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"Challenges to Organic Farming and Sustainable Land Use in the Tropics and Subtropics"

Water for Agriculture — A Global Systems Analysis Perspective

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Abstract

The global issues of water security and food security are closely linked. Sustainable plant production requires a sustained provisioning of water, either in the form of "green" or of "blue" water. The term "green and blue water" was introduced by Falkenmark (1993) to better assess the role of water in plant production. Green water is defined as the fraction of water that is evapotranspirated, i.e. the water supply for all non-irrigated vegetation. Green water can be called either productive with respect to plant production (if transpirated by crops or natural vegetation) or non-productive (if evaporated from soil and open water). Blue water refers to the water flows in groundwater and surface water (river, lakes). It represents the water that can be withdrawn e.g. for irrigation or is available for *in-situ* water use like navigation. In areas without enough green water in the soil to achieve satisfactory crop growth, crops can be irrigated with blue water. The distinction between green and blue water helps to understand the linkages between rainfall, soil, land productivity and water availability for human water use. One example is rainfall harvesting, which increases the fraction of green productive water and decreases both the amount of green unproductive and blue water (the latter possibly being detrimental to downstream water users).

Another powerful term is "water productivity", which can be defined as produced crop mass (or its economic value) as a ratio of the applied (or consumed) water volume (Molden, 1997). While the term has mostly been used for irrigated agriculture, it is equally applicable in dryland farming, where many efforts are made to enhance productivity under drought conditions. Water being a scarce resource, the goal is to increase water productivity. To achieve a sustainable development, however, it is not only necessary to increase water productivity but also to take into account any trade-offs that might exist between water productivity and other (ecological) goals. An example are efforts to decrease water use for paddy rice production, which, however, requires increased inputs of nutrients and pesticides.

To increase water productivity under irrigated conditions, a good land and water management is required, which consists of a comprehensive and integrated set of measures related to technology, economy, institutional issues and knowledge transfer, and which should be based on a good knowledge about the dynamics of the system. As the dynamics of the system, in particular under the impact of global change, are influenced by processes and drivers at various spatial and institutional scales, a multi-scale approach that considers the interrelation between farm, community, basin, country and global scales is best suited to support sustainable development.

To address the linked issues of water and food security at the global scale, we have developed the global model of water availability and water use WaterGAP (Alcamo et al., 2002), which, with a spatial resolution of 0.5°, computes both water availability (as

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surface runoff, groundwater recharge and river discharge) and water use (for irrigation, livestock, households and industry). The Global Hydrology Model of WaterGAP (Döll et al., 2002) provides, for example, information on how much water is potentially available for irrigation purposes (taking into account domestic and industrial water demands) and how this might change due to climate change.

The Global Irrigation Model of WaterGAP (GIM), simulates net and gross irrigation water requirements in each 0.5 degree grid cell as a function of climate, crop type (rice and non-rice) and the area that is equipped for irrigation (Döll and Siebert, 2002). A digital global map of the areas that were equipped for irrigation around 1995 was developed for this purpose (Döll and Siebert, 2000), and is now being improved in cooperation with FAO (http://www.fao.org/ag/agl/aglw/aquastat/irrigationmap/index.stm). GIM was tested against independent data of irrigation water use, and an uncertainty and sensitivity analysis was performed (Siebert, 2001). In the context of the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), GIM was applied to assess the impact of climate change on global irrigation requirements (Döll, 2002).

As a next step, we want to improve GIM by modeling a larger variety of crop types, which is made difficult by the fact that FAO agricultural production country values do not distinguish between irrigated and dryland farming. Besides, it is planned to couple WaterGAP with a global agroeconomic model in order to derive consistent scenarios of the future food and water situation. These global scenarios can provide a framework for deriving water and food scenarios at smaller scales, which aim at supporting regional or local land and water management.