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AT THE FARM LEVEL, REDUCING AGRICULTURAL WATER FOOTPRINTS

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ABSTRACT

Beijing is one of the world's most water-stressed cities. Reducing agricultural water consumption has long been the cornerstone of municipal water strategy. The potential to decrease the life cycle (cradle to gate) water footprints of wheat and maize, which account for 94 percent of local grain output, was evaluated in this paper. The wheat-maize rotation system's consumptive and derivative water consumption was modeled using ISO 14046 under various irrigation and nitrogen (N) application choices. Although there was no significant production reduction when irrigation water volume was reduced by 33.3 percent compared to current practice, the water scarcity footprint and the water eutrophication footprint were reduced by 27.5 percent and 23.9 percent, respectively. Similarly, decreasing the nitrogen application rate by 33.3 percent from present practice did not result in a substantial yield decrease, but it did result in a 52.3 percent reduction in water eutrophication while keeping a comparable water scarcity footprint. These findings show that better water and fertilizer management has a lot of promise for lowering crop water footprints at the farm level. This scenario in Beijing is likely to be indicative of the difficulty that many of China's water-stressed areas face in finding a long-term agricultural solution.

KEYWORDS: *Crop Production; Life Cycle Assessment; Water Scarcity Footprint; Water Eutrophication Footprint; Sustainable Water Use.*

1. INTRODUCTION

Excessive water use and pollution are depleting and deteriorating freshwater supplies in many areas of the globe. The strain that mankind puts on freshwater systems must be alleviated quickly. Agriculture accounts for about 92 percent of all water use and pollution in the world, with crop production accounting for approximately 89 percent of this. As a result, from the standpoint of goods and services production, the solution is largely reliant on agricultural production patterns being optimized. The water footprint measure has been used as a key tool in recent years to make the effects of humanity's use and production on global freshwater resources visible. However, it has lately been realized that there isn't just one water footprint technique, but a number of them. A variety of methods have been developed in the context of life cycle assessment [1](LCA), which is the analytical technique used to quantify the various environmental interventions caused by products from cradle to grave .

With the exception of the WFN's proposed water footprint method, which uses the term in the context of water volumes used, a variety of methods have been developed in the context of life cycle assessment (LCA), which is the analytical technique used to quantify the various environmental interventions caused by products from cradle to grave. Several previous studies based on LCA have shown that impact-oriented methods are more relevant than volumetric water footprint indicators in reflecting the environmental effects of water usage. This is due to the fact that various kinds of water usage and local water shortage situations exist. As a result, the International Organization for Standardization (ISO) developed the LCA-based ISO 14046 water foot printing standard to offer a globally uniform approach.

Wheat, tomato, tea, mango, and cotton textile are just a few of the crops and crop-derived products that have been the subject of LCA-based water footprint case studies. However, most prior farm-scale water footprint studies only report on the environmental effects of consumptive and derivative water usage, but seldom on irrigation or fertilization management, have both of which had room for improvement. To accomplish both sustainable water usage and food production objectives, the water footprint indicator should be supported by corresponding mitigation measures. Beijing is one of the world's most water-scarce cities. In the last five years, average water resources per capita have dropped to 138 m3, considerably below the globally accepted minimum of 1000 m3. The amount and quality of accessible water resources in the Beijing area have become a[2] cause of widespread concern as a result of fast population development and urbanization.

Agricultural water usage reduction has long been utilized as a policy tool to conserve water resources. Over the last 20 years, the total cultivated land area has declined as a result of this strategy. Current policies, on the other hand, seek to preserve agricultural land in the interests of food security and to encourage cropping systems that provide more ecological services. In this context, practical solutions should rely on cropping pattern adjustments along with advances in farming techniques to further explore the possibilities of water-saving from agricultural output. Cropping patterns changes in peri-urban areas and rural communities around the Beijing metropolitan area may have a significant effect on water supplies, according to a prior research [3].

Cropping grains in greenhouses instead of intensive vegetables may decrease local blue water use by 7216 m3 ha1 year1 and nitrogen pollution by 45 kg ha1 year. These findings proved that adjusting cropping patterns has the ability to alleviate strain on local water supplies. To relieve local water stress, a wheat-maize main cereal cropping rotation has been proposed. Improvements in conventional agricultural methods are also required to minimize the effect of grain production on water resources in the Beijing area. Current farm management of irrigation and fertilization for the wheat-maize rotation system, on the other hand, usually entails excessive application of these inputs, resulting in not only water waste but also chemical contamination of nearby water bodies. Improving agricultural water and fertilizer management may significantly decrease irrigation water use and pollution.

Beijing could use such steps to boost grain output while also looking at the possibilities for agriculture to alleviate water stress. The goal of this research was to see whether there was any way to reduce the water footprint of the wheat-maize rotation system by improving irrigation and fertilization management. Field tests were performed to evaluate crop yields under various water and nitrogen management scenarios[4]. The effect of crop output on water availability and water degradation was then assessed using a water footprint method based on the ISO 14046 water foot printing standard, which was represented as the water scarcity footprint and the water eutrophication footprint, respectively.

The findings will be disseminated widely in order to improve knowledge of how to alleviate water stress from agricultural cultivation in other parts of China where a sustainable food supply is needed. The Beijing region's typical cereal farming pattern is a rotation of wheat and maize. Currently, the combined area of these two crops is about 1.5 105 hectares, accounting for 94% of total cereal growing area. Field experiments were performed in[5] Changzhou district (39 571 N, 116 401 E; 18.8 m above sea level), one of Beijing's major crop producing regions, from 2006 to 2009 to evaluate the water and fertilizer usage efficiency of the wheat-maize cropping system. Tongzhou has a continental monsoon climate. The average total rainfall is 593 mm, with the most of it falling between April and September. Sandy loamy topsoil lying on loamy subsurface has been described as the soil texture. In 2006–2008, irrigation experiments were performed, and fertilization studies were added in 2008–2009. [6]Reduced irrigation water usage levels were compared to the irrigation volume (FI) of local farmers as a baseline.

The farmers' current irrigation technique is to provide 50 mm of water to each crop growth stage of overwintering, seedling establishment, jointing, and grain filing for wheat, and jointing and booting for maize. I-1 was an irrigation reduction option for wheat during the filling stage and maize at the jointing stage. I-2 was the option of decreasing irrigation during seedling establishment and the filling stage in wheat, as well as the jointing stage in maize. For wheat, I-3 was an option for decreasing irrigation during overwintering, seedling establishment, and the filling stage, while for maize; it was an option for reducing irrigation during the jointing stage. There was no irrigation on I-4.

In fertilization studies, the local farmers' nitrogen application practice (FN) was used as a baseline against which decreased fertilizer application levels (N-1, N-2, and N-3) were evaluated. Farmers are now administering 112.5 kg ha1 of nitrogen to wheat before sowing and at the jointing stage, and to maize before seeding and at the booting stage. When compared to farmers' practices, N-1 and N-2 were the choices for lowering N application by 33.3 percent and 66.7 percent for each fertilization stage. N-3 was a zero-number-of-nothing application. Other local customary agronomic techniques were used for sowing date and depth, planting density, pest and weed management, and irrigation and fertilizer trials. Crop production and the physical amount of agricultural inputs (fertilizer, fuel, power, and pesticides) were gathered and characterized for each crop growing season[7].

2. DISCUSSION:

The framework for product water foot printing established by ISO was used in this research. A water footprint evaluation may be presented as a single value or as a profile of impact category indicator findings, according to ISO 14046. This research presented water scarcity and water eutrophication footprints separately to make interpretation easier and eliminate possible ambiguity in normalization and aggregation procedures. As a result, there were no weighting techniques that included consumptive and derivative water consumption into a single measure. The derivative water footprint has previously been evaluated using a critical dilution volume indicator, referred to as the "grey water footprint". The grey water footprint findings, on the other hand, are highly dependent on the water quality criteria used.

Furthermore, the grey water footprint has been shown to be misleading, since the word grey water is already used in the water sector to refer to nutrient-rich sewage from homes that is not contaminated by feces or urine. A number of additional flaws connected with grey water have already been addressed. As a result, the derivative water footprint was calculated using the aquatic eutrophication potential technique in this research. This research was restricted to modeling the derivative water footprint associated with nitrogen released to water due to a lack of accurate data on phosphorus and pesticide losses. Because of its importance in GHG emissions reporting and reduction, the N cycle in agricultural soils has been intensively researched in China, and credible models to estimate fluxes exist.

The DNDC model, which has been calibrated and verified and proven to provide accurate [5]findings, was used to simulate N leaching from the wheat-maize rotation system in this research. For wheat-maize planting, the predicted quantity of N leaching varied from 0.6 to 2.1 g kg1 (i.e., 10.9–20 kg ha1) under the farmers' present practice of 450 kg N application per hectare. Other field investigations in the adjacent North China Plain have estimated the quantity of N leaching in the range of 1.5 to 81.8 kg ha1 for wheat and maize under local N treatment ranging from 400 to 600 kg N per hectar. Because of variations in climate, soils, and management methods, N leaching differs across research. However, the findings of this research revealed that lowering farmers' irrigation and N application rates may reduce N leaching, which is consistent. Future modeling must incorporate phosphorus and pesticides released to water from agricultural systems in order to provide a complete evaluation of possible water degradation effects. Implications of the Water Footprint

Most prior research, on the other hand, concentrated only on reporting water footprint values rather than providing realistic management solutions. According to one estimate, humanity's water footprint must be decreased by 50% in order to achieve the sustainable use of world freshwater. In areas with high WSI, it is more is critical to reduce water use and pollution. With a WSI of 1.00, the Beijing area suffers significant water stress because to its location in China's water-scarce northern region. Several studies have evaluated Beijing's agricultural water usage and recommended political and technical solutions. These studies, on the other hand, were based on conventional water usage assessments, disregarding the environmental effects of water use and pollution from the viewpoint of a life cycle assessment.

Using the LCA-based water foot printing technique, this research demonstrated the wheat-maize rotation system's significant potential for decreasing water usage and N leaching in the Beijing area. Farmers that use a lot of water and N fertilizer don't get a greater yield, according to the findings. Poor irrigation and fertilization methods therefore come at a financial cost to farmers, as well as contributing to the aggravation of local water shortages and pollution issues. Maintaining current wheat and maize yields, irrigation water for wheat-maize farming may be decreased by 100 mm, resulting in a 27.5 percent reduction in water scarcity and a 23.9 percent reduction in water eutrophication footprint. Based on the area of wheat, total irrigation water usage and N leaching may be decreased by 2.4 107 m3 and 1.4 105 kg, respectively, for a total area of 2.3 104 ha of wheat-maize cultivation.

The irrigation trials in this research, on the other hand, took place during seasons with typical rainfall patterns. The optimal irrigation scheme found in this research may not be feasible in seasons when rainfall patterns deviated significantly from the average. To solve such circumstances, ongoing testing in different locations is required. The one-year research for the N management trials revealed that local farmers' N application rate was high, which is consistent with previous data. According to the research, lowering current N treatment rates by 150 kg ha1 may sustain agricultural yields while significantly reducing N loss to the environment. However, it is debatable if this N management optimization is long-term sustainable in terms of agricultural production.

The crop yields in this experiment may have been aided by leftover nitrogen from earlier rotations. However, it seems that N application rates may be safely decreased in the near term while farmers work to better match N treatments to long-term crop needs[8].

It's worth noting that the water and nitrogen management trials in this research were done separately. As a result, the best water and nitrogen delivery strategies described here cannot be used simultaneously. Numerous studies have shown that water-fertilizer management has a coupling impact on crop production as well as water and fertilizer usage efficiency.

In the wheat-maize rotation system, further study is required to determine a suitable co-allocation of water and fertilizer application that may decrease crop water footprint while preserving crop yields. Actually, decreasing the amount of water and fertilizer used to crops not only reduces the crop's water footprint, but also saves money and mitigates other environmental effects including greenhouse gas emissions. Furthermore, methods such as installing water-saving irrigation equipment (e.g., drip and sprinkler irrigation equipment), rainwater collecting, irrigation with recycled water, and fertilizing by soil testing may all be used to enhance water and fertilizer management. Aside from technology, improved agricultural water management may be achieved via changes in the legislative and regulatory environment, as well as more agricultural and environmental education for farmers and consumers[9].

3. CONCLUSION

Because agriculture accounts for a large portion of humanity's water use and pollution, changing agricultural production patterns is critical to reducing water footprints. 7074 Water 2015, 7, 7066–7077 Beijing is one of the world's most water-stressed cities. The area of conventional wheat-maize planting is expected to be expanded in the interests of agricultural land conservation and water stress relief. However, in the case of wheat and maize production, present agricultural practices include extensive irrigation and fertilization, resulting in significant water waste and contamination. Our research, which is based on field trials, shows that improving cereal cropping agricultural methods in water-stressed Beijing has a huge potential for lowering water footprints.

Water and nitrogen application optimization may significantly decrease both the water shortage and water eutrophication footprints while preserving wheat and maize yields. Total water scarcity and water eutrophication footprints may be reduced by 27.5 percent and 23.9 percent, respectively, by reducing irrigation water volume by 100 mm (33.3 percent) for wheat-maize farming. Similarly, by decreasing N application by 150 kg ha1 (33.3%), the overall water eutrophication footprint could be reduced by 52.3 percent, but the water shortage footprint remained the same.

However, because the irrigation and N application experiments were carried out separately during seasons with typical rainfall, more research is needed to quantify the combined effects of water-fertilizer options on crop yield, water consumption, and pollution emissions under different rainfall conditions. To accomplish sustainable agricultural water management in the Beijing area, future policy directives and farming system design should pay greater attention to improving crop management regimes, as well as updating irrigation and fertilization systems. This scenario in Beijing is likely to be indicative of the problem confronting many of China's agricultural areas, where excessive irrigation and fertilization inputs are presently in use, and a sustainable food production method must be developed[10].

REFERENCE:

1. J. Huang, C. Xu, B. G. Ridoutt, and F. Chen, “Reducing agricultural water footprints at the farm scale: A case study in the Beijing region,” Water (Switzerland), 2015.

2. A. Galan-Martin, P. Vaskan, A. Antón, L. J. Esteller, and G. Guillén-Gosálbez, “Multi-objective optimization of rainfed and irrigated agricultural areas considering production and environmental criteria: a case study of wheat production in Spain,” J. Clean. Prod., 2017.

3. A. E. Ercin, M. M. Aldaya, and A. Y. Hoekstra, “The water footprint of soy milk and soy burger and equivalent animal products,” Ecol. Indic., 2012.

4. J. A. Foley et al., “Solutions for a cultivated planet,” Nature, 2011.

5. D. Zhao, Y. Tang, J. Liu, and M. R. Tillotson, “Water footprint of Jing-Jin-Ji urban agglomeration in China,” J. Clean. Prod., 2017.

6. A. M. Hennecke, M. Mueller-Lindenlauf, C. A. Garcia, A. Fuentes, E. Riegelhaupt, and S. Hellweg, “Optimizing the water, carbon, and land-use footprint of bioenergy production in Mexico - Six case studies and the nationwide implications,” Biofuels, Bioprod. Biorefining, 2016.

7. D. Chico, M. M. Aldaya, and A. Garrido, "A water footprint assessment of a pair of jeans: The influence of agricultural policies on the sustainability of consumer products," J. Clean. Prod., 2013.

8. J. Wang, L. Li, F. Li, A. Kharrazi, and Y. Bai, "Regional footprints and interregional interactions of chemical oxygen demand discharges in China," Resour. Conserv. Recycl., 2018.

9. M. M. Mekonnen and A. Y. Hoekstra, "Water footprint benchmarks for crop production: A first global assessment," Ecol. Indic., 2014.

10. Y. Ono, Y. D. Kim, and N. Itsubo, "A Country-Specific Water consumption inventory considering International Trade in Asian countries using a Multi-Regional input-output table," Sustain., 2017.