Final report

World food supply and water resources: an agricultural-hydrological perspective (AgroHyd)

Leibniz-Institute: Leibniz-Institute for Agricultural Engineering Potsdam-Bornim
Reference number: SAW-2011-ATB-5
Project period: 01.04.2011 - 31.12.2014
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Executive summary

About AgroHyd

Agriculture is and will remain the major worldwide user of water resources. To meet the food demands of a growing world population, the water productivity of our farming systems (i.e. "more crop per drop") must be increased rapidly. Changing rainfall patterns and water levels in local water bodies are jeopardizing agricultural production in many regions. In order to develop strategies to adapt farming methods to changes in regional water availability, we need to know how much water is currently being used on farms to produce plant and animal food products. The researcher group "AgroHyd" developed the web-based modeling database ATB-Modeling Database to calculate water-based indicators (e.g. farm water productivity - the ratio of farm output to water input) for different kinds of farm systems in plant and live-stock production. We are modeling the water demand for agricultural processes at the farm scale with farm data gathered from various world regions. The goal was to build a database of water indicators from the various regions that will allow us to evaluate differences in water productivity between farm systems and regions.

Project results

In summary, a farm-scale modeling tool to evaluate the farm and crop water use in current farming methods has been developed that is applicable for many regions of the world. The parallel work on the international level (e.g. farms in Brazil, New Zealand, Vietnam, USA, and Uruguay) and the local project allowed the development of the AgroHyd Farmmodel to incorporate enough flexibility in input and interfaces to adapt the model to very different plant production systems, climates and locations. For example, the decision to develop a globally compatible GIS-based farm and field location input system in order to accommodate farms in potentially many locations increased the versatility of the model system. The decision opened up many possibilities of using large open access georeferenced databases for many of the required data inputs. Therefore, a flexible database was developed that allows the import of a wide range of data, which can be expanded as data becomes available and the model develops.

It has been shown that the AgroHyd Farmmodel can be used to explore changes in agronomic practices that are being considered to adapt to changing regional water availability. The strategy for the further development of the tool – e.g. whether for direct use by farmers, or only for experts – is currently under development. The complexity of the topic and the myriad of questions that can be asked with such a model mean that many different "tools" could be developed for end-users, depending on their wishes. For example, the tool could be developed further to allow local irrigation management to calculate effects of changing the crop schedules, and plan staggered crop schedules in various parts of the region. In a parallel development of the web-service, farmers or farm advisors could access data on typical indicator ranges to be found in their region and choose appropriate options to explore on their farms.

Activity report and results report

Objectives of the project

The objective of the established working group was to increase water productivity in agriculture. Agriculture is and will remain the major worldwide user of water resources. Water is a key input in food and feed production. Plants transpire large amounts of water over a growing season. Water evaporates from soil and plant surfaces. Drinking water and technical water for barn cooling and cleaning are necessary to raise dairy and meat-producing animals. To meet the food demands of a growing world population, the water productivity of our farming systems (i.e. “more crop per drop”) must be increased rapidly. Changing rainfall patterns and water levels in local water bodies are jeopardizing agricultural production in many regions. In order to develop strategies to adapt farming methods to changes in regional water availability, we need to know how much water is currently being used on farms to produce plant and animal food products. Surprisingly, consistent and accessible data on farm water use and how different farming methods affect it are missing.

The researcher group “AgroHyd” addressed this gap by developing the web-based AgroHyd Farmmodel to calculate water-based indicators (e.g. farm water productivity - the ratio of farm output to water input) for different kinds of farm systems in plant and live-stock production. The project divides into five work packages, which build on and complement one another (Fig. 1).

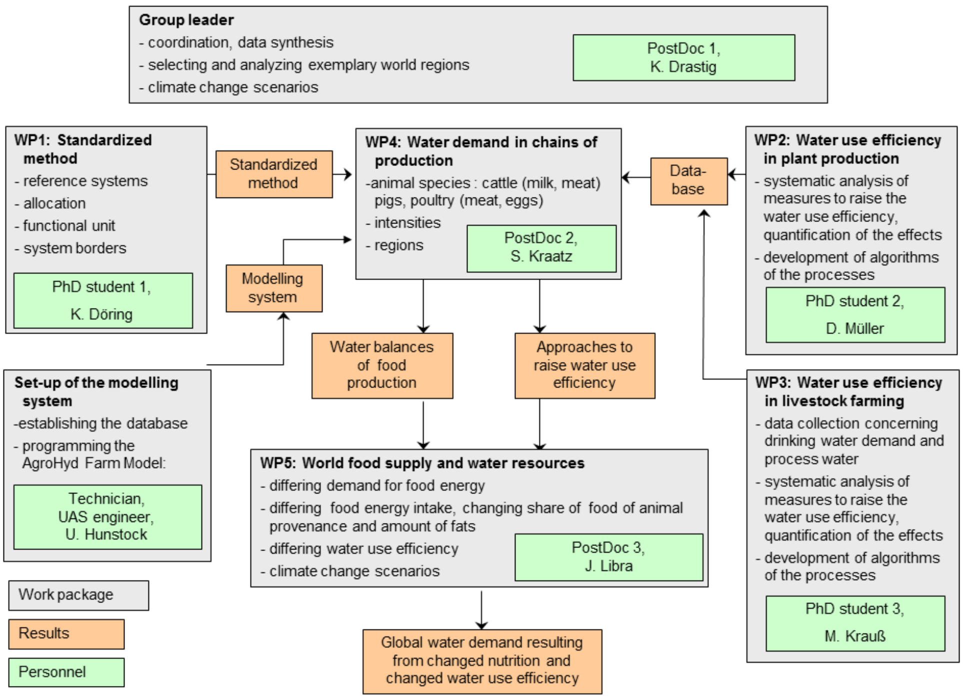

Fig. 1: Work arrangements and group structure

Development of the performed work including deviations from the original concept, scientific failures, and issues related to the organization or technical application

The objective of the project was to quantify water use in different agricultural operation systems, to show possibilities of using the water more efficiently, and on this basis to assess the impact of different alimentation scenarios on the water balance.

Within the **work package standardized method** (WP1), a standardized method to balance the water demand for food production was further developed. After examining the different methodological approaches, a standard was derived to describe the procedure for water balancing in detail. Different allocation approaches (e.g. for mass or energy) were examined. The functional unit (kg food product) currently used was substituted by a more suitable unit (e.g. kJ food energy). System boundaries had to be expanded to include the preceding process sequences proportionately, i.e. the water demand for producing e.g. farm inputs and machinery. The focus was first on the calculation of the indirect water demand for farm buildings in milk production, which was assessed for the first time. Four standardized barn types for dairy cows, a young cattle barn, a calf barn, and storage facilities were investigated. The materials and masses of each building type and equipment were determined. The water needed in the process of material production was taken from the Ecoinvent database. The further investigation was to calculate the bandwidth of the developed indicators on the basis of collected data sets of different farms.

In the two following work packages on water use efficiency, the impacts of individual measures had to be quantified, interactions were analyzed, and especially effective, site-specific measures had to be derived. For this purpose, literature data was interpreted; algorithms developed and own modeling and simulations implemented. The resulting modules and databases were planned to be able to quantify water use efficiency in plant production under different site-specific conditions, and to quantify a broad spectrum of measures in plant production and livestock farming. The data obtained from these two work packages had to be assembled into a database, which in turn was further processed in work package 4.

In the work package **water use efficiency in plant production** (WP2), investigations concentrated on exemplary areas of domestic plant production (wheat, rye, oilseeds, and potatoes) and further products (e.g. rice and cassava). Different measures were investigated with regard to a quantitative increase in water use efficiency. Optimizing of crop rotation and increasing of humus accumulation were promising possibilities. Other measures under investigation were the enhancement of root growth and the selection of efficient irrigation techniques. A

The water demand in livestock farming (milk and meat from dairy cows and broiler chicken production) was estimated on the basis of exemplary animal species in the work package **water use efficiency in livestock farming** (WP3). Measures to increase water use efficiency in livestock farming were derived from this. Data was acquired by literature research and measurements on farms. In dairy farming a distinction had to be made between drinking water and process water. Both amounts of water were quantified, taking into account the climate in animal housing, animal performance, use and feeding, as well as drinking behavior. The amounts of water used in different milking systems had to be compared and analyzed under the aspect of water use efficiency. The objective of the first investigation of one PhD-student was to quantify the effects of dairy management strategies such as feeding strategies, milk yield and replacement rate on the water productivity of milk. The study region was based on site conditions of North-East Germany. The water input was considered as the sum of crop transpiration from precipitation, the total irrigation water, and the drinking water of the animals. Four feeding strategies, based on the maximization of grass silage, maize silage, pasture and concentrate, were analyzed. In the Teaching and Research Institute for Welding Technology Ruhlsdorf/Groß Kreutz (Germany) 38 water meters and wireless modules for the communication of the data were installed. As planned before this work was financed by the ATB budget, The volume of drinking water and the volume of process water for the cleaning of the facilities were detected separately.
The effects of fattening systems on the water productivity in broiler chicken production with consideration given to conditions in Germany were quantified. Four fattening systems were analyzed in terms of water use for feed production, drinking, cleaning and the parent stock. The fattening systems differed in intensity, ranging from fast fattening with a fattening period of 30 days and a carcass weight of 1.1 kg to slow fattening with a period up to 46 days and a carcass weight of 2.1 kg. During the fattening period the broiler chicken were fed with performance-linked feed.

Within the work package **water demand in chains of production** (WP4), the modeling system AgroHyd Farmmodel used for calculating the water demand in different agricultural operation systems for entire chains of food production was developed and applied. In the modeling system, water use in both the plant and livestock production is taken into account. Various farming systems for producing plant-derived food, such as wheat, rye, potatoes, rice, cassava, and cooking oils were investigated. In addition, livestock farming systems were analyzed, including fodder production, reproduction, dairy cows (milk, meat) and poultry (meat). The standardized method from work package 1 was applied for the water balancing. The modules and databases from work packages 2 and 3 were integrated into the system context. Consequently a number of parameters were varied for different systems of plant production and livestock farming to determine water use efficiency of different site conditions, different intensities of land-use and different methods of livestock farming. The impacts of individual measures and combinations of measures on the overall system, as well as impacts of changes in the system (e.g. higher milk yield or longer lifespan of dairy cows) in various regions were investigated. Globally relevant regions were chosen for closer investigation. The countries Brazil, USA, New Zealand, Uruguay, and Vietnam were chosen. The adaptation of farm management for food production in different regions is not finished yet.

In the work package **world food supply and water resources** (WP5), global scenarios of typical alimentation were chosen on the basis of literature research to quantify the water demand. For this purpose the daily food energy intake, the portion of food of animal origin and the amount of fats were varied. The demand for foods corresponding to typical alimentations in certain regions was determined, and the water demand for producing this food with varying water use efficiency was assigned (data from work package 4). The scenarios had to be selected in close coordination with the co-operation partners at the International Food Policy Research Institute (IFPRI). Conclusions were drawn as to how the water demand will develop with different world food supply scenarios, taking climate scenarios into account too, and what measures for raising water use efficiency in the overall system are the most effective.

Work packages 1, 2 and 3 were each attended by one PhD student.

The PhD-student responsible for the WP2 **water use efficiency in plant production** went on parental leave for one year. An additional research scientist was engaged for the time of her absence. The student decided not to complete her PhD-thesis after her parental leave. One more PhD student was associated to the reaearcher group AgroHyd working on effects of irrigation and fertilization on soil carbon contents and yields. He finfished his thesis in June 2015.

The student of the WP (3) **water use efficiency in livestock farming**.is still working on his PhD-thesis. Two of his publications were already accepted and the last publication is submitted to be published in Biosystems Engineering.

Two PostDoc-researchers were responsible for work packages 4 and 5. One PostDoc was chosen for the Leibniz-Mentoring Program and through this supported for her further career. One PostDoc-Researcher went on parental leave for one project year.

Guided by the PostDoc-researchers a UAS-engineer programmed the modeling system.

Deviating from the original concept, a UAS-engineer was engaged. The setup of the modeling system was delayed, because the engineer came to the conclusion, that Java based applications will no longer be available on all end-systems. So he chose a Java independent system for the model set-up.

The PostDoc-researcher responsible for the work package **world food supply and water resources** spent one month at the International Food Policy Research Institute (IFPRI) in Washington (DC). Here the researcher worked on the global water simulation model and a global world food supply model. The cost of the stay was financed by a grant from the Small Grants Program for International Agricultural Research of the GIZ (Programm International Agricultural Research). Co-operation with the renowned IFPRI led to special qualification of one postdoc-researcher.

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Evaluation of the results obtained in relation to the objectives, scientific state of the art, possible prospects for application and follow-on projects

Several whole farm modeling tools have already been developed, which incorporate water on different levels of complexity. Some models incorporate the calculation of a daily water balance (IFSM, FASSET, APSIM, GPFARM), while other models reduce the yield of a crop in dependence on the available precipitation and the potential evapotranspiration (Hurley Pasture Model, SEPATOU). Since the focus of such tools is on farm production and profitability, the quantification of the water flows as explicit outputs and the consideration of the indirect water use has been neglected.

The AgroHyd Farmmodel has been developed by the AgroHyd team to quantify water use, i.e. the use of precipitation, soil water and irrigation water at the farm scale, and to calculate water-use indicators based on farm operating data. These indicators can be used to assess agricultural measures for their merit in improving the productive use of water in different agricultural operation systems. The developed **AgroHyd Farmmodel** is flexible and adaptable to different regions and farming systems. The tool enables farmers and decision-makers to evaluate the farm water consumption in plant production at the field level and in livestock systems.

The method involves balancing the natural and the technical water inflows and water outflows within a farm for a large number of farm systems (Figure 2). Instead of treating the farm as a “black box”, the model combines agriculture and hydrologic processes at the farm scale. The linked on-farm processes are considered within the system boundaries (“cradle to farm gate”). The model includes direct water flows e.g. rainfall, tap water, irrigation water, transpiration, interception losses from plant leaves and mulch and evaporation from soil.

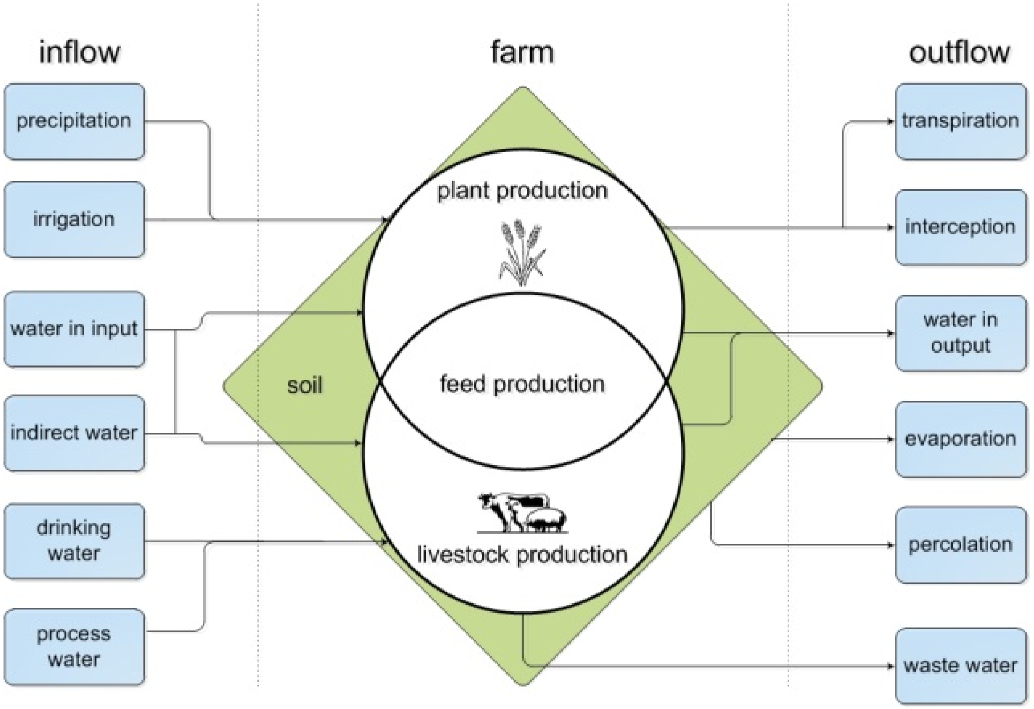

Fig. 2: Water flows and boundaries of farm system

The benefit of the model lies within its speed and inherent flexibility which allows further water-related indicators, agricultural measures and water-related processes in different regions and farm systems to be easily implemented. The description of the Model demonstrates the development of a new solution to handle comprehensive farm and regional data, providing a tool to explore possibilities to enhance the productivity of water use in different farming systems.
The AgroHyd Farmmodel can be used e.g. to calculate the evapotranspiration for individual crops at the farm level as well as the regional level (Figure 3).

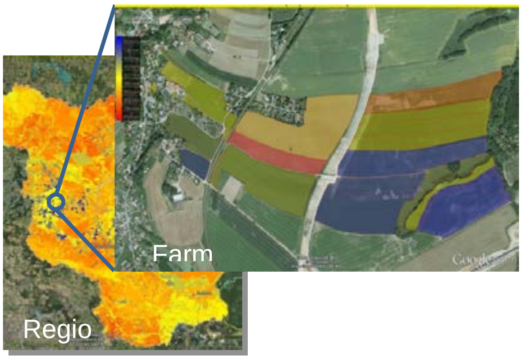

Fig. 3. Model results for crop transpiration, different colors stand for different heights of transpiration [mm]

Within plant production different cultures, crop rotations and irrigation can be modeled. Furthermore the change of available water capacity can be simulated through the change of the soil parameters. Within livestock production the agricultural measures intensity, feeding strategies, milk yield and replacement rate can be modeled.

Although pre-chains are considered in LCA, e.g., for energy and greenhouse gases, this has rarely been done for water so far. One exception is de Boer et al. (2012), who accounted for the water used for inputs such as purchased diesel, gas, electricity and fertilizer. The **indirect water demand** for livestock houses calculated from the AgroHyd team ranges from 1.4 to 1.9 m^3 animal $place^{-1}$ yr^{-1} and varies marginally between barn variants. For calf houses and young cattle houses, indirect water demand ranges from 0.3 to 0.8 m^3 animal $place^{-1}$ yr^{-1}. The demand for indirect water for technical equipment ranges from 0.2 to 0.7 m^3 animal $place^{-1}$ yr^{-1}. The indirect water demand for storage ranges from 0.01 to 0.5 m^3 m^{-3} yr^{-1}. Related to milk production, the indirect water demand is with 0.3 L kg^{-1} milk negligibly low.

Several options to increase water productivity in dairy farming have been reported. Increasing the performance of the cows can improve water productivity under Ethiopian conditions, since the share of maintenance related to the performance is reduced (Peden et al., 2009). An increasing share of crop residues and by-products in the diets can also increase the livestock water productivity (Descheemaeker et al., 2010). Diets should contain high digestible components and the nutrient composition has to be near the demand of the animals (Blümmel et al., 2009). Haileslassie et al. (2011) describe an increasing water productivity in the Indo-Ganga basin with intensifying the milk production up to 2,000 liters cow^{-1} year^{-1}. For Australian conditions a milk yield of 5,350 kg cow^{-1} year^{-1} showed a higher water productivity than a 1,500 kg lower milk yield (Armstrong et al., 2000). This was caused by a better feed conversion into milk and a higher utilization of the pasture. It has been found that feed production accounts for the main share of water input in livestock production (Singh et al., 2003). The effects of dairy management strategies on the water productivity of milk was investigated within the AgroHyd team by varying the milk yield between 4000 and 12,000 kg fat corrected milk (FCM) cow^{-1} year^{-1} in steps of 2000 kg. Feed water productivity on a dry mass (DM) basis varied widely between 1.5 kg (DM) m^{-3} of water input for grass silage and 2.6 kg(DM) m^{-3} for maize silage, 0.8 – 1.8 kg (DM) m^{-3} for grain and 0.4 kg (DM) m^{-3} for soybeans from Brazil. The water productivity of milk increased with an increasing milk yield. The lowest water productivity was calculated at 4000 kg (FCM) with 1.1 kg (FCM) m^{-3} water input. At a milk yield of 8000 kg (FCM) the water productivity was 1.5 kg (FCM) m^{-3} and at 10,000 and 12,000 kg (FCM) it was 1.6 kg (FCM) m^{-3}. The most beneficial conditions related to water productivity in dairy farming exemplarily for site conditions of North-East Germany are found to be with a milk yield about 10,000 kg (FCM) and a grass silage and maize silage based feeding.

Studies of the water use in livestock production systems focus mainly on water demand for milk and beef production (Armstrong et al., 2000; de Boer et al., 2012; Descheemaeker et al., 2010; Haileslassie et al., 2009; Haileslassie et al., 2011; Molden et al., 2007; Moore et al., 2011; Peden et al., 2007; Peters et al., 2010; Rockström et al., 2010; Singh and Kishore, 2004; Zonderland-Thomassen and Ledgard, 2012). Renault and Wallander (2000) calculated the water productivity of poultry for Californian conditions. Crop transpiration and soil evaporation were considered to be water input. Renault and Wallander (2000) estimate the water productivity of poultry at 0.244 kg m^{-3} water, the water productivity of meat protein at 33 g m^{-3} water, and the water productivity of food-energy in poultry at 1.4 MJ m^{-3} water. Chapagain and Hoekstra (2003) estimate the virtual water content of poultry, including crop transpiration, soil evaporation, service and drinking water, to be between 0.9 and 4.2 m^{3} water kg^{-1} poultry. The world average is estimated at 1.5 m^{3} kg^{-1} (Chapagain and Hoekstra, 2003). The wide range of water productivity or virtual water content is due to the regions investigated and their climatic conditions, the intensity of production and the water included in the water input. The effects of fattening systems on the water productivity in broiler chicken

production with consideration given to conditions in Germany were quantified using the AgroHyd Farmmodel. The water productivity of the feed components varied from 0.4 kg dry mass per m³ water input for soybean meal to 1.8 kg dry mass per m³ water input for maize. In all fattening systems the water input for feed production accounted for 90 to 93 % of the total water input. The share for the parent stock was 7 to 10 %, while drinking and cleaning water accounted for less than 1 %. For all fattening systems the water productivity was 0.3 kg carcass weight per m³ water input, 2.8 MJ food-energy per m³ water input and 57 g food-protein per m³ water input. The shorter fattening period and lower feed demand in the more intensive fattening systems were compensated by the higher carcass weight and higher water productivity of the feed components in the more extensive systems.
Technical water use in a dairy cow barn was measured on a well-managed teaching and Research Institute for Welding Technology Ruhlsdorf/Groß Kreutz (Germany). The drinking water intake varied between 40.2 L per cow per day and 167.7 L per cow per day. The cows drink most of the water during the hours of light in the barn. Former regression functions of the drinking water intake of the cows were reviewed and a new regression function based on the ambient temperature and the milk yield was developed. The cleaning water demand varied from 11.8 to 207.9 L per cow per day with a mean of 28.6 L per cow per day in the automatic milking system, and from 12.5 to 170.8 L per cow per day with a mean of 33.8 L per cow per day in the herringbone parlour. The total technical water use in the barn makes only a minor contribution to water use in dairy farming compared with the water use for feed production.

The information on technical water demand in the barn, the water productivities in plant and livestock production provides the basis for further calculations with the AgroHyd Farmmodel along the food chain: the determination of the water demand for the production of food in typical human diets. Such calculations were carried out exemplarily using regional diets, farming practices and climate conditions in Brandenburg and Berlin. The selection of the regional diet components was based on the database of the European Food Safety Agency (EFSA), which provides data on regional food consumption throughout Europe. Nutritional information on the diet components was imported from the extensive USDA nutrient database, so that diets can be assessed as to whether they achieve the recommended daily reference values for nutrients. Through the use of standardized EFSA food groups and the provision of pan-European food consumption data, the calculations may be extended in a next step to other regions.

Work on extending the application of the AgroHyd Farmmodel to farming operations in other relevant world regions was supported in part by a grant from the BMZ Small Grant Program for International Agricultural Research. Through this small grant, the methodology to balance water flows at the farm scale was extended to Vietnam, where large volumes of water are used for food production, competing with rapidly growing domestic and industrial water uses. A regional case study was carried out in the Vietnamese Ninh Thuan Province, in cooperation with the Southern Institute for Water Resources Planning (SIWRP) in Vietnam (Ho Chi Minh City) and IFPRI in Washington, DC., USA. The Ninh Thuan Province is part of the South-East region of Vietnam which comprises the only semi-arid zones of Vietnam. Eighteen farmers in the lowland coastal area and the upland region of the Ninh Thuan Province were surveyed. At the moment, sufficient water is available in most years, but in the future, climate change can strongly impact on crops causing water scarcity due to abnormal weather. Optimizing the distribution of water in the lowlands can profit the whole region. Using less water downstream will reduce water withdrawal from the Cai River, making more water available upstream for irrigation in uplands.

The water productivity results for the Vietnamese farm survey data showed that farmers in Ninh Thuan are generally using their water resources wisely and efficiently in response to crop water requirements. The analysis of various climate change strategies such as changing crop rotations and/or planting dates showed that they have potential to increase water efficiency in the region. One option in the lowland, for example, could be to regularly grow corn instead of rice in the dry winter-spring season. Another option requiring further analysis is the staggering of rice seed dates in various parts of the lowland irrigation system to determine if it would reduce the overall water requirements on certain days or critical periods. The optimization of water requirement to the various sections of the irrigation system for the lowland areas for rice cultivation may improve water availability to other crops in the region.

Further analysis of these options identified as having water saving potential is required through the combination of more farm and field observations with background data on the local water resources, before recommendations can be made for farmers in the region. For example, a next step would be to work with the irrigation district to explore the potential of linking of the farm water model with an irrigation water model to further explore water saving options of staggered rice plantings.

In summary, a farm-scale modeling tool to evaluate the farm and crop water use in current farming methods has been developed that is applicable for many regions of the world. The parallel work on the international level (e.g. farms in Brazil, New Zealand, Vietnam, USA, and Uruguay) and the local project allowed the development of the AgroHyd model to incorporate enough flexibility in input and interfaces to adapt the model to very different plant production systems, climates and locations. For example, the decision to develop a globally compatible

GIS-based farm and field location input system in order to accommodate farms in potentially many locations increased the versatility of the model system. The decision opened up many possibilities of using large open access georeferenced databases for many of the required data inputs. Therefore, a flexible database was developed that allows the import of a wide range of data, which can be expanded as data becomes available and the model develops.

It has been shown that the AgroHyd Farmmodel can be used to explore changes in agronomic practices that are being considered to adapt to changing regional water availability. The strategy for the further development of the tool – e.g. whether for direct use by farmers, or only for experts – is currently under development. The complexity of the topic and the myriad of questions that can be asked with such a model mean that many different "tools" could be developed for end-users, depending on their wishes. For example, the tool could be developed further to allow local irrigation management to calculate effects of changing the crop schedules, and plan staggered crop schedules in various parts of the region. In a parallel development of the web-service, farmers or farm advisors could access data on typical indicator ranges to be found in their region and choose appropriate options to explore on their farms.

Follow-on projects:

- "Water Footprint Assessment of meat and dairy products" funding: National Council for Scientific and Technological Development, Brazil (Volume:275,000.00 US$, Project duration: 01.2014 - 12.2016)
- "Linking increases in water use efficiency for food production at the farm scale to global projections", Funding: Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (BMZ) und der Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Volume: 60,000 Euro, Partner: International Food Policy Research Institute (IFPRI), Southern Institute for Water Resources Planning (SIWRP)
- "Integriertes Wasserressourcenmanagement in Isfahan: Zayandeh Rud Einzugsgebiet" Phase II (Volume: 353.480€, Duration: 1.3.2015 – 28.2.2018, Partner:)
- "Ermittlung pflanzenspezifischer Parameter zur Verbesserung der Modellierung der Wasserproduktivität auf Basis der Thyrower Dauerversuche", Funding: DFG, (in preparation)

Statement, whether scientific findings can be turned into profitable business activities and if such activities has been carried out or if they are expected; Records of granting of patents or industrial corporations

The turning into profitable business activities are expected if farmers and other decision makers use the results of the AgroHyd Farmmodel as a reference to develop strategies to improve local water productivity by the assessment of the effect of agricultural measures on the water demand on farm scale.

Input of the co-operation partners which contributed significantly to the success of this project

The International Food Policy Research Institute (IFPRI) in Washington (DC) hosted one PostDoc-researcher at two research stays at the International Food Policy Research Institute (IFPRI) in Washington (DC). At her first stay she worked on the global water simulation model and a global world food supply model. At her second stay she was trained to work with the agro-economic IMPACT-WATER . Furthermore she participated in the Kick-off of the joint Vietnam project “Linking increases in water use efficiency for food production at the farm scale to global projections“.

The co-operation with the renowned IFPRI led to special qualification of Dr. J. Libra.

Qualification works resulting from the project:

Michael Krauss (in preparation) Water productivity in animal production: The influence of management strategies on water demand of feed, dinking and servicing of dairy cows and broiler chicken, PhD-thesis

Katharina Karbach (2015) Water productivity of poultry production in the region São Carlos, Brazil Humboldt-Universität zu Berlin, Masterthesis

Denise Peth (2015) Bewertung des Wasserbedarfs im deutschen Weinbau, Humboldt-Universität zu Berlin, Masterthesis

Nathalie Froese (2014) Wasserproduktivität von Grünland für die thermische Verwertung und die Biogasproduktion in Deutschland, Brandenburg University of Technology (BTU) Cottbus – Senftenberg, Masterthesis

Ronja Gebel (2013) Entwicklung von Ernährungsszenarien, Universiy of Potsdam, Bachelorthesis

Jens Keßler (2013) Wasserproduktivität in der Hähnchenfleischproduktion, Humboldt-Universität zu Berlin, Masterthesis

Axel Schäfer (2012) Landwirtschaftliche Bewässerung in Brandenburg, Leibniz Universität Hannover, Masterthesis

Anika Krause (2012) Wasserproduktivität in der Biogasproduktion, Humboldt-Universität zu Berlin, Masterthesis

List of publications, which resulted from the project

Peer-Reviewed

Krauß, M.; Keßler, J.; Prochnow, A.; Kraatz, S.; Drastig, K.(2015): Water productivity of poultry production: The influence of different broiler fattening systems. Food and Energy Security. : 1-10 Online: http://https://dx.doi.org/10.1002/fes3.51

Trost, B.; Prochnow, A.; Baumecker, M.; Meyer-Aurich, A.; Drastig, K.; Ellmer, F.(2015): Effects of nitrogen fertilization and irrigation on N2O emissions from a sandy soil in Germany Archives of Agronomy and Soil Science. (61): 569-580

Krauß, M.; Kraatz, S.; Drastig, K.; Prochnow, A. (2014): The influence of dairy management strategies on water productivity of milk production. Agricultural Water Management. Online: http://dx.doi: 10.1016/j.agwat.2014.07.015

Trost, B.; Ellmer, F.; Baumecker, M.; Meyer-Aurich, A.; Prochnow, A.; Drastig, K. (2014): Effects of irrigation and fertilization on soil carbon contents and yields on a sandy soil in Germany. Soil Use and Management. : 1-10 Online: http://dx.doi.org/10.1111/sum.12123

Trost, B.; Klauss, H.; Prochnow, A.; Drastig, K. (2014): Nitrous oxide emissions from potato cropping under drip irrigation in eastern Germany. Archives of Agronomy and Soil Science. 60 (11): 1519-1531 Online: http://dx.doi.org/10.1080/03650340.2014.903561

Döring, K.; Kraatz, S.; Prochnow, A.; Drastig, K. (2013): Indirect water demand of dairy farm buildings. Agricultural Engineering International the CIGR Ejournal. 15 (4): 16-22

Cao, X.; Ro, K.; Libra, J.; Kammann, C.; Lima, I.; Berge, N.; Li, L.; Li, Y.; Chen, N.; Yang, J.; Deng, B.; Mao, J. (2013): Effects of biomass types and carbonization conditions on the chemical characteristics of hydrochars. Journal of Agricultural and Food Chemistry. 61 (39): 9401-9411 Online: http://dx.doi.org/10.1021/jf402345k

Drastig, K.; Kraatz, S.; Libra, J.; Prochnow, A.; Hunstock, U. (2013): Implementation of hydrological processes and agricultural management options into the ATB-Modeling Database to improve the water productivity at farm scale. Agronomy Research. 11 (1): 31-38 Online: http://agronomy.emu.ee/

Kraatz, S.; Sinistore, J.; Reinemann, D. (2013): Energy intensity and global warming potential of corn grain ethanol production in Wisconsin (USA). Food and Energy Security. 2 (3): 207-219 Online: http://dx.doi.org/10.1002/fes3.27

Trost, B.; Prochnow, A.; Drastig, K.; Meyer-Aurich, A.; Ellmer, F.; Baumecker, M. (2013): Irrigation, soil organic carbon and N2O emissions. A review. Agronomy for Sustainable Development. 33 (4): 733-749 Online: http://dx.doi.org/10.1007/s13593-013-0134-0

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Ausstellung "Reflektionen über Wasser". Bernd Krenkel – Fotografien Anlässlich des Projektstarts von AgroHyd; ATB, 18.05. - 30.06.2011

Measures for securing and making available the research data and products generated in the project

Data generated within the project was published in various forms as can be seen in the publication list. The measurements of the technical water use in the dairy cow barn on the Teaching and Research Institute for Welding Technology Ruhlsdorf/Groß Kreutz (Germany) are still running under the supervision of the ATB. In order to actually enable use the data is furthermore quality assured each week.

The AgroHyd Farmmodell is used by the students within the lecture “Agricultural water management” at the Humboldt-Universität zu Berlin held by Dr. Katrin Drastig to calculate farm water use and water related indicators on different scales. Within the follow-on project “Integriertes Wasserressourcenmanagement in Isfahan: Zayandeh Rud Einzugsgebiet” the AgroHyd Farmmodell web service is used to make climate data available to project partners and farmers who are using the irrigation module. It is planned to make the web service of the transpiration calculation based on the extended FAO 56 dual crop coefficient method (Allen et al., 1998).available for the public.

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