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Review

Reducing the global environmental impact of livestock production: the minilivestock option

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ABSTRACT

Livestock production is among the most ecologically harmful of all anthropogenic activities. It has massive direct and indirect contributions to global warming besides causing widespread ecodegradation in other ways. But livestock production cannot be reduced because, as it is, the global demand for animal protein is far higher than the supply. Whereas in developed countries people get about 95 g of protein per day in their diets, of which nearly 60% is made up of animal protein, in developing countries the protein intake is only about 45 g/day and of it a mere 15% is made up of animal protein. This gap in the availability of animal protein for a large fraction of the world's population who desires it, is continuing to increase because of the increased globalization-induced rich-poor gap across the world.

Besides the fact that conventional ways of animal protein production using livestock—chicken, goat, pork, beef—are highly eco-degrading; in terms of availability of pasture lands as well as enhancement in productivity of edible zoomass with inputs from science and technology, the upper limits of animal protein production have already been reached. The ocean-based food production has similarly reached unsustainable levels. As a consequence, now onwards the demand will increasingly outstrip supply.

In this backdrop it is essential that we look at the potential of minilivestock, especially insects. As brought out in this paper, human beings have evolved as entomophagous species and there are even suggestions that some of the special proteins and other constituents present in the insects might have helped the human brain to develop as rapidly as it did to enable its evolution into *Home sapiens*. Moreover, several species of insects are prized delicacies in advanced countries like Japan, Australia, and Europe. Hence, insects are not restricted to being 'subsistence food' of grossly impoverished people as one might imagine though a lot of species do help the world's poor to survive. If other virtues of insects are considered— especially their high food-to-zoomass conversion efficiency, quick growth rate, enormous variety, and world-wide distribution—their potential as a much more sustainable source of animal protein than conventional livestock would become obvious.

1. Introduction: adverse impacts of livestock

Despite technological advances occurring hand-in-hand with the increasing portability of technological and managerial knowledge (made possible by information technology and globalization), nearly a billion people—or one in every eight—are going hungry in the world (FAO 2014a, b). As human populations increase, and towns expand into cities and cities into mega-cities, there will be increasing reduction in agricultural land while the demand to produce more food will continue to increase.

If the challenge to produce, in general, more food at lesser strain to the environment is going to get bigger with time, an even more daunting challenge is to provide the world with adequate quantities of animal protein (Pimentel and Pimentel, 2008). This challenge is made bigger by the fact that, on one hand, a large section of the global population gets much less animal protein than it desires while, on the other hand, it requires much more energy, land, and water to produce animal protein compared to equivalent quantities of other forms of food (Pimentel and Pimentel, 2003, 2008; Steinfeld et al., 2006). There is much more extensive harm to environment—in terms of soil

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erosion, water resource depletion, pollution, global warming, and loss of bio diversity—than the production of equivalent quantities of other forms of food (Pimentel et al. 1975; Steinfeld et al., 2006).

1.1. Impacts on land-use and biodiversity

According to the Food and Agriculture Organization (FAO, 2006), the livestock sector utilizes and impacts, through grazing and feedcrop production, as much as 3.9 billion hectares of land, or 30% of the non-polar terrestrial surface on the planet. In these areas, more often than not, livestock are a major source of land-based pollution, releasing huge quantities of nutrients and organic matter, pathogens and drug residues onto soil and into rivers, lakes and coastal zones (Aarnink et al., 1995; Losey and Vaughan, 2006; Fiala, 2008). Each of the over 100 million head of cattle in production in the USA generates about 9000 Kg of solid waste per year (Losey and Vaughan, 2006), heavily burdening the earth's environment. There are sharp land-use changes necessitated by livestock production because forests and other landscapes have to be converted to pastures and fodder-generating monocultures. (van Huis et al., 2013). Indeed livestock exert impacts on vast landscapes, altering them unrecognizably (Abbasi and Abbasi, 2010a). Convertion of natural habitats into lands suitable for just a few plant and animal species plays havoc with the region's biodiversity (Fig. 1). About 70% of the previously forested land in the Amazon basin has been converted to pastures, and much of the remaining 30% into croplands, for livestock feed (van Huis et al., 2013).

Overall, as much as 78% of the world's agricultural land and 33% of the world's cropland goes in the service of livestock production (Steinfeld et al., 2006).

1.2. Contribution to global warming

Livestock production is a major contributor to global warming: 35–40% of global anthropogenic methane and 9% of global anthropogenic CO_2 emission are caused by it (Steinfeld et al., 2006; Fiala, 2009; Tauseef et al., 2013). This is induced by deforestation for pasture and feedcrop land, pasture degradation, and livestock-related direct emission. Enteric fermentation and manure, together, constitute 80% of the methane emission (Abbasi et al., 2013; Tauseef et al., 2013).

Livestock activities also contribute substantially to the emission of nitrous oxide which is the most potent of the three major greenhouse gases (GHGs): 65% of global N_2O anthropogenic emissions. They form 75–80 percent of all agricultural emission. Current trends suggest that this level will substantially increase over the coming decades (Tauseef et al., 2013).

Emissions from livestock manure and urine cause 64% of global anthropogenic ammonia emission (Aarmink et al., 1995). Although not a GHG, NH_3 indirectly contributes to N_2O emission as it is converted to N_2O by specialized soil bacteria (Wrage et al., 2001).

Overall, raising, maintaining and utilizing livestock contribute about 18% of total anthropogenic greenhouse gas emission, second only to the top global warming sector: energy. Arguably, agriculture is the leading cause of anthropogenic climate change (Sachs, 2010), and the biggest source of global pollution (Abbasi and Abbasi, 2010b). Livestock contribute a lion's share to the adverse impacts of agriculture (Pimentel et al., 1975; Pimentel and Pimentel, 2008).

1.3. Stress on water and soil resources

The water used by the livestock sector is more than 8% of the global human water use. The major part of this is water used for

Manner of biodiversity loss caused by livestock	*Intensity of livestock production*		*Level of impact on biodiversity*		
	Very intense	Conventional	Intra-species	Inter-species	Ecosystem
Forest fragmentation	↑	↗	●	●	●
Land use interference	↑	↗	●	◉	◉
Desertification		→	●	◉	●
Climate change	↑	↗	◉	◉	◉
Invasive livestock		↘	◉	○	○
Invasive plants	→	↘	◉	○	○
Competition with wildlife	↑	↘	◉	○	◉
Overfishing	↗		●	●	●
Livestock diversity erosion	↑		○	◉	○
Toxicity	↑		◉	◉	◉
Pollution	↑	→	●	●	●

Fig. 1. Impact matrix of livestock production on biodiversity ■ Very strong ■ strong ■ Moderate □ Week. Slanted arrows show decreasing or increasing effect; vertical arrows represent rapid increase and horizontal arrows indicate a constant rate of impact (adapted from FAO, 2006).