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Applying Water Footprint Theory to estimate the Various Water Consumption of Livestock in the Gaza Strip

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Abstract

Water conservation constitutes the most important challenge facing humanity in recent times. This study aims to estimate the water footprint of livestock in the Gaza Strip. The Hoekstra methodology was used and the study found that the livestock water footprint was 211 million m3 consumed in the three uses service, drinking, and for water used to irrigate the crops as fodder. The results show the largest consumption is related to broiler chickens due to the large quantity consumed. The indicator's application is necessary for decision-makers in sustainable planning processes.

Keyword: Livestock, Water Footprint, Gaza Strip, Water management

Introduction

The water footprint was introduced by Hoekstra (2003) as a consumption-based indicator of water consumption, measuring all direct and indirect freshwater consumption in the supply chain of a product, service, or production process. This indicator defines each contribution to water consumption geographically and temporally, showing the amount of water consumed by source and the amount of pollutants by type of pollution. It is a volumetric measure of water use and pollution (Aldaya et al., 2011).

The Components of water footprint contain three different cateogeries, the colors blue and green refer to the different water sources from which the water is consumed, and the color gray to the polluted water as described (Herath, 2013; Hoekstra, 2011).

Based on the availability of trade data and the need for national water security, most water footprint applications has been done at the national scale. However, the number of regional and urban scale applications is progressively increasing.(Chen & Chen, 2013; Konar et al., 2012). An assessment of the blue and green water footprint was conducted at the urban level in Milan (Vanham et al., 2014), Beijing (Wang et al., 2013), United Kingdom (Acquaye et al., 2017), Australia (Wiedmann & Allen, 2021). In addition, a case study was conducted in the German capital, Berlin, Lagos, Nigeria, and Delhi India. (Hoff et al., 2014) as well as California and Illionis (Mubako et al., 2013).

Livestock water footprint consists of various components: the direct water footprint of feed and the indirect water footprint related to drinking water and service as described in Mekonnen and Hoekstra (2012) and expressed in terms as MCM/ year.

The virtual water content of an animal is defined as the total quantity of water that was used to grow and process its feed, to provide its drinking water, and to clean its housing and the like (Hoekstra, Chapagain, Aldaya, & Mekonnen, 2011). It is subject to the breed of an animal, the farming system, the feed consumption, and the climatic conditions of the place where the feed is grown.

Based on the fact that no study similar to this study was conducted in the Gaza Strip, this study includes estimating the water footprint of livestock with its three levels for all animal types, according to the statistics of the Ministry of Agriculture.

Methods

There are three components of the virtual water content (VWC) of a live animal expressed as in Eqn (1):

$WFl = WF_{feed} + WF_{drink} + WF_{serv}$……………………………………….…..(1)

WF_{feed} is related to feed water consumption, WF_{drink} is related to drinking water consumption, and WF_{serv} is related to service water consumption water which refers to the water used to clean the farmyard, wash the animals, and carry out other services.

The assessment of livestock product water footprint has been derived by multiplying the virtual water content (VWC) of a type of livestock product with its production and then summing up all types of livestock categories.

The total virtual water of feed consists of two terms the first represents the partial amount of VWC used from Gaza water resources to breed animals while the other term represents the out virtual content of some kinds of feeding like barley and wheat and beans imported from outside countries. The water footprint related to animal feed has two sides: several feed ingredients and the water that is used to mix the feed. It's notable that the water that is used to mix the feed within the industrial footprint so it excluded in this calculation. WF feed calculated as in Eqn (2):

$$\text{WF feed} = = \sum_{c=1}^{c=n} F\left(\frac{ton}{y}\right) * WFf\,\frac{m3}{ton} \quad \text{.....(2)}$$

Where: F indicted the annual amount of feed consumed (ton/y). WFf is the water footprint of the feed component (m3/ton). All this classification for animal category a and in nation c.

Results and Discussion

Water Footprint of Drinking & Servicing

The virtual water content of live animals (VWC) in terms of drinking and servicing components is presented in Table (1). It's derived from local authority and reviewed literature, generally in all countries no enough data related to water used for servicing and almost all references assume the servicing quantity equals 50% of drinking quantities for animal life span. Table (1) shows the main animals in Gaza Strip and details of daily consumption as well as live weight livestock in the Gaza Strip including: Dairy cows, Beef cattle, Sheep, Goat, Laying hens, Broiler chicken, and camels.

Table (1)

Virtual Water Content of Drinking& Servicing of Alive Animal in the Gaza Strip

Type	Drinking m3/ animal	Servicing m3/ animal	Live weight ton/ animal	Details
Dairy cow	114	57	0.5	dairy cow included (calve 0-1 year, heifers 1-3year and milking cows 3-10 year with range of daily consumption 14.5 , 27.4, 38.4 L/day / animal respectively).

Beef cattle	36	18	0.45	Beef cattle included calve 5 month and adult cow 36-month with average daily consumption 40 L/day / animal).
Sheep	4.5	2.26	0.053	Sheep included lambs (0-2month and adult ewes 24 month with average daily consumption 6.3 L/day / animal
Goat	4.2	2.1	0.04	Goat included kids 0.2 month and adult 30 month with average daily consumption 4.77 L/day / animal
Laying hens	0.14	0.07	0.002	Laying hens included chick with 1 week and start laying eggs 25 week with average daily consumption 0.16 L/day / animal and adult 75 weeks
Broiler chicken	0.01	0.005	0.0022	Broiler chicken included chick with 5 weeks with 0.15 L/day / animal and adult 7 weeks with 0.21 L/day / animal
Camels	25	11	0.25	Beef cattle included and adult cow 36-month with average daily consumption 28 L/day / animal).

It can be determined from the table that the largest quantity withdrawn by dairy cows is 114 m3 per animal because they have a long lifespan of approximately 10 years, and also because they need a lot of water to produce milk. While laying hens and broilers were the birds that consumed the least in terms of drink and service.

Water Footprint of Animal Feed

Table (2) shows the livestock type and WF component and the average quantity needed ton/animal /year.

Table 2

Crop Water Needed for Livestock's feed in the Gaza Strip

Feed type	Avg. quantity Ton/animal/year	WF m3/ton	Crop water m3/animal/year
Dairy cow			
Barley	0.3212	1040	334
Wheat	0.1703	997	130
Wheat bran	0.0937		
Maize	0.3833	100	38
Soya bean	0.2981	185	55
Clover/straw	7.5	661	4957

Total water consumption in the form feed/year			5514
VWC of feed = Age * Total water = 22056 m3/ton			
Beef cattle			
Barley	0.15	1040	156
Wheat	0.38	997	379
Maize	0.55	100	55
Soya bean	0.43	185	79.55
Clover/straw	1.46	661	965
Total water consumption in the form feed/year			1634
VWC of feed = Age * Total water = 4902 m3/ton			
Sheep			
Wheat	0.115	997	70
Wheat bran	0.0356		
Maize	0.1437	100	14.3
Soya bean	0.0944	185	17.46
Total water consumption in the form feed/year			102
VWC of feed = Age * Total water = 204 m3/ton			
Goats			
Wheat	0.0562	997	36.7
Wheat bran	0.0174		
Maize	0.0703	100	7
Soya bean	0.0462	185	8.5
Total water consumption in the form feed/year			52.2
VWC of feed = Age * Total water = 131 m3/ton			
Laying hens			
Wheat	0.00438	997	4.36
Maize	0.01825	100	1.82
Soya	0.004745	185	0.88
Total water consumption in the form feed/year			7.06
VWC of feed = Age * Total water = 8.47 m3/bird			
Broiler chicken			
Barley	0.0147	1040	15.28
Wheat	0.0280	997	27.91
Maiz	0.029	100	2.9
Soya bean	0.024	185	4.44
Total water consumption in the form feed/year			50.53
VWC of feed = Age * Total water yearly/52 = 3.4 m3/ bird			

It is clear from the table above that dairy cows are the animals with the highest virtual water content, which reached 22,056 m3/ton, followed by beef calves due to the nature of their large weights and their need for water in large quantities, while chickens and turkeys require little water content and therefore came at the end of the ranking. This result changes depending on the number

of each animal, which is clearly shown in the following table (3) that represents the total footprint in the Gaza Strip for all purposes (drinking, servicing, and feeding).

Virtual Water Content of Livestock

Multiplying the total animal needs for all purposes (drinking, servicing, and feeding) with the animal number in the Gaza Strip equals the total virtual water content for each type as shown in Table (3).

Table 3

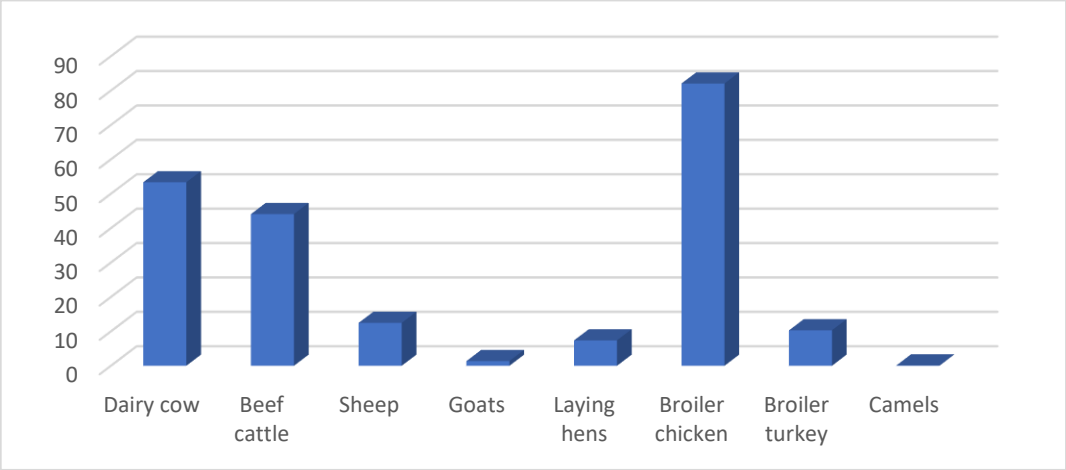
Total VWC for All types of Animal Consumption in the Gaza Strip.

	Animal Consumption						
	Type	Quantity	Drinking	servicing	feeding	Total / animal	Total 10^6 m3
1	Dairy cow	2400	114	57	22056	22227	53.34
2	Beef cattle	8900	36	18	4902	4956	44.1
3	Sheep	59200	4.5	2.26	204	210.7	12.47
4	Goats	9900	4.2	2.1	131	137.3	1.35
5	Laying hens	850,000	0.14	0.07	8.47	8.68	7.37
6	Broiler chicken	24,027868	0.01	0.005	3.4	3.415	82.05
7	Broiler turkey	1125000	0.04	0.02	9.1	9.16	10.3
8	Camels	840	25	11	98	134	0.11
	Total						211.14m3

It appears from the table that the water footprint of livestock is relatively large, reaching 211.11 million cubic meters. What is allocated for drinking and service was 2 million cubic meters, and the rest is for the water content of the feed. It is worth mentioning that feed consumption is not dependent on Gaza Strip sources, but rather a large portion of it is imported from outside. The green fodder and field crops produced locally in the Gaza Strip do not have a water footprint of more than 9 million cubic meters consumed domestically by animals was calculated within the virtual water content of crops using the CROPWAT model(Mizyed, 2024). Broiler chickens constituted 38% of the water footprint of livestock, due to the large numbers produced in the Gaza Strip (24 million chickens) and the large local consumption linked to people's culture and social behaviour. Camels are considered the animals that consume the least amount of water, due to their relatively low numbers in the Gaza Strip and their physical nature, which does not need much water. Figure (1) exemplifies the water consumption percentage of each type.

Figure 1

Water Consumption Percentage of each Livestock Type.



Conclusion

Applying the concept of the water footprint constitutes a modern tool for water management, and an important indicator used in the effective planning of the decision maker in decisions related to natural resources, especially water, as the water footprint of livestock in the Gaza Strip was determined according to the existing components. These results open the door for further study in order to rationalize the use Water according to international standards, and adopting the idea of importing virtual water into green fodder to save water instead of growing it locally.

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