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THE WATER FOOTPRINT OF GLOBAL CROP PRODUCTION AND FOOD PROCESSING

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Abstract :The concept of water consumption for growth and development of human race over the world, is a age-old problem. Further, population growth, economic growth, dietary-shift, industrial setup etc. demand more water. Among the above facts, agricultural production and food processings are the major consumer of water. To visualize the present setup of water requirement and demand for future, this present piece of work has been undertaken. This review work presents a brief review of the water footprint of crop production and food processing and the sustainability of the blue water footprint. The estimated global consumptive (green+blue) water footprint ranges from 5938 to 8508 km^3/year. The water footprint is projected to increase by as much as 22% due to climate change and land use change by 2090.Approximately 57% of the global blue water footprint is shown to violate the environmental flow requirements. At present it is highly essential to improve the sustainability of water and project ecosystems that depend on it. Awareness should be created among the people for increasing the water productivity, setting benchmarks, setting caps on the water footprint river basins, shifting the diets to food items in the lower water requirement and checking the food waste, through government organization, NGOs, public sectors and road- shows

Keywords: Agricultural production, food and diet processing, water footprint, food waste

INTRODUCTION

It is the universal truth that the environment of the globe is composed with mainly two factors i.e. abiotic or non living(climatic, adaphic, light, various types of energy, water etc.) and biotic or living (probiotics including bacteria, viruses, microbes, plants, animals etc.). Both the factors are dependent on each other, Water is an essential requirement for sustaining all form of cellular structure , functions , metabolic activities that lead to growth, development, reproduction/yield of all plants and animals in addition to socio-economic developmental condition of the concerned Nations.
Further, the most critical resources of water for agriculture, aquaculture, animal husbandry, crop production, food processing, economic development of the globe cannot be ruled out.

Due to rainfall, ground water reserves, and proximity to river basins, the country's water availability varies greatly from region to region. This has an impact on both water allocation and water use efficiency. Water scarcity, a global phenomenon, is becoming increasingly widely recognised globally as a result of environmental changes. The UN Environment Programme (UNEP), the World

Commission on Environment and Development (WCED), and the UN Conference on Environment and Development convened in RIO DE JANEIRO were all established as part of the Global Environmental Governance framework to address the water shortage Rio Summit(1992)suggested for various water harvesting devices to combat the regular occurrence of floods and droughts around the world as a result of global warming. Since then, numerous water shed systems have been implemented in India and other countries. The balance of regenerated and consumable resources becomes out of balance over time as a result of changes in the larger system of people and environment.

The Flow diagram given below indicates a problem chain, which is rather easy to comprehence. In actual situations, the problems chains are normally complex requiring in-depth investigation to reveal picture .

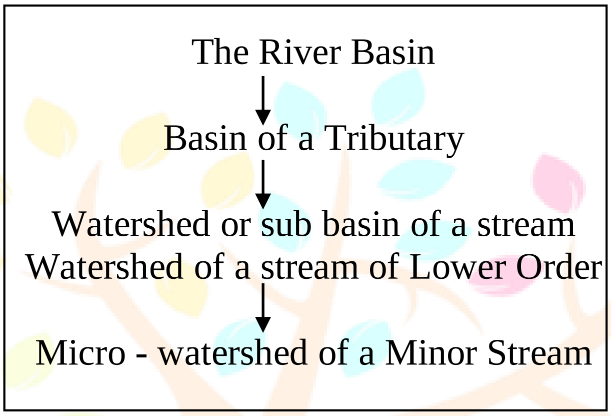

Fig.1 flow diagram of watershed system

As water plays an important role in all vital functions of all living organisms, different industries, socio-economic activities and growth and development of nation. It is worthy to understand the water footprint of above activities in general and further crop production and food processing in particular.

Hence, the present piece of investigation is aimed to review the available literature/data o above stated topics for further work to understand the concept of water footprint(WF), different types of water footprint and their role in sustainability of environment.

REVIEW OF LITERATURE

1.Crop water relationship and requirement

The most important resource for agriculture is water, which now takes precedence even above soil. It is necessary for the continuation of all living forms, the production of food, the growth of the economy, and overall health. The average annual rainfall in the nation is approximately 1170 mm, but it varies greatly in both time and place.

Agriculture is largest user of water resources accounting for about 80% of the total water withdrawal. Among the different sources of irrigation water, ground water play an important role in the India's irrigated farming which contributes about 60% of the net cultivated area irrigated by ground water (Shah et al. 2006). Water is finite resource the availability of water is declining with each passing day. The per capita water availability in 2001 was 1820 m^3 per year and it is projected that by 2025, the per capita water availability will further reduce significantly to 1341 m^3 and 1140 m^3 in 2050.Going by Falkenmark criteria, most of the Indian states will have reached the water stress condition by 2025 and almost water scarcity condition by 2050.A total renewable water resource of Uttar Pradesh was

77.19 BCM in 2011 and it is varying from region to region. The highest total renewable water resource was found in western region (28.93 BCM) followed by eastern region (27.60 BCM), central region (15.86 BCM) and lowest in Bundelkhand region (4.80 BCM). The scarcity of water would further hamper the food security, as the scarcity of water will directly suppress the agricultural production. Growing physical shortage of water on the one hand, and scarcity of economically accessible water owing to increasing cost of production and supply of the resource on the other, had preoccupied researchers with increasing productivity of water use in agriculture in order to get maximum production or value from every unit of water used.

The term "produced yields per unit of water utilised," sometimes known as "crop per drop," is relevant to economists and engineers who are interested in evaluating the viability and effectiveness of agricultural water management. It assists in locating areas of excessive water use or water-restricted production gaps, which supports advancements in agricultural water management. Crop water productivity is a term used in the literature to describe physical and combined physical and economic water productivity of water expressed as net or gross present value of crop produced prior to cubic meter of water (Rs/m) and kilograms of crop produced from one cubic meter of water used or diverted (kg/m3). (Krishna et al. 2008)

To meet the growing demand for food, fiber, and biofuels, agricultural production must almost double by 2050 compared to 2012. More water will undoubtedly be needed because of this. In Sub-Saharan Africa and South Asia, where output must more than double by 2050, the majority of the growth in agricultural production is anticipated to take place [FAO; Food and Agricultural Organization: Rome, Italy, 2017]. Almost 30% of an increase is anticipated for the remainder of the world. Between 1961 and 2018, agricultural production increased by 260% [FAO, FAOSTAT Online Database; FAO: Rome, Italy]. The harvested crop area increased by 47% over the same time period, indicating that an increase in crop yields is responsible for 113% of the rise in production.Crop yield rose by 72% between 1961 and 1990, but by just 43% between 1991 and 2018, indicating that yields are currently rising more slowly than in earlier decades FAO(2020). More irrigation, better crop varieties, pesticide inputs, and improved soil and water management were all major contributors to the higher crop yield. It is not anticipated that the rise in crop productivity would last forever. Most of the world's major crop harvests have started to stagnate (Grassini et.al. 2013; Ray et.al., 2012).Future output increase may be constrained by soil salinization, climate change, and soil deterioration. (Rey et al. 2013) have demonstrated that it is impossible to meet the expected food demand by 2050 at the current rate of yield increase. They suggested that in order to close the gap in food production, crop area expansions must occur, but doing so will have a greater negative impact on biodiversity.

The number of crops used for non-food purposes like animal feed, bioenergy, and industrial uses has an impact on the amount of food that is available for human consumption. Just 67% of the crop produced globally, or 55% of the calories produced, may be directly consumed by people (Cassidy et.al., 2013). The remaining crop was used for bio-energy (9% by weight), other industrial uses, and animal feed (24% by mass). When it comes to transforming feed into human-edible food, animal production is less effective than crop production (Mekonen et.al., 2016; Wirenius et.al., 2003; Bouwman et.al., 2005; Tilman et.al., 2011) Hence, just 12% of the 36% of global calories needed for animal feed will eventually be incorporated into the human diet [Cassidy et al., 2013].

According to Hoekstra et al. (2011)2, the global water footprint (WF) of agricultural output in 2011 was 8362 km3 per year (80% green, 11% blue, and 9% grey). Between 2010 and 2050, it is anticipated that the global water consumption would increase by 20% to 30% [Burek et al., 2016]. Resources such as land and water are expected to become more scarce in the future due to the considerable growth in demand for these resources. To fulfil the rising demand for food and end poverty and hunger permanently, agriculture must use water efficientlyThe issue is how to feed the world's population without further harming fresh water supplies and ecosystems. For the purpose of feeding the world, a number of researchers have called for sustainable intensification [Tilman et. al., 2011; Cassman et. al., 2020; Drechsel et. al., 2015; Garnett et. al., 2013 Godfray et. al., 2010], dietary changes, and a decrease in food waste [Folet et. al., 2011; Jalava et. al. A lot of research [Kummu et. al., 2012; Liu et. al., 2019; Liu et. al., 2018; Mekonnen et. al., 2012] have demonstrated the benefit of virtual water trade in global water conservation lowering water shortage and it will help to minimise the risk of water scarcity.The WF of food production, the water requirements for various food products and diets, and the WF of food loss and waste are briefly reviewed in this study. The report concludes by highlighting the unsustainable nature of the current agricultural output and the countries' and primary crops' contributions to the blue WF.

2 WATER FOOTPRINT

Freshwater is a scarce and delicate resource that is necessary for sustaining life, economic growth, and the environment. The way society has managed—and continues to manage—our precious water resources, despite its widely accepted importance, has given rise to a number of significant environmental concerns that are related to water. Water scarcity is a problem in many river basins around the world. Surface and groundwater reserves are being depleted all over the world, and many water bodies are being polluted with various pollutants. Ecosystems and soils have therefore deteriorated, sometimes irreparably. The habitats of the species that rely on these water sources are being destroyed at frighteningly rapid rates. Finally, there has been a significant rise in the vulnerability of water systems to (climate) shocks.

A multidimensional indication of volumetric water use and contamination is the water footprint (WF). The WF indicates (net) water consumption, which it directly relates to a beneficial human activity, in contrast to standard water use indicators like abstraction or withdrawals, which often represent (gross) volumes taken from a water body (e.g., growing a potato or washing a car). Water that is "lost" from the system and cannot be used for other purposes at that specific time or location is referred to as consumption in WF terminology. In other words, a WF designates water appropriation in a manner that is both time- and place-specific.(Rick et.al., 2020)

Information on water flows, vegetation dynamics, and human demands are necessary for the water footprint (WF). The term "blue water flow" refers to both groundwater infiltration and river discharge. Rainfall that has been temporarily stored in the soil and on top of vegetation is what creates the green water flow. The water required to restore the environment's carrying capacity following human intervention is known as the grey water flow (Hoekstra, 2014; Liu et al., 2017) Over three fifths of precipitation is thought to follow the green pattern globally, and two fifths the blue (Lovarelli et al., 2016). Therefore, the three elements of the WF are: 1) WFblue, which is the amount of blue flow water consumed for industrial, domestic, and crop irrigation purposes; 2) WFgreen, which is the amount of green flow water consumed to sustain the growth of crops, pasture land, forestry plantations, and ecosystems; and 3) WFgray, which is the amount of water needed to assimilate or dilute pollutant or fertiliser inputs (Cazcarro et al., 2015; Hoekstra et al., 2016; Hoekstra, 2017).

The WFcrop is defined as the water used as a result of evapotranspiration, irrigation needs, and fertiliser applications during the growing season, according to climate and soil conditions and crop parameters. The total water used by all crops eventually determines the basin's WFagricultural (Salmoral et al., 2011; Schyns et al., 2015; Chukalla et al., 2018).

The management of water resources is made more effective and sustainable by establishing water consumption in a river basin. Water quality and the final destination of the returned water are crucial since the remaining fraction of the extracted water, which was not used, returns to the system and is still usable downstream (Hoekstra et al., 2012). However, there aren't many studies that focus on evaluating the WFagricultural in river basins, especially in the case of the Mediterranean, where agriculture depends on irrigation to make up for dry spells (Billib et al., 2009; Cortés et al., 2012; Pellicer-Martínez and MartínezPaz, 2018). Due to the unpredictable availability of blue and green water in these locations brought on by irregular rainfall, agriculture represents the largest water user in these areas.

2.1Water footprint of crop production

According to Naresh et al. (2017), the water footprint of rice consumption in a country is computed by combining the water footprints in the locations where the rice consumed in a country is cultivated at a higher spatial resolution. In India, the water footprint per unit, total rice production, and percolation calculated was 403 (m3 ton-1) and 432.9 (billion m3 yr -1). The percapita water footprint of rice consumption is quite high in Thailand (547 m3 cap -1 yr -1) compared to India (239 m3 cap -1 yr -1), with their water footprints related to rice consumption 63,364 and 250,305 (Mm3 yr -1), respectively. One cup of coffee needs 140 liters of water; 1 liter of milk needs 1000 liters of water; 1 kg of wheat needs 1350 liters of water; 1 kg of rice needs 3000 liters of water and1 kg maize needs 900 liters of water.

According to Ding et al. (2018), the grain yield-based WF for spring wheat, barley, canola, sunflower, lentils, and chickpea ranged between 1.08 and 1.80, 0.90 and 1.38, 1.71 and 2.58, 1.94 and 4.28, 1.47 and 2.37, and 1.39 and 1.79 m3 kg-1, whereas the protein yield-based WF ranged between 7.69 and 10.44, 8.27 and 16.47, 3.79 and 7.75, All crop WFs dropped with time, which might be ascribed to precipitation effects.

According to Mekonnen and Hoekstra (2011), the average water footprint for cereal crops is 1644 m3 ton1, however the footprint for wheat is rather substantial (1827 m3 ton1), while the footprint for maize is relatively little (1222 m3 ton1). Rice has a water footprint that is similar to that of all cereals combined. Sugar derived from sugar beets 10 has a lower water footprint than sugar derived from sugar cane. Furthermore, the blue component of beet sugar's total water footprint (20%) is lower than that of cane sugar (27%), while water footprints for vegetable oils vary greatly: maize oil 2600 m3 ton−1; cotton-seed oil 3800 m 3 ton−1; soybean oil 4200 m3 ton−1; rapeseed oil 4300 m3 ton−1; palm oil 5000 m3 ton−1; sunflower oil 6800 m3 ton−1; groundnut oil 7500 m3 ton−1; linseed oil 9400 m3 ton−1; olive oil 14500 m3 ton−1; castor oil 24700 m3 ton−1

2.2.1. The Water Footprint of crop production(Global scenario)

High spatial resolution assessments of the water required to grow crops have been made in numerous international studies [Hanasaki et.al., 2010]. Global agricultural production estimates for the consumptive (green plus blue) WF range from 5938 to 8508 km3/year (Table 1). The different WF estimates result from variations in the modelling strategy, input data, including climate and cultivated area, the number of crops and their specifications, and the models employed. Unlike to previous writers that selected 20 or fewer individual crops and grouped the other crops into two or four significant groupings, Mekonnen and Hoekstra [Mekonnen et.al., 2011] clearly evaluated the WF of 146 individual crops in terms of product coverage. Huang, Hejazi, Tang, Vernon, Liu, Chen, and Calvin [31] predicted that the WF under climate and land use change will decrease by as much as 22%

even though the estimated future global WF related to crop production under climate and land use change [Huang et.al., 2019] was within the range of estimates for the current period. Due to the growth in the world's irrigated area, the blue WF's increase in the WF is particularly significant, rising by 70% by 2090..

table 1. estimates of the consumptive water footprint (wf) of global crop production.

Study	Period	Products Coverage	Global Water Footprint Related to Crop Production (km^3/year)		
			Green	Blue	Total
Hoekstra and Chapagain [2008]	1997–2001	164 individual crops	5330	1060	6390
Siebert and Döll [2010]	1998–2002	20 individual crops and 6 major groups	5505	1180	6685
Liu and Yang [2010]	1998–2002	17 individual crops and 5 major groups	4987	951	5938
Hanasaki, Inuzuka, Kanae and Oki [2010]	1985–1999	Assumed 1 major crop per grid	5550	1530	7080
Fader, Gerten, Thammer, Heinke, Lotze-Campen, Lucht and Cramer [2011]	1998–2002	12 crop functional types	6000	923	6923
Mekonnen and Hoekstra [2011]	1996–2005	146 individual crops	5771	899	6670
Rost, Gerten, Bondeau, Lucht, Rohwer and Schaphoff [2008]	1971–2000	12 crop functional types	7250 1	600–1258	7850–8508 1
Huang, Hejazi, Tang, Vernon, Liu, Chen and Calvin [2019]	1971–2000		4887	1121	6008
	2071–2099	12 crop categories	5440	1909	7349

Source: (Mesfin et.al., 2020)

About 86% of the consumptive WF of crop production was related to the production of crops that can be used directly for human food consumption. The other 14% was for fodder crops, fiber, rubber, and tobacco. Some of the food crops, such as maize, rapeseed, palm oil fruit, soybeans, and sunflower, are also used for biofuel production. This will lower the total WF that is used for human food consumption.

Table 1 displays the global WF associated with the production of crops used for human consumption. The WF is fairly widespread over the Indus River Basin, most of India, Eastern China, the Northeastern United States, the Egyptian Nile Delta, Western Indonesia, and many European nations. The key nations with a sizable portion of the total global WF are represented in the pie chart. 38% of the total green, blue, and grey WF worldwide is made up of China, India, and the US.

Hoekstra and Hung [Hoekstra et.al., 2008] performed the first estimation of the WF (cubic metre per tonne of produce) for 38 crops for numerous nations. Hoekstra and Chapagain expanded on that study by including a significant amount of unprocessed as well as processed agricultural and animal products [Chapagainet.a., 2004]. For 354 primary and processed crop products, Mekonnen and Hoekstra [Mekonnenet.al., 2011] assessed the green, blue and grey WF (cubic metre per tonne of product). The prime crops' WF was carried out with a spatial resolution of 5 arc minutes. Mekonnen and Hoekstra [Mekonnen et.al., 201] classified the animal production into grazing, mixed, and industrial systems in 2012 and evaluated the WF (cubic metre per tonne of product) for 106 animal products.Together, these databases are a rich source of data for other WF studies.

2.1.2 Water footprint on crop production (National Scenario)

Whereas most crops cultivated in the kharif season primarily rely on green water (rainfall) and are supplemented by blue water (artificial irrigation), crops grown in the rabi and zaid seasons mostly rely on irrigation water and are only partially satisfied by off-season rainfall for their crop cycle (Table 1). Rice, maize, jowar, and tiny millets were the main crops planted during the kharif season. Wheat and barley were grown during the rabi season.

The Bundelkhand region's rice crop was expected to have the greatest crop water requirement of 9130 m3/ha, while the Western region's jowar crop had the lowest crop water requirement of 3565 m3/ha. While in the rabi season, wheat crops in the Bundelkhand region were expected to require the most water (8286 m3/ha), and barley crops in the Western region required the least (2219 m3/ha).

Arhar, moong, and urd were the three main pulse crops grown by farmers in different parts of Uttar Pradesh during the kharif season, while gramme, pea, peas and beans, and lentil were planted during the rabi season. The Western region had the highest crop water requirements for kharif pulses, while the Central region had the lowest requirements, with 4142 m3/ha and 3765 m3/ha, respectively.

Rice, maize, moong, urd, and sunflower are among the crops grown in Uttar Pradesh during the zaid season. In comparison to urd, moong, and maize, rice and sunflower had a very tiny area share among these crops. There is only one crop planted in the Zaid oilseed, which is sunflower, whereas Zaid cereal includes maize and rice, Zaid pulses include moong, and Zaid beans include urd (Table 1). At 11461m3/ha, rice has the highest crop water requirement of all the zaid cereals in the Central area. Whereas maize in the Western area used the least amount of water, 6719m3/ha. In the zaid pulse category, the Central region had the highest crop water requirement (6387 m3/ha), and the Western region had the lowest crop water requirement (5878 m3/ha).

Physical water productivity by region

Table 2 shows the physical water productivity findings by region for the various crops cultivated in Uttar Pradesh. The bajra crop had the highest water productivity of the kharif cereal crops grown in the state, measuring 1.749, 1.248, and 0.796 kg/m3 in the Eastern, Central, and Bundelkhand regions, respectively. In the Western region, the highest water productivity was found for the maize crop (1.67 kg/m3), which was followed by the bajra crop. While in the Eastern, Central, and Bundelkhand regions, the minimum water productivity for the rice crop was determined to be 0.709, 0.708, and 0.313 kg/m3, respectively. In the case of kharif pulses, arhar crops had the highest agronomic water productivity while moong crops had the lowest throughout all regions of the state.In contrast to other regions, the water productivity of all kharif pulses was found to be lowest in the Western region, ranging from 0.099 to 0.404 kg/m3.

Table.2 Comparative advantage of crops production in different regions of Uttar Pradesh

Name of the region	**Comparative advantage in restect to**		
	Water Productivity	**Crop Yield**	**Crop Yield and water productivity**
Eastern	Rice(k),Jowar,Bajra,Small millets,Arhar,Urd(k),Moong (k),Groundut,Tobacco,Cotton		Gram Sesamum
Central		Rice,Jowar,Arhar,Moong(k) ,Groundnut,Linseed,Rice(z), Ued(z),Sunflower,Tobacco, Potato	Soybean
Bundelkhand	Potato	Small millets,Linseed	Moong(z)
western	Linseed,Rice(z),urd(z),Sunflower	Bajra,urd(k),Cotton	Maize(k),Wheat,Barley,Pea and beans,Lentil,Rapeseed,mustard,Maize(z) ,Sugarcane

Note: K = kharif, R = Rabi and Z = zaidSource: (Kumari et.al., 2017)

For the sesamum (k) oilseed crop, the water productivity was calculated to be 0.105, 0.066, 0.061, and 0.61 kg/m3, respectively, in the Eastern, Central, Bundelkhand, and Western regions. Physical water productivity was calculated for groundnut (k) and found to be 0.488, 0.437, 0.341, and 0.346 kg/m3 in the Eastern, Central, Bundelkhand, and Western regions, respectively. The soybean (k) crop's water productivity was calculated, and the highest value was found in the Central region at 0.529 kg/m3, while the lowest value was discovered in the Eastern region at 0.013 kg/m3.

Wheat and barley crops were cultivated in the state during the rabi season, with barley having a higher water production than wheat. In the Eastern, Central, Bundelkhand, and Western regions, respectively, water productivity for wheat crops was determined to be 0.417, 0.478, 0.289, and 0.565 kg/m3, and similarly for barley crops, it was calculated to be 1.412, 1.462, 1.324, and 1.775 kg/m3. The Eastern region had the highest water productivity for gramme with 0.357 kg/m3, and the Bundelkhand region had the lowest with 0.196 kg/m3. The Western region had the highest water productivity for the lentil crop, at 0.732 kg/m3, and the Bundelkhand region had the lowest, at 0.192 kg/m3.

The water productivity for rabi oilseed crops—rapeseed, mustard, and linseed—was predicted to be highest in the western region and lowest in the bundelkhand region.

The maize crop recorded the highest water productivity in the Eastern and Central region among the crops planted in the state during the zaid season (rice, maize, moong, urd, and sunflower). Sunflowers in the western region have the highest water production, followed by maize crops. However, in the Bundelkhand region, only sunflower and moong crops are farmed on a small scale.The state also produced cotton, sugarcane, cotton, tobacco, and potato, which are all profitable crops. Potato had the highest water productivity of all crops, with respective values of 7.580, 7.45, 7.733, and 5.040 kg/m3 in the Eastern, Central, Bundelkhand, and Western regions. The cotton crop in every region had the lowest water production.

2.1Water footprint of food processing

The problem of feeding an expanding population is well understood. The concern is, how can food production reach those levels given the scarcity of water, which is crucial in agriculture and food processing?Water reconditioning and recycling in various sectors of the food supply chain offer potential solutions to this problem. Yet, the food business, particularly at the processing stage, is highly sensitive to this idea due to unfavourable non-science-based beliefs about the qualities of this water and associated contamination hazards (Casani, Rouhany, &Knchel, 2005). If more scientific knowledge is made available, risk perception may become less skewed. Sadly, there has been little research into the effects of using reconditioned water in food processing settings.

Water is used at various phases of the food production chain, including irrigation, processing, cooling, heating, and cleaning. Irrigation contributes for 37% of total freshwater withdrawal in the United States, with the industrial industry accounting for the remaining 5e10% (EPA, 2013). The food processing industry alone accounts for more than 30% of all water utilised in production (Australian Food Statistics, 2007).

Although though the quantity of water used in the food processing industry is minimal, it is crucial to note that food processing facilities consume high-quality water and are usually located near urban areas. As a result, they not only compete with the community for natural resources, but food industries also produce a substantial amount of wastewater, which if not properly treated can have serious environmental consequences.
Coupled with water shortages, harsher environmental restrictions, and the rising expense of municipal water and wastewater treatment, all of these issues encourage food firms to seek alternate ways to produce food effectively and sustainably (Maguire, 2015).

2.2Water footprint of different diets

Global demand for animal and processed food products is predicted to rise in the coming decades [Tilman et.al. 2014]. These dietary changes will have an impact on people's water, energy, land, and carbon footprints. Sustainable Healthy Diets, according to a recent FAO and WHO report, are "... dietary patterns that support all dimensions of individuals' health and wellbeing; have low environmental pressure and impact; are accessible, inexpensive, safe, and equitable; and are culturally acceptable" [FAO 2019]. The statement also emphasises the importance of national food-based dietary standards that take into account the country's social, cultural, economic, ecological, and environmental concerns.

A vast number of research [Tilman et.al. 2014] suggested that a healthy diet with less animal-based food products will have a commensurate benefit in terms of lowering environmental impacts and resource use. Hoekstra was one of the first to investigate the effect of food on WF intake [Hoekstra et.al. 2012]. According to Mekonnen and Hoekstra [Hoekstra et.al. 2012], the WF of animal food products is substantially higher on average than the WFs of crop food items with similar nutritional energy value. Beef had a WF per calorie that was 20 times higher than grains and starchy roots. Beef had a WF that was six times greater than pulses per unit of protein.As a result, substituting nutritionally equal plant-based foods for animal-based foods reduces WF consumption. Hoekstra [Hoekstra et.al. 2012] demonstrated that substituting nutritionally equal plant-based meals for meat-based diets reduced overall WF consumption by 36% in industrial countries and 15% in poor countries. Vanham, Mekonnen, and Hoekstra [Vanham et.a. 2012] indicated that the WF of EU28 food consumption will fall by 23% by shifting from current to healthy and by 38% to vegetarian diets. The decrease in WF was primarily due to a decrease in meat intake. Vanham, Hoekstra, and Bidoglio [Vanham et.a. 2013] found that substituting current diets with vegetarian diets reduced WF consumption by 27% to 41% for different regions of the EU28.Kim, Santo, Scatterday, Fry, Synk, Cebron, Mekonnen, Hoekstra, de Pee, Bloem, Neff, and Nachman [Vanham et.a. 2012] investigated the WF of 9 progressively plant-based diets that met the criteria for a healthy diet in a larger worldwide study encompassing 140 nations. The results showed that plant-based diets containing a small number of low-food chain animals (forage fish, bivalve mollusks, insects) had lower WFs than entirely plant-based (vegan) diets. However, the degree of changes in the WF varies greatly across countries due to dietary changes, patterns of reference consumption, trends in food imports, and the water intensity of food products. The findings highlight the significance of trade, culture, and nutrition in the examination of WF eating habits.

Healthy diets, on the other hand, may not necessarily lower WF consumption, especially when animal products are replaced by foods with relatively high WFs, such as fruits and pulses [Mekonnen et.al. 2018]. Dietary advice should therefore strive to encourage a healthy diet while having the least possible environmental impact. Furthermore, these research highlight the necessity of dietary control and boosting nutritional water production in order to reduce the strain on water supplies.

2.3Water footprint in textiles

According to Porter et al. (1972), the activities for converting textile fibres into fabrics demand a large amount of freshwater while discharging considerable quantities of chemicals onto water streams. Nevertheless, the adoption of the WF idea accelerated study into the measurement and management of water resources across textile production chains. To compute the WF of cotton output in the world's top cotton-producing countries.

Chico et al. (2013) investigated the WF of cotton and wood-based trousers manufactured in Spain. In both situations, the growing stage is the key WF hotspot, but freshwater intake and pollution during the production stage vary depending on the kind of fabric and processing method. Wood-based jeans (1454m3 per unit) are often more eco friendly than cotton jeans (3233m3 per unit).

Rudenko et al. (2013) developed an integrated approach for assessing the financial and freshwater reserves of the cotton chain in Uzbekistan using the value chain and WF principles. In fact, the writers evaluated both macroeconomic and microeconomic studies of Uzbekistan's production of cotton, processing, and exports. According to the microeconomic results, the WF of a cotton t-shirt is 2865m3, and the value added is around 0.7 US dollars (USD) per item. From a macroeconomic standpoint, cotton exports total 1234 million USD, accounting for 22% 11 of overall world exports, while the linked WF totals 20286m3, accounting for 72% of total export WF.

3.Discussion

There is a huge scope in this field, a lot of research can be done, since in the only Uttar Pradesh and made a segmented list of water production in there different are according to which water footprint can be observed . Just like that research shold be done for the entire country in different sectors, region, etc. This will help in saving the different types of water resources for longer run and in short will also help in the water sustainability.

4.Conclusion

In rhe world all animals, more or less require food,shelter and cloth for their survival which are directly or indirectly related to water requirement. Both agricultural production, food processing of animals and plant products require more water. In general, vegetarian diets have smaller water footprint(WFs). The animal diets like meat, beef, etc. If more sustainable diets are promoted, it is important to take these WFs into account. WFs are dominated by green WFs, while blue and grey WFs are much smaller. The blue and grey WFs have a larger environmental impact . 57% of the world blue WF is unsustainable. Only six crops dominate this unsustainable footprint: wheat, rice, cotton, sugar cane, fodder, and maize, and they are grown in only five countries: India, China, the United States, Pakistan, and Iran. Population growth and dietary changes, such as increased meat consumption, are predicted to increase water demand. The worldwide WF is predicted to vary between 5938 and 8508 km3/year, increasing by up to 30% between 2010 and 2050.Hoekstra has advocated In setting an upper limit on the WF per river basin; (ii) setting WF benchmarks per product; and (iii) defining fair WF shares per community to encourage sustainable water use.

To avoid unsustainable water use, combination of virtual water trade and economic evaluation should be taken into account. Furthermore , awareness should be created among the people, through Government agencies, social studies and NGOs regarding WFs to consume water

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