	South America	30	2 656 284	28 355 229	18 399 822	very poor	fair	**fair**	0	n.a.
Brunei	South-East Asia	1	1000	590 083	590 083	fair	fair	**fair**	41 513	0
Bulgaria	Eastern Europe	1	800 000	11 034 060	11 034 060	very poor	fair	**fair**	86 372	0
Burkina Faso	Western Africa	10	24 331	2 757 477	2 723 515	poor	fair	**fair**	1337	28 945
Burundi	Eastern Africa	8	14 400	338 353	24 229	excellent	very poor	**good**	0	0
Cambodia	South-East Asia	21	284 172	867 100	537 055	fair	very good	**very good**	7 346 838	1 887 695
Cameroon	Western Africa	36	20 970	1 300 415	1 739 517	poor	very good	**fair**	0	65 537
Canada	North America	270	785 046	3 664 480	693 806	fair	good	**good**	189 254	n.a.
Cape Verde	Western Africa	1	2779	404 523	404 523	good	very poor	**fair**	0	0
Central African Republic	Western Africa	24	135	2 595 067	8 845 312	very poor	excellent	**good**	0	0
Chad	Western Africa	11	14 020	11 585 520	2 872 441	poor	very good	**good**	0	130 753
Chile	South America	13	1 900 000	5 801 591	2 547 695	poor	good	**good**	0	n.a.
China	East Asia	2414	53 823 000	387 005	149 312	very good	very good	**good**	110 027 672	n.a.
Colombia	South America	33	900 000	3 463 207	2 127 824	poor	fair	**fair**	305 919	n.a.
Comoros	Eastern Africa	4	130	48 447	23 839	excellent	excellent	**very good**	0	0
Congo, Dem. Rep.	Western Africa	1	10 500	233 798 683	233 798 683	very poor	very good	**good**	0	0
Congo, Rep	Western Africa	2	217	17 158 886	590 730	fair	very poor	**poor**	0	0
Costa Rica	Central America	8	103 084	642 259	944 203	fair	fair	**fair**	0	n.a.
Cote D'Ivoire	Western Africa	1	72 750	32 316 231	32 316 231	very poor	good	**fair**	0	27 326
Croatia	Eastern Europe	1	3000	5 675 863	5 675 863	very poor	very poor	**very poor**	3224	0
Cuba	Central America	15	870 319	734 561	774 494	fair	poor	**fair**	0	n.a.
Cyprus	Near East	9	55 813	102 795	81 702	excellent	good	**good**	9427	0
Czech Republic	Eastern Europe	1	24 000	7 868 122	7 868 122	very poor	poor	**poor**	55	0
Denmark	Western Europe	1	476 000	4 260 345	4 260 345	very poor	very poor	**very poor**	243	0
Djibouti	Eastern Africa	5	407	434 531	173 210	very good	very poor	**fair**	0	0
Dominican Republic	Central America	31	269 710	156 667	186 440	very good	good	**good**	0	n.a.
East Timor	South-East Asia	1	14 000	1 290 097	1 290 097	poor	fair	**fair**	141 290	0
Ecuador	South America	22	863 370	1 168 061	914 831	fair	fair	**fair**	714 920	n.a.
Egypt	Northern Africa	26	3 245 650	3 785 072	366 380	good	good	**good**	1 961 473	3 208 725
El Salvador	Central America	1	44 993	2 051 927	2 051 927	poor	very good	**good**	0	n.a.
Eritrea	Eastern Africa	1	28 124	12 175 259	12 175 259	very poor	poor	**very poor**	0	4621
Estonia	Eastern Europe	1	4000	4 325 320	4 325 320	very poor	very poor	**very poor**	263	0
Ethiopia	Eastern Africa	9	160 785	12 584 053	10 197 682	very poor	fair	**poor**	0	14 895
Fiji	Oceania	2	3000	967 209	1 838 800	poor	fair	**fair**	0	n.a.
Finland	Western Europe	1	64 000	31 286 011	31 286 011	very poor	very poor	**very poor**	1039	n.a.
France	Southern Europe	22	2 000 000	2 490 354	2 743 917	poor	fair	**fair**	291 147	0
French Guyana	South America	1	2000	8 362 955	8 362 955	very poor	fair	**fair**	0	n.a.
Gabon	Western Africa	26	4450	1 021 554	1 476 439	poor	good	**fair**	0	0
Gambia	Western Africa	3	1670	358 586	390 843	good	fair	**good**	0	71 670
Georgia	Central Asia	1	300 000	6 979 779	6 979 779	very poor	fair	**fair**	43 961	n.a.
Germany	Western Europe	15	531 120	2 370 523	3 076 418	very poor	fair	**fair**	16 555	0
Ghana	Western Africa	9	6374	2 663 105	861 620	fair	very good	**good**	0	1555
Greece	Southern Europe	1	1 422 000	13 212 760	13 212 760	very poor	fair	**fair**	297 326	647 003
Grenada	Central America	1	219	41 508	41 508	excellent	poor	**good**	0	n.a.
Guadeloupe	Central America	1	2000	177 668	177 668	very good	good	**very good**	0	n.a.
Guam	Oceania	1	312	55 038	55 038	excellent	very poor	**good**	0	n.a.
Guatemala	Central America	22	129 803	494 303	375 233	good	good	**good**	0	n.a.
Guinea	Western Africa	23	92 880	1 068 124	1 537 311	poor	poor	**poor**	0	42 205
Guinea Bissau	Western Africa	1	17 115	3 370 176	3 370 176	very poor	very poor	**very poor**	0	108 149
Guyana	South America	10	150 134	2 112 413	432 368	good	fair	**good**	0	n.a.
Haiti	Central America	9	91 502	303 796	396 653	good	good	**good**	0	n.a.

Table A1. Continued.

Honduras	Central America	18	73 210	622 137	431 031	good	fair	**fair**	84	n.a.
Hungary	Eastern Europe	1	210 000	9 274 395	9 274 395	very poor	fair	**fair**	26 277	0
India	South Asia	555	57 291 407	577 832	418 698	good	good	**good**	64 989 028	152 440 746
Indonesia	South-East Asia	89	4 459 000	2 133 773	929 478	fair	good	**good**	11 630 619	516 156
Iran	Near East	25	6 913 800	6 488 740	4 599 816	very poor	good	**good**	1 908 232	n.a.
Iraq	Near East	18	3 525 000	2 399 113	1 218 600	poor	fair	**fair**	166 202	n.a.
Israel	Near East	33	183 408	67 738	31 251	excellent	good	**very good**	35 035	n.a.
Italy	Southern Europe	20	2 698 000	1 506 391	1 811 753	poor	fair	**fair**	239 901	344 425
Jamaica	Central America	14	25 214	79 097	110 296	very good	good	**very good**	0	n.a.
Japan	East Asia	47	3 129 000	794 798	702 829	fair	good	**good**	3 238 580	n.a.
Jordan	Near East	8	76 912	1 126 990	294 032	good	fair	**fair**	362	n.a.
Kazakhstan	Central Asia	19	1 855 200	14 145 120	12 729 831	very poor	good	**fair**	5 263 375	n.a.
Kenya	Eastern Africa	8	66 610	7 308 011	1 382 698	poor	good	**fair**	0	0
Korea, Dem. Rep.	East Asia	1	1 460 000	12 244 011	12 244 011	very poor	good	**fair**	1 321 814	n.a.
Korea, Republic	East Asia	15	880 365	659 376	395 459	good	fair	**good**	1 682 588	n.a.
Kuwait	Near East	6	6968	288 451	680 602	fair	very good	**very good**	0	n.a.
Kyrgyzstan	Central Asia	41	1 075 040	486 307	286 062	good	good	**good**	1 252 028	n.a.
Laos	South-East Asia	18	295 535	1 281 555	1 013 132	poor	very good	**very good**	1 579 030	660 757
Latvia	Eastern Europe	1	20 000	6 431 369	6 431 369	very poor	poor	**poor**	0	0
Lebanon	Near East	26	117 113	39 722	50 242	excellent	fair	**very good**	22 771	n.a.
Lesotho	Southern Africa	1	2722	3 049 045	3 049 045	very poor	fair	**poor**	0	0
Liberia	Western Africa	1	2100	9 612 261	9 612 261	very poor	very poor	**very poor**	0	0
Libya	Northern Africa	25	360 500	6 477 352	432 994	good	good	**good**	0	143 525
Lithuania	Eastern Europe	1	9000	6 459 028	6 459 028	very poor	poor	**poor**	0	0
Macedonia	Eastern Europe	1	55 000	2 541 962	2 541 962	poor	poor	**poor**	14 873	0
Madagascar	Eastern Africa	6	1 087 000	9 868 007	8 236 266	very poor	fair	**fair**	0	0
Malawi	Southern Africa	10	28 000	1 185 072	490 930	good	good	**good**	0	0
Malaysia	South-East Asia	14	362 600	2 365 595	567 143	fair	good	**good**	5 617 450	135 570
Mali	Western Africa	34	191 470	3 689 200	3 241 291	very poor	fair	**fair**	326 681	653 718
Malta	Southern Europe	1	2000	40 055	40 055	excellent	very poor	**fair**	0	0
Martinique	Central America	1	3000	115 445	115 445	very good	fair	**good**	0	n.a.
Mauritania	Western Africa	13	49 200	8 026 288	4 147 985	very poor	good	**fair**	1323	51 061
Mauritius	Eastern Africa	1	17 500	183 361	183 361	very good	good	**very good**	0	0
Mexico	Central America	32	6 104 956	6 121 135	4 072 214	very poor	fair	**fair**	1 956 154	n.a.
Moldova Rep.	Eastern Europe	1	307 000	3 388 941	3 388 941	very poor	very good	**good**	3987	n.a.
Mongolia	East Asia	18	57 300	8 678 282	7 070 172	very poor	good	**fair**	138 701	n.a.
Morocco	Northern Africa	27	1 258 200	2 493 714	2 336 883	poor	good	**fair**	0	92 040
Mozambique	Southern Africa	10	116 715	7 880 772	5 426 595	very poor	very good	**good**	0	0
Myanmar	South-East Asia	14	1 841 320	4 783 485	3 921 831	very poor	fair	**fair**	13 091 993	3 582 744
Namibia	Southern Africa	10	6142	8 246 880	7 608 665	very poor	good	**good**	0	0
Nepal	South Asia	75	1 168 349	196 349	143 668	very good	good	**very good**	2 067 770	2 463 348
Netherlands	Western Europe	1	565 000	3 478 820	3 478 820	very poor	fair	**poor**	5418	0
New Zealand	Oceania	16	577 882	1 679 748	2 996 306	poor	fair	**fair**	0	n.a.
Nicaragua	Central America	19	61 365	673 557	427 918	good	fair	**fair**	6364	n.a.
Niger	Western Africa	8	66 480	14 845 330	2 353 231	poor	fair	**poor**	0	109 218
Nigeria	Western Africa	9	300 350	10 144 308	12 469 784	very poor	poor	**poor**	0	167 607
Northern Marianna Islands	Oceania	4	60	7843	4708	excellent	very poor	**good**	3233	n.a.
Norway	Western Europe	1	127 000	31 435 582	31 435 582	very poor	poor	**poor**	1053	n.a.
Oman	Near East	8	72 630	3 917 788	1 322 773	poor	very good	**very good**	123 569	n.a.
Pakistan	South Asia	112	14 417 464	771 245	490 643	good	good	**good**	3 393 750	25 964 976
Palestine	Near East	17	19 466	36 577	11 530	excellent	good	**very good**	0	n.a.
Panama	Central America	10	34 626	749 726	669 811	fair	poor	**fair**	595	n.a.
Paraguay	South America	1	67 000	40 033 587	40 033 587	very poor	poor	**poor**	0	n.a.
Peru	South America	25	1 195 228	5 186 247	2 540 813	poor	fair	**fair**	116 131	n.a.
Philippines	South-East Asia	12	1 550 000	2 476 588	2 420 277	poor	fair	**fair**	3 668 113	17 486
Poland	Eastern Europe	1	100 000	31 074 704	31 074 704	very poor	fair	**fair**	2179	0
Portugal	Southern Europe	7	632 000	1 303 693	1 435 741	poor	good	**good**	17 812	100 129
Puerto Rico	Central America	79	37 079	11 348	12 715	excellent	fair	**very good**	0	n.a.
Qatar	Near East	1	12 520	1 125 261	1 125 261	poor	good	**good**	0	n.a.
Reunion	Eastern Africa	1	12 000	250 925	250 925	good	very poor	**good**	0	8 827
Romania	Eastern Europe	1	2 880 000	23 715 940	23 715 940	very poor	fair	**fair**	39 938	0
Russian Federation	Russian Federation	88	4 878 000	19 234 888	5 028 884	very poor	poor	**poor**	6 180 020	n.a.
Rwanda	Eastern Africa	1	4000	2 531 838	2 531 838	poor	good	**fair**	0	0
Sao Tome and Principe	Western Africa	1	9700	96 663	96 663	excellent	very poor	**good**	0	0
Saudi Arabia	Near East	14	1 730 767	13 785 211	5 964 304	very poor	good	**good**	42 172	n.a.
Senegal	Western Africa	4	71 400	4 932 187	1 995 968	poor	good	**good**	0	283 781
Serbia and Montenegro	Eastern Europe	1	57 000	10 247 622	10 247 622	very poor	poor	**poor**	4 944	0
Sierra Leone	Western Africa	5	29 360	1 448 465	2 475 078	poor	good	**fair**	0	2224
Slovakia	Eastern Europe	1	174 000	4 889 727	4 889 727	very poor	fair	**fair**	2036	0
Slovenia	Eastern Europe	1	2000	2 024 675	2 024 675	poor	poor	**poor**	2963	0
Somalia	Eastern Africa	17	200 000	3 738 850	3 939 119	very poor	fair	**poor**	0	521 289
South Africa	Southern Africa	45	1 270 000	2 716 145	3 074 240	very poor	fair	**poor**	0	143 529
Spain	Southern Europe	17	3 268 306	2 968 187	3 323 641	very poor	good	**good**	349 598	1 332 525
Sri Lanka	South Asia	26	570 000	256 983	285 239	good	good	**good**	2 301 825	2 257 224
St. Kitts and Nevis	Central America	1	18	29 556	29 556	excellent	fair	**very good**	0	n.a.
St. Lucia	Central America	1	297	63 905	63 905	excellent	good	**very good**	0	n.a.
Sudan	Eastern Africa	62	1 946 200	4 052 908	2 286 757	poor	very good	**good**	0	944 060
Suriname	South America	1	51 180	14 674 639	14 674 639	very poor	poor	**poor**	0	n.a.
Swaziland	Southern Africa	1	67 400	1 732 063	1 732 063	poor	very poor	**poor**	0	0
Sweden	Western Europe	1	115 000	44 775 499	44 775 499	very poor	poor	**poor**	8 011	n.a.

Table A1. Continued.

Switzerland	Western Europe	1	25 000	4 058 894	4 058 894	very poor	fair	**fair**	28 105	0
Syria	Near East	13	1 266 900	1 433 681	1 022 356	poor	good	**good**	184 991	n.a.
Taiwan, Province of China	East Asia	23	525 528	158 178	140 295	very good	very good	**very good**	1 765 431	n.a.
Tajikistan	Central Asia	2	719 200	7 090 702	3 150 233	very poor	good	**good**	1 021 262	n.a.
Tanzania	Southern Africa	1	150 000	94 549 369	94 549 369	very poor	poor	**poor**	0	0
Thailand	South-East Asia	76	4 985 708	680 171	377 064	good	very good	**very good**	26 609 734	6 630 135
Togo	Western Africa	1	7008	5 726 793	5 726 793	very poor	fair	**poor**	0	680
Trinidad and Tobago	Central America	1	3600	504 986	504 986	fair	fair	**fair**	0	n.a.
Tunisia	Northern Africa	23	384 943	673 995	332 076	good	fair	**fair**	0	0
Turkey	Near East	73	4 185 910	1 069 316	1 099 341	poor	good	**good**	2 004 936	453 243
Turkmenistan	Central Asia	5	1 744 100	9 779 032	8 841 162	very poor	very good	**good**	2 383 627	n.a.
Uganda	Eastern Africa	11	9 120	2 203 246	5 007 171	very poor	very good	**good**	0	0
Ukraine	Eastern Europe	1	2 454 000	56 917 149	56 917 149	very poor	fair	**fair**	73 986	n.a.
United Arab Emirates	Near East	8	280 341	984 729	645 184	fair	good	**good**	78	n.a.
United Kingdom	Western Europe	1	142 687	24 408 258	24 408 258	very poor	fair	**poor**	58 709	0
United States of America	North America	3506	27 913 872	269 534	238 739	very good	good	**very good**	10 719 481	n.a.
Uruguay	South America	1	181 200	17 703 613	17 703 613	very poor	good	**good**	0	n.a.
US Virgin Islands	Central America	2	185	18 007	20 972	excellent	very poor	**good**	0	n.a.
Uzbekistan	Central Asia	13	4 223 000	3 264 072	1 197 314	poor	very good	**very good**	5 210 733	n.a.
Venezuela	South America	24	570 219	3 800 359	1 332 888	poor	fair	**fair**	9988	n.a.
Vietnam	South-East Asia	32	3 000 000	1 027 496	740 739	fair	good	**good**	10 747 900	8 192 239
Yemen	Near East	19	388 000	2 352 871	920 210	fair	good	**good**	83 407	n.a.
Zambia	Southern Africa	7	46 400	10 773 311	3 797 335	very poor	fair	**fair**	0	0
Zimbabwe	Southern Africa	1	116 577	39 184 102	39 184 102	very poor	poor	**poor**	0	0
	World	10 825	273 723 445	1 241 912	330 249	n.a.	n.a.	n.a.	325 636 618	n.a.

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