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A comparison of policies to reduce the methane emission intensity of smallholder dairy production in India

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ABSTRACT

Within the dairy sector, the effects of climate change are particularly diverse as cows are affected by, and a significant contributor to climate change. With a burgeoning body of work indicating the importance of livestock's contribution to climate change (via Greenhouse Gas (GHG) emissions), the dairy sector will increasingly be targeted for emission reduction. Yet, gaps in knowledge remain as to the effectiveness of interventions in achieving emission reductions. The investigation examines two high-profile Indian policies to evaluate their effectiveness in reducing the methane emission intensity of milk production in Odisha, India. Selected policies included the installation of smallscale anaerobic digesters and the control of Foot and Mouth Disease (FMD). The interventions were evaluated at the cow level informed by data collected from 115 smallholder dairy producers in Puri (n = 31) and Khurda (n = 84) districts in Odisha, India. The installation of an anaerobic digester was found to increase methane emission intensity by 4.41–5.01%. Control of FMD reduced methane emission intensity by 3.68–12.95% depending on the infection scenario considered. The findings highlight the importance of contextually relevant and multi-sectoral approaches to mitigation as the increase in methane emission intensity following anaerobic digester installation represents movement of emissions from the energy sector into the dairy sector where mitigation is inherently more complex. Thus, the long-term usefulness of anaerobic digester installation as a mitigation strategy is limited.

1. Introduction

The livestock sector is a key feature of the Indian economy contributing approximately 4.1% to GDP in 2012–2013 (Government of India, 2014a). The dairy sector is the most important component of the Indian livestock sector contributing 65.1% of the total value (Government of India, 2014b). The Indian dairy sector is the largest in the world composed of approximately 44.5 million milking cows (Government of India, 2014b) representing 16.7% of the world's dairy cattle population (FAO, 2013).

The Indian dairy sector is primarily composed of smallholders who are responsible for 70% of India's bovine (cattle and buffalo) population (Datta et al., 2015). Within India, smallholder operations are characterized by small landholdings (< 2 ha) and small herd sizes (an average of 0.89 female cattle per household) of low productivity (Datta et al., 2015). The average daily milk production of India's crossbred cows is 7.0 kg/cow and 2.4 kg/cow for indigenous cows (Government of India, 2014b). However, a great deal of variability is noted between states. For example, Odisha has lower average levels of milk production at 6.2 kg/cow per day for crossbred and 1.5 kg/cow per day for indigenous cows (Government of India, 2014b).

Due to constraints associated with feeding, breeding, health and management (Government of India, 2012b) the low levels of milk production make the Indian dairy sector one of the most greenhouse gas (GHG) emission intensive (Gerber et al., 2011). Indian estimates of emission intensity (see Swamy and Bhattacharya, 2006; Jha et al., 2011; Patra, 2012) are considered partial estimates as they are not weighted to consider the associated dairy population (such as; replacement heifers, cull calves, etc.) and focus heavily on methane (CH_4) emission from enteric fermentation and manure management practices. Nitrous oxide emissions receive little attention due to their limited importance within the smallholder sector (Swamy and Bhattacharya, 2006; Patra, 2012). Similarly, carbon dioxide produced during respiration is excluded as this represents the return of photosynthesized carbon dioxide to the atmosphere and does not affect net carbon dioxide emissions from livestock (IPCC, 2006a). Indeed, emission inventories from India's National Communications to the United Nations Framework Convention on Climate Change (UNFCCC) are considered

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complete emission estimates (see Government of India, 2004, 2012a). However, these reports do not consider the emission intensity of milk production.

Indian crossbred dairy cows are estimated to produce between 0.53 and 0.70 kg CO_2 equivalents/kg of milk (Swamy and Bhattacharya, 2006; Jha et al., 2011). Indigenous Indian cattle have a higher methane emission intensity producing between 1.03 and 2.40 kg CO_2 equivalents/kg of milk (Swamy and Bhattacharya, 2006; Jha et al., 2011). In terms of Fat and Protein Corrected Milk (FPCM), the emission intensity of indigenous and crossbred milk production was found to 6.5 kg CO_2 equivalents/kg of FPCM milk and 1.4 kg CO_2 equivalents/kg of FPCM milk, respectively (Patra, 2012). Although the value offered by Patra (2012) is a more complete estimate of emission intensity as it is weighted to consider the associated dairy population, the author includes all cattle (including draft animals) within the dairy sector. In doing so, the emission intensity offered is likely to be an overestimation.

Indian estimates of emission intensity appear comparable to the emission intensity estimates from northern production systems. For example, in the United states Capper et al. (2009) found an emission intensity of 1.35 kg CO_2 equivalents/kg of milk for modern (year 2007) intensive methods of production. Similarly, in the United Kingdom Foster et al. (2007) found emission intensity to be 1.14 CO_2 equivalents/kg of milk. However, these authors employed a Life Cycle Assessment (LCA) approach which is common practice for dairy sector emission estimates in the global north (see FAO, 2010; Kristensen et al., 2011; Opio et al., 2013). The LCA approach provides a more comprehensive estimate of emission intensity as the emissions associated with feed production and processing are included (in addition to enteric and manure management sources) (FAO, 2010). Thus, it is likely that the emission intensity of Indian milk production will be significantly larger should a LCA approach be used. Using a LCA approach, Gerber et al. (2013) estimated the average emission intensity of South Asian integrated crop-livestock systems to be 5.5 kg CO_2 equivalents/kg of milk. The global average was found to be 2.7 kg CO_2 equivalents/kg of milk (Gerber et al., 2013).

It is inevitable that the Indian dairy sector will be targeted for GHG emission reduction due to the high emission intensity and sheer size of the sector. However, achieving emission reductions from the Indian dairy sector is inherently complex due to the contributions livestock make to the country's economy and food security. As such, India is currently without any dairy sector GHG emission mitigation policies. Yet, the Indian government policy position can be gleaned from existing documents which indicate emission reductions must be achieved without reducing productivity or dairy cattle population size (Government of India, 2011b).

Internationally, authors have begun to question whether reductions in GHG emission can be achieved without a reduction in livestock population. For example, Webb et al. (2014) found that achieving a 20% reduction in UK livestock sector GHG emissions was not possible without reducing output (or exporting emissions overseas). Similarly, reduced stocking rates were required to reduce emissions from the New Zealand dairy sector (Adler et al., 2013; Doole, 2014). Thus, achieving emission reductions without reducing the national herd size represents a significant challenge. Indeed, the development of a low emission dairy sector under the guise of sustainable intensification may be possible (Gerber et al., 2011, 2013; Herrero et al., 2015). However, intensification is particularly challenging within India due to chronic feed shortages (Government of India, 2012b, 2013). As such, questions remain as to whether emission intensity can be reduced to the level required to offset the increases in emission expected in response to increasing demand (Delgado et al., 1999; Pica-Ciamarra and Otte, 2009).

A range of existing Indian policies are likely to have an impact on the GHG emission intensity of the dairy sector. In this circumstance, policymakers could reconsider existing policies within an overarching climate change framework. For example, over the past 30 years, the installation of smallscale anaerobic digesters has been a government priority. By the end of 2017, 5.6 million smallscale anaerobic digesters will have been installed with over 6.5 million installations expected by 2022 (Government of India, 2011c). However, the effect of anaerobic digesters on dairy sector GHG emissions is largely unknown as the energy sector has been the focus of research. As a result, no studies have been undertaken to evaluate the impact of anaerobic digesters on dairy sector emissions, despite system leakage being identified as a potential concern (e.g. Bruun et al., 2014).

Disease control is a stand-alone priority within Indian livestock policy (Government of India, 2013). From a mitigation perspective, disease control provides significant co-benefits as improved productivity (and reduced cull rates) will reduce GHG emissions (Hospido and Sonesson, 2005). Foot and Mouth Disease (FMD) could be targeted as significant resources have been allocated to its control. During 2013–2014, the Indian government spent Rs. 2.5 billion on FMD control (Government of India, 2014b). It is estimated that the Indian bovine (cattle and buffalo) population receive 150 million doses of FMD vaccination annually (Knight-Jones and Rushton, 2013). Despite such investments India has the world's highest incidence rate (along with China) at 3.39% (Knight-Jones and Rushton, 2013). During 2013, it is estimated that 75 255 bovines (including cattle and buffalo) were affected by the disease, resulting in the death of 7 736 individuals (Government of India, 2014b). However, such infection levels likely underestimate the importance of the disease. For example, at a prevalence of 3.39% (Knight-Jones and Rushton, 2013) assuming a herd size of 44.5 million (Government of India, 2014b) it would be expected that approximately 1.5 million dairy cows would be affected (assuming no vaccination program is in place). Such a figure is more commensurate to the annual median cost of production losses (i.e. Rs. 126 billion (Knight-Jones and Rushton, 2013)).

Therefore, the aim of the investigation was to compare two policies to determine their effectiveness in reducing the GHG emission intensity of milk production in Odisha, India. The installation of smallscale anaerobic digesters and the control of FMD in dairy cattle were selected due to their high profile and importance within Indian livestock policy. Indeed, a range of Indian policies will also affect the emission intensity of milk production. However, the selected policies were locally relevant and had been implemented widely throughout the research sites. The interventions were evaluated at the herd level informed by data collected from 115 smallholder dairy producers in Puri (n = 31) and Khurda (n = 84) districts of Odisha, India.

2. Methods

2.1. Household-level sampling and data collection

Villages were randomly selected within a 40 km area of the Odisha state capital, Bhubaneswar. The villages were within a high potential dairying zone which was characterized by sufficient water, market access, and relatively reliable animal health infrastructure. Cattle owning households (n = 115) were purposively sampled from Puri (n = 31) and Khurda (n = 84) districts. Local community leaders helped to identify cattle owning households. A portion (n = 35) of the sampled households were found to be affected by FMD in the 12-months preceding the interview. A total of 47 crossbred Jersey cows were identified as being affected. Surveys were conducted in the local language (Oriya) with responses being translated into English at the time of the interview. A voice recorder ensured all interviews were recorded verbatim. Interviews were transcribed into Microsoft Access 2010.

2.2. The interview

Farmers were asked a range of questions detailing their dairy operation. Demographic and socio-economic information of sampled households is provided in York et al. (2016). For each cow, farmers