Water Footprint of Transplanted and Direct Seeded Rice

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ABSTRACT

Water is an important natural resource required for crop production; hence agricultural practices have a major impact on global water cycle. Sustainability of agricultural system depends on its water footprint. Water footprint is a useful indicator of consumption and pollution of water. Water footprint is the total volume of direct and indirect freshwater used, consumed and polluted during all processes involved in formation of a product. The blue water footprint refers to consumption of blue water resources i.e. surface and ground water, while the green water footprint refers to consumption of green water resources i.e. rainwater which may be stored in the soil as soil moisture. The amount of water polluted due to a process is quantified by the grey water footprint. Quantification of water footprint is very much needed to obtain sustainable agricultural production. Rice crop grown in Tarawri, village Karnal, Haryana was selected for the current study. Rice is grown in the village as both transplanted rice (TSR) and direct seeded rice (DSR). Data related to weather, crop yield and crop management practices were collected from farmers' field growing both TSR and DSR. CROPWAT model was used to calculate evapotranspiration (ET) of rice crop. Water footprint of both TSR and DSR were calculated following methodology given by Hoekstra et. al., 2009. Total water footprint of rice production was found to be 1071.1 m^3 ton^{-1} in case of transplanted rice, while it was 953.8 m^3 ton^{-1} in case of direct seeded rice. Results showed that in case of transplanted rice blue water footprint was 41%, while green water footprint was 34%. But growing direct seeded rice increased the green water footprint to 53% and reduced blue water footprint to 27%. Blue water footprint is an indicator of fresh and ground water consumed during a process, while green water footprint is an indicator of rain water consumed for a process. So the results imply that growing DSR would reduce the use of fresh and groundwater and help in better utilization of rainwater.

1. INTRODUCTION

As human populations grow, it imposes more and more demand for natural resources and the impacts are our ecological footprint. Footprints of crop production are key indicators in determining sustainability of agricultural system. Water is an important natural resource required for crop production; hence agricultural practices have a major impact on global water cycle. Water footprint is a determinant of agricultural sustainability. The concept of water footprint was first introduced by Hoekstra (2003) and subsequently elaborated by Hoekstra and Chapagain (2008). Water footprint refers to the total volume of direct and indirect freshwater used, consumed and polluted during all processes involved in formation of a product. The water footprint of a product is expressed in volume of water per unit of product (m^3 ton^{-1}). It has three components i.e. Blue Water Footprint, Green Water Footprint and Grey Water Footprint (Fig. 1). The blue water footprint refers to consumption of blue water resources i.e. surface and ground water while the green water footprint refers to consumption of green water resources i.e. rainwater stored in the soil as soil moisture. Grey water footprint is the indicator of water polluted due to a process and is defined as the volume of freshwater that is required to assimilate the pollutant load based on existing ambient water quality standards.

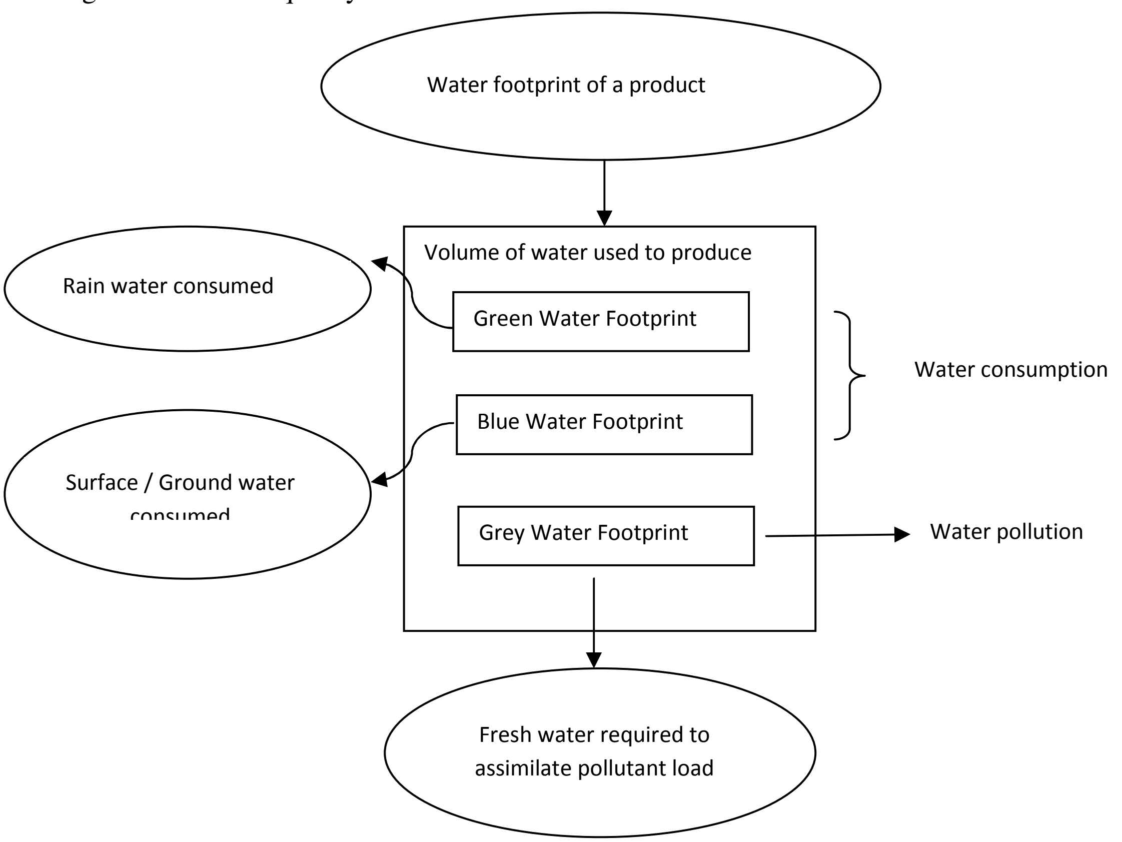

Fig 1. Schematic diagramme showing the different components of Water footprint of a product

The water footprint of rice production and consumption is quite significant in south Asian countries. A relatively large total blue water footprint as a result of wheat production is observed

in the Ganges and Indus river basins, which are known for their water stress problems (Mekonnen and Hoekstra, 2010). The two basins alone account for about 47% of the blue water footprint related to global wheat production. In the period 2000-04, the global average water footprint of paddy rice was 1325 m3 ton^{-1} (48% green, 44% blue, and 8% grey) (Chapagain and Hoekstra, 2010). According to Holcomb, (2010), the estimated total water footprint of growing rice in Punjab is 1606 m3 ton^{-1}. For the largest number of people living on the planet rice is staple food (Mom, 2007). The increasing demand for rice in combination with increasing water scarcity is a threat for food security and the sustainability of rice cultivation

2. METHODOLOGY

The following study takes into account the production of a product i.e. the cultivation of rice crop under different water management practices. Rice crop grown in Tarawri, village Karnal, Haryana was selected for the current study. Rice is grown in the village as both transplanted rice (TSR) and direct seeded rice (DSR). Visit was conducted to farmers' field growing both TSR and DSR. Data on crop management practices like application of irrigation water, fertilizers, pesticides and output data like economic yield of rice crop was collected. Water footprint of both TSR and DSR were calculated following methodology given by Hoekstra et. al., (2009).

Using weather data of the location and crop management data collected from field blue and green crop water use was quantified using the CROPWAT 8.0 model of Food and Agriculture Organization (FAO). Blue and green water footprint is obtained by dividing blue and green crop water use by yield of rice crop. The grey water footprint was calculated based on the application of nitrogen (N) fertilizer to rice crop, leaching fraction of N from rice field, actual and maximum permissible N concentration in water bodies. In this study data on nitrogen fertilizer application was only used to quantify the grey water footprint. According to Hoekstra et. al., (2009), grey water footprint is expressed as a dilution water requirement which means the most critical pollutant with the greatest application rate need to be considered.

3. RESULTS

Total water footprint (TWFP) of rice production was found to be 1071.1 m^3 ton^{-1} in case of transplanted rice; while it was 953.8 m^3 ton^{-1} in case of direct seeded rice (Fig 2). Application of irrigation water is less in DSR by around 25%. This has resulted in less total water footprint in DSR.

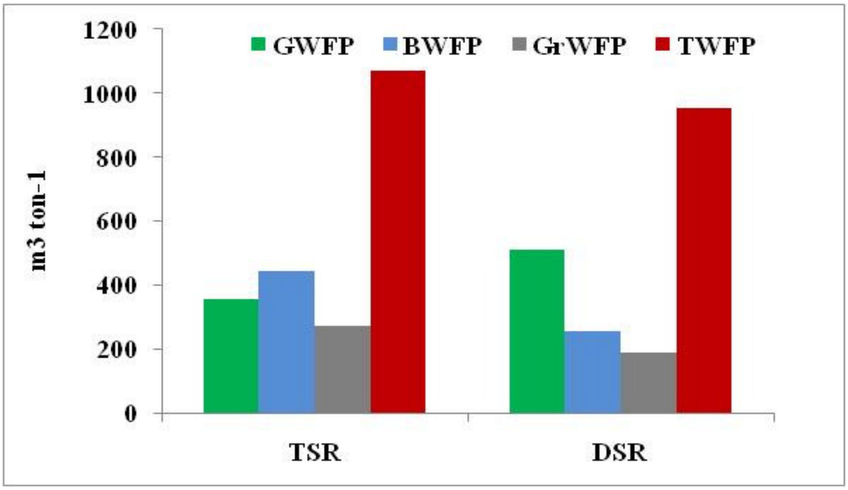

Fig 2. Water footprint of growing transplanted (TSR) and direct seeded rice (DSR).

Results also showed that in case of transplanted rice blue water footprint was 41%, while green water footprint was 34%. But growing direct seeded rice increased the green water footprint to 53% and reduced blue water footprint to 27% (Fig 3).

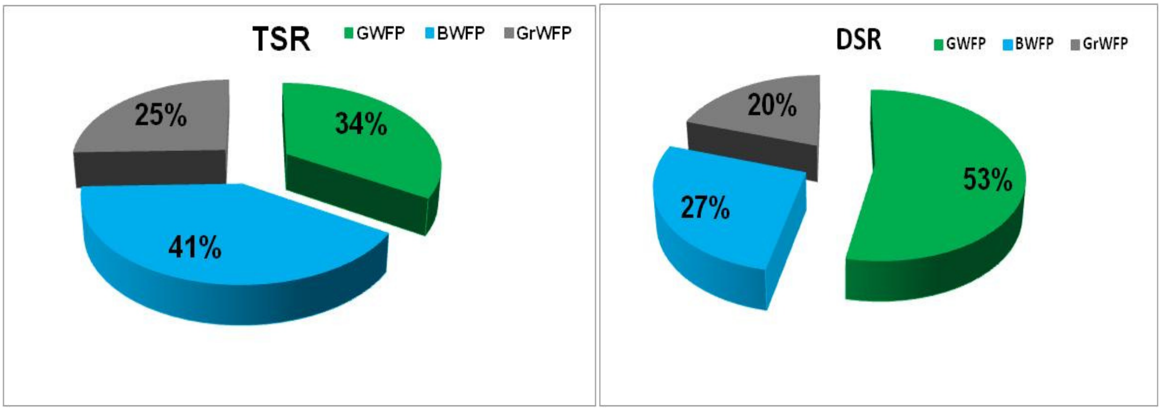

Fig 3. Percent share of blue, green and grey water footprint in transplanted and direct seeded rice

In case of direct seeded rice increase in green water footprint is an indicator that the crop has utilized more amount of rain water present in soil as soil moisture. So the share of irrigation water in the total water footprint got reduced to 27%. Grey water footprint of DSR was less (20%) than that of transplanted rice (25%). This was attributed to the fact that in case of direct seeded rice application of less irrigation water resulted in lower leaching rate of nitrogen which reduced the grey water footprint.

4. CONCLUSION

Blue water footprint is an indicator of fresh and ground water consumed during a process, while green water footprint is an indicator of rain water consumed for a process. So the results imply that growing DSR would reduce the use of fresh and groundwater and help in better utilization of rainwater.

REFERENCES

[1] Chapagain, A.K. and Hoekstra, A.Y. (2010) The green, blue and grey water footprint of rice from both a production and consumption perspective. Value of Water, Research Report Series No. 40 UNESCO-IHE Institute for Water Education, Delft, the Netherlands, pp. 1-48.

[2] Hoekstra, A. Y. (2003) Virtual water trade: Proceedings of the International Expert Meeting on Virtual Water Trade, Value of Water Research Report Series No. 12, UNESCO-IHE, Delft, The Netherlands.

[3] Hoekstra, A. Y. and Chapagain, A. K. (2008) Globalization of water: Sharing the planet's freshwater resources, Blackwell Publishing, Oxford, UK, 232 pp.

[4] Hoekstra, A. Y., A. K. Chapagain, M. M. Aldayal, and M. M. Mekonnen (2009). Water Footprint Manual - State of the Art 2009. <http://www.waterfootprint.org/downloads/ WaterFootprint Manual2009.pdf>.

[5] Holcomb, M.K. (2010) Quantifying the Water Footprint: Growing Crops Sustainably in Northwest India. Paper submitted in partial requirements of the Undergraduate Honors Program. School of Environment and Natural Resources The Ohio State University

[6] Mekonnen, M.M. and Hoekstra, A.Y. (2010) A global and high resolution assessment of the green, blue and grey water footprint of wheat Hydrol. Earth Syst. Sci. Discuss 7: 2499-2542.

[7] Mom R. (2007) A high spatial resolution analysis of the water footprint of global rice consumption. Master Thesis, University of Twente, Enschede, The Netherlands