Water Footprint of Thai Beef Meat Production

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Abstract – The water consumption of a range of Thai beef production systems from the Department of Livestock Development farms in Tak province was estimated in 2011. A Life Cycle Assessment (LCA) systems model was used to estimate the water consumption for 3 genotypes: Charolais x Brahman (CB), Charolais x Brahman x Native (CBN), and Charolais x Native (CN) fattening cattle. It included direct water consumption for drinking, washing, cleaning and more, as well as virtual water in the diet (that is, water that had been used to grow grass and concentrate feedstuffs). This was partitioned into green water assumed to be equal to the precipitation and the soil water absorbed by the crop. The crop evapotranspiration requirement would be calculated using different complex approaches. The blue water use depended mainly on process water and drinking water consumption. The grey water use depended on process water that caused pollution. Results showed that CB, CN, and CBN cattle had a water footprint averaging 5,078.39, 5,132.17, 5,215.91 Kg respectively, for 1 Kg of lean meat production. The major water footprint was the green water footprint. This report highlighted the importance of considering water use in context for a tropical climate where crop and grassland water requirements are adequately met by green water from rainfall.

Key Words – beef, meet, water footprint

I. INTRODUCTION

In the livestock sector, there is a discussion about the amount of water used in meat production. It is topical to discuss the amount of water needed to produce kilograms of meat, which led to discussions about the role of meat in a sustainable diet, and even suggestions that consumers might be "Facing the opportunity to ration" [1]. The quoted figures usually averaged 15,500 L/Kg for beef and 6,000 L/Kg for lamb. However, there were few studies on this topic and not all water sources were discussed. If livestock were fed on concentrates produced under irrigation in water stressed environments, this water use might have a significant impact. However, if they were fed on grass grown in rain, the impact of water use might not be significant. This also questions the meaning of "need" or "use". When fossil fuels were used, they changed their chemical form and released water and CO_2 as the main product. On the contrary, water did not change its chemical form but it might be contaminated by pollutants.

The water footprint concept of Hoekstra *et al.*[2] is a measure of a nation's appropriation of global water resources. It could be considered to be the sum of the all the water used in the production of the goods and services consumed by a nation/an individual/organisation. Such figures were useful to convey the magnitude of an activity's dependence on freshwater systems, however, in order to make the water footprint estimate more useful, it was common to differentiate between blue, green and grey water footprints. The blue water use depended mainly on process water and drinking water consumption and the grey water use depended on process water that caused pollution. Green water is assumed to be equal to the precipitation and the soil water absorbed by the crop. This research was aimed to calculate water footprint for 1 kg beef meat production.

II. MATERIALS AND METHODS

This assessment was based on the methodology for Life Cycle Assessment (LCA). The assessment encompassed the entire production chain of CB (Charolais x Brahman), CBN (Charolais x Brahman x Native), and CN (Charolais x Native) fattening beef cattle, from feed production to the final lean meat from slaughter house in two sections: 1) cradle to farm-gate and 2) farm-gate to slaughter house.

III. RESULTS AND DISCUSSION

Growth and carcass performance of Thai beef

The average daily gain (ADG) during fattening periods of CB cattle was 0.95 kg per day (Table 1), leading to CB cattle having the highest slaughter weight of 491.11 kg. For CN cattle, they were from native cows with the smallest size. The target slaughter live weights were determined 450 kg. The slaughter weight differed significantly ($P < 0.05$) among the 3 breeds.

The two groups, CB and CBN with F1 (CxB) and F2 (CxBN) progeny, were bred for a slaughter program. They could get higher heterosis for higher growth performance, easy raising, good adaptivity and low cost production [4]. The results of slaughter traits are shown in Table 1. For dressing percentage, the CB cattle were significantly higher ($P < 0.05$) than the other breeds by the effects of additives and heterosis. Similar to the findings of Oh *et al*. [5], the carcass percentage of 50% Charolais was bigger than 25% Charolais. The carcass weight was an important factor affecting meat quality through its effect on fatness [6]. Rossi *et al*. [7] described that a premium product could offset the feed cost.

Table 1 Growth performance and carcass traits of Thai beef cattle

	CB	CBN	CN
No of fattening cattle	9.00	26.00	7.00
No of cow	11.00	33.00	9.00
W1 (kg)*	$263.11^a \pm 20.48$	$213.90^b \pm 21.07$	$212.69^b \pm 19.65$
W2 (kg)*	$491.11^a \pm 19.77$	$429.35^b \pm 20.24$	$417.71^c \pm 26.68$
ADG (Kg/day)**	$0.95^a \pm 0.04$	$0.90^b \pm 0.04$	$0.85^c \pm 0.04$
DMI (Kg/day)**	$11.31^a \pm 0.58$	$9.65^b \pm 0.60$	$9.46^b \pm 0.68$
%Carcass*	$53.69^a \pm 1.43$	$53.29^a \pm 1.88$	$52.68^b \pm 0.93$
Lean meat (Kg/head)*	$190.64^a \pm 9.64$	$169.92^b \pm 11.75$	$162.41^b \pm 9.86$

** highly significant ($P<0.01$) * significant ($P<0.05$) W1=initial weight, W2=final weight, ADG = average daily gain, DMI=dry matter intake

Water footprint for meat production

This part of the water footprint consisted of forage crop, feed production, housing management, electricity use, transportation and pollution. The water footprint from farm to gate and from gate to slaughter house of CBN cattle was higher than CN and CB, respectively (Table 2). The mean blue water consumption for the production of 1 kg lean meat of CN was lower than CB and CBN. The CN cattle were cross-breeds from native cattle. They had heat tolerance traits, so the drinking water requirement was lowest due to genetics and physiology.

Table 2 Water Footprint for meat production from farm to gate to slaughter house.

	CB	CBN	CN
Water Footprint			
(Kg/Kg lean meat)	5,078.39	5,215.91	5,132.17
- Green[a] (%)	93.98	93.97	93.98
- Blue[b] (%)	6.00	6.00	5.99
- Grey[c] (%)	0.03	0.03	0.03

[a] green water is assumed to be equal to the precipitation and the soil water absorbed by the crop.
[b] blue water use depended mainly on process water and drinking water consumption.
[c] grey water use depended on process water that caused pollution.

It was clear that green water had a lower opportunity cost than blue water, and in many cases had no cost at all. Green water may be considered as a 'gift' [8]. This study showed that the footprint of Thai beef production (Kg/kg lean meat) was similar to that of other countries. The hydrological impact of Thai beef meat production was very small. The farming systems analyzed in this study were small holder farms. Therefore, the grey water footprints were very low in the 3 groups. It was related to manure management that farmers used as fertilizer resulting in low pollution.

The blue water consumption was very small for meat in all systems [9]. Drinking water was almost half the blue water used by the meat production. Therefore, technologies that reduce wastage/leakage in drinking water systems on farms can reduce overall water use. The amount of blue water associated with the feed increased slightly.

IV. CONCLUSION

This study calculated the water footprint in beef production from every step of the production chain. For beef production, all water use might be too high. However, as they were produced in small holder farms, the production based on pastures, crop residues, and crop processing by-products incurred no or very limited feed water costs. The grey water footprint was very low. The blue water footprints were from drinking water and used water which was affected by genetics and physiology. The biggest water footprint was the green water footprint. This was from feed and from rain. Thus, the water footprint could be reduced by replacing whole grain with higher proportions of other crops and agricultural byproducts.

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