Global dataset of monthly crop-specific irrigated areas around the year 2000

Felix Portmann, Stefan Siebert, Petra Döll (Institute of Physical Geography, University of Frankfurt am Main, Germany)

JOHANN WOLFGANG GOETHE UNIVERSITÄT FRANKFURT AM MAIN

Senckenberganlage 36, D-60325 Frankfurt am Main
Tel.: +49 (0)69-798-25014, Fax: +49 (0)69-798-25058
E-mail: portmann@em.uni-frankfurt.de

Introduction

Agricultural water balance modelling helps to assess the stress on water resources, especially on the scarce "blue water" in rivers, lakes and aquifers. The knowledge which crops grow where and when under either rainfed or irrigated conditions enables to calculate the volumes of "blue" and "green water" (the part of precipitation that evaporates or transpires through vegetation) used for crop growth more precisely than in former studies (see references). The dataset under development considers 26 irrigated crops including all major food crops, permanent cultures, cotton, and irrigated grassland. For each month of the year the irrigated area of each crop in each 5 arc minute grid cell (size 8 km by 8 km at the equator), representative for 1998 to 2002, will be provided. A similar dataset of rainfed crops will also be produced.

Data Sources and Methods

4 major datasets (A-D) are combined to calculate monthly crop-specific irrigated areas at a 5 min grid, all using comparable periods around the reference year 2000 (Fig. 1), for crop classes specified in Tab. 1.

A) Areas equipped for irrigation (AEI), 5 min grid, Global Map of Irrigation Areas (Siebert et al. 2006) (Fig. 2).
B) Cropland extent, 5 min grid (University of Wisconsin) (Fig. 3, Leff et al. 2004).

C) Cropping calendars of 26 irrigated crop classes, with monthly actually irrigated area and total (annual) harvested area of each crop. Level: national (221 countries or areas) or sub-national (for 7 of the countries, on regional and province or state level: Argentina, Australia, Brazil, China, India, Indonesia, USA). Data sources: whenever possible, national statistics or databases or reports compiled from them (FAO AQUASTAT reports, EUROSTAT, World Bank, and others). For 90 developing countries, irrigation calendars of FAO were updated. Calendar information without discrimination of rainfed and irrigated cultivation e.g. for selected main crops (e.g. JAWF et al. 1994).
D) Harvested crop areas for currently 23 crop classes, irrespective of whether being irrigated or rainfed, 5 min grid (University of Wisconsin) (Fig. 4, Leff et al. 2004).

From datasets A and B the "intersection area" of minimum areas (Fig. 5) is derived. Joining with the maximum monthly crop area for each entity from the tabulated cropping calendar (C) and possibly creating additional cropland where AEI is present results in maximum extent of irrigation within the year on a 5 min grid.

Finally, the maximum monthly extent, the cropping calendar (C) and the rainfed and irrigated harvested area (D) are combined in different steps in order to spatially distribute the crop-specific irrigated areas for each crop and each month of the year on a 5 min grid.

Tab. 1: List of considered crops or crop groups

No.	Crop
1	Wheat
2	Maize
3	Rice
4	Barley
5	Rye
6	Millet
7	Sorghum
8	Soybeans
9	Sunflower
10	Potatoes
11	Cassava
12	Sugar cane
13	Sugar beets
14	Oil palm fruit
15	Rapeseed / Canola
16	Groundnuts / Peanuts
17	Pulses
18	Citrus
19	Date palm fruit
20	Grapes/Vine
21	Cotton
22	Cocoa
23	Coffee
24	Others perennial
25	Managed grassland/pasture
26	Others annual

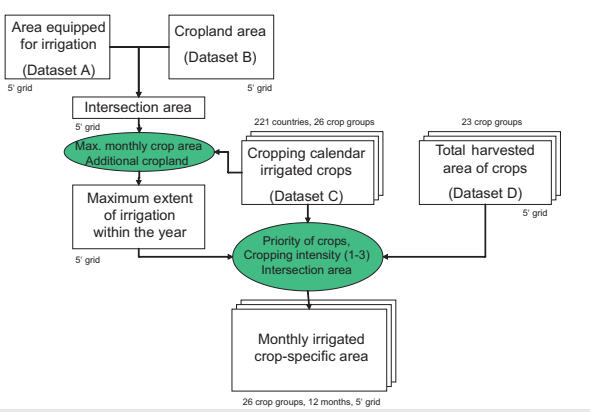

Fig. 1: Data fusion scheme for the calculation of monthly crop-specific irrigated areas

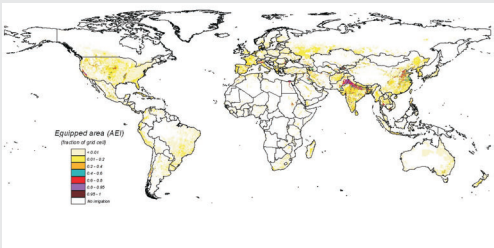

Fig. 2: Area equipped for irrigation (AEI), Global Map of Irrigation Areas, fraction of grid cell area, for 2000, data source: Siebert et al. 2006

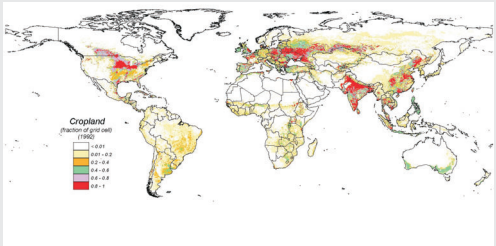

Fig. 3: Cropland extent for 1992, fraction of grid cell area, data source: Leff et al. 2004

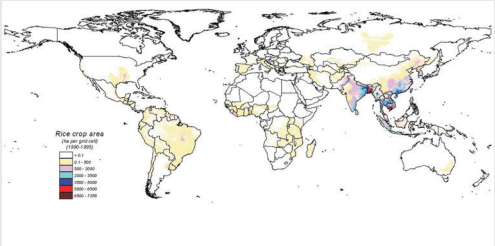

Fig. 4: Rice crop area for 1990-1995, area in ha per grid cell, data source: Leff et al. 2004

Preliminary Results

The coupling of area equipped for irrigation (AEI) (Fig. 2) and cropland extent (Fig. 3) yields the intersection area (Fig. 5). For most grid cells, more than 95 % of AEI is covered by cropland as given in the cropland extent dataset (Fig. 6).

Global sums of monthly irrigated crop area of 4 major selected crops (wheat, rice, maize, cotton) show different annual cycles, e.g. multi-cropping of rice (Fig. 7). The rice cycle reflects multicropping in the major production regions, while irrigated wheat production is predominantly winter wheat. Maize and cotton are mainly grown during northern hemisphere summer.

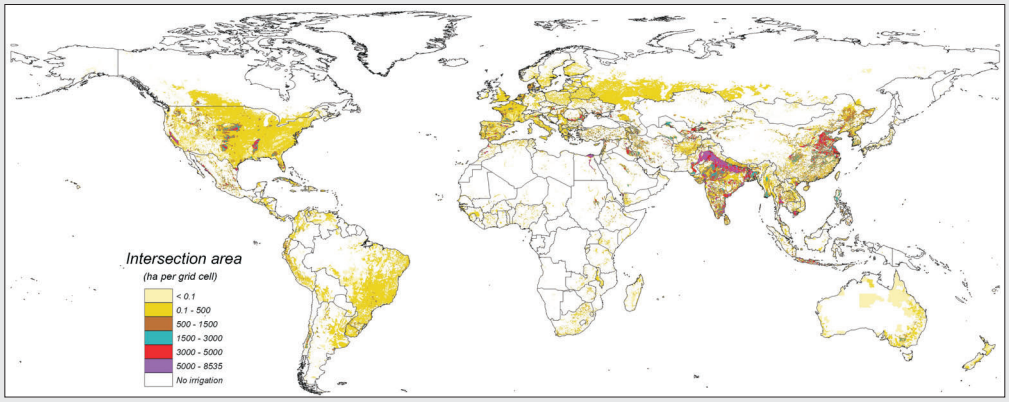

Fig. 5: Intersection area of area equipped for irrigation and cropland extent, area in ha per grid cell (5 min grid), for 2000

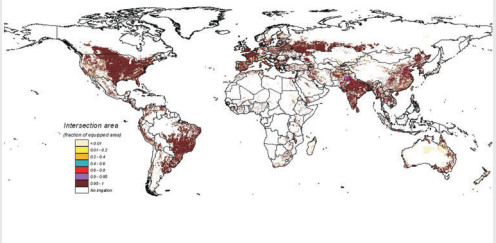

Fig. 6: Fraction of intersection area that is contained in area equipped for irrigation, for 2000

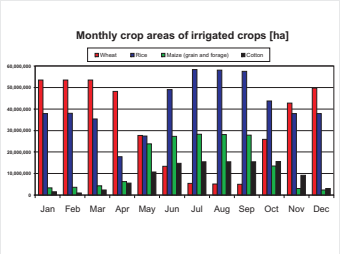

Fig. 7: Monthly irrigated crop area of wheat, rice, maize, and cotton, global sums in ha, for 1998-2002

Discussion

The generation of the global monthly crop-specific irrigated areas on a high-resolution 5 arc min grid is quite complex, as consistency to defined values of equipped area (AEI) and harvested area is required.

Spatial resolution of the gridded data sources is high (8 km by 8 km at the equator) and location mismatch of AEI, cropland extent, and crop harvested area could result in zero overlap. However, the spatial match is good on a global scale (Fig. 6).

In the statistics, the discrimination of irrigated/non-irrigated areas for whole crop groups or for specific crops is not always present. Unspecified crops were put into the group "others". This means, that the area of crops no. 1-23 is a conservative estimation.

The cropping calendars are simplified, especially with respect to multiple cropping periods.

The global averages of monthly crop-specific irrigated area of 4 selected major crops show different annual course. Our preliminary work results in global irrigated harvested area of 315 million ha (on 279 million ha of AEI). Based on remote sensing, Thenkabail et al. (2006) estimated 481 million ha.

The final dataset can be used for assessing at global, continental, or regional scales
- "blue" and "green" virtual water trade
- water use
- food production
- biogeochemical cycles.

Acknowledgements
Through our co-operation with the Center for Sustainability and the Global Environment (SAGE) at the University of Wisconsin, Madison, Wisconsin, we are indebted to Navin Ramankutty and Chad Monfreda for the provision of beta versions of their data sets on cropland extent and harvested crop areas for the year 2000.
Furthermore we want to thank Nicole Stuber and Christian Bauer from the University of Frankfurt that assisted in the compilation of cropping calendars.

References

Joint Agricultural Weather Facility (JAWF); United States Department of Agriculture (USDA) - World Agricultural Outlook Board and United States Department of Commerce - National Oceanic and Atmospheric Administration (NOAA) (1994): Major world crop areas and climatic profiles. USDA Agricultural Handbook, No. 664: xii, 279. Washington, D.C.
Chapagain, A. K. and Hoekstra, Arjen Y. (2004): The water footprint of nations - Volume 1: Main report. Value of Water Research Report Series No. 16 - Vol. 1: 76. Delft.
Leff, Billie; Ramankutty, Navin and Foley, Jonathan A. (2004): "Geographic distribution of major crops across the world." Global Biogeochemical Cycles 18(GB1009): 1-27.
Siebert, Stefan; Hoogeveen, Jippe; Döll, Petra; Faures, Jean-Marc; Felick, Sebastian and Frenken, Karen (2006): The Digital Global Map of Irrigation Areas - Development and Validation of Map Version 4. Trapentag 2006. Bonn.
Thenkabail, P. S.; Biradar, C. M.; Turral, H.; Noojipady, P.; Li, Y. J.; Vithanage, J.; Dheeravath, V.; Velpuri, M.; Schull, M.; Cai, X. L. and Dutta, R. (2006): An Irrigated Area Map of the World (1999) Derived from Remote Sensing. Research report 105: 65. Colombo, Sri Lanka.
Yang, Hong; Wang, L.; Abbaspour, Karim C. and Zehnder, Alexander J. B. (2006): "Virtual water trade: an assessment of water use efficiency in international food trade." Hydrology and Earth System Sciences 10: 443-454.

http://www.geo.uni-frankfurt.de/ipg/ag/dl/index.html