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Animals, environment and sustainability: Global warming reducing and inducing attributes of the farm animals

VIR SINGH[1]✉ and AKANKSHA RASTOGI[2]

Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand 263 145 India

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ABSTRACT

Animals, environment and sustainability are related with each other. The intricate soil-plant-animal relationship is vital for the very ecological integrity of the biosphere. Animal diversity, both inter- and intra-species, has multiple socio-economic attributes. In an agroecosystem with uncultivated land, cultivated land, livestock and households as the integral components, livestock play crucial role in transferring nutrients from ecologically more sustainable ecosystem (forest/ rangeland/ grassland) to ecologically vulnerable one (cultivated land), and in the recycling of nutrients in the cultivated lands. Draught animal power (DAP) is a key source for realizing sustainability in traditional agricultural systems which is ensured by their role in enhancing ecological processes—cropping diversification, agro-biodiversity maintenance, and soil fertility management. Farm animals also play negative role leading to environmental degradation through overgrazing and carbon emissions. Grazing animals significantly affect an ecosystem in triple ways, viz. herbivory, physical effects, and deposition. Overgrazing alters community structure as well as ecosystem functioning, including primary productivity and it has triggering effects on an ecosystem. Farm animals are key agents as well as sufferers of the on-going climate change. Their role in land degradation, water pollution, biodiversity erosion and release of GHGs contributes to exacerbate global warming.

Keywords: Animals, Draught animal power (DAP), Environment, Overgrazing, Sustainability

Sustainability is based on sound and healthy environment, and the environment is phenomenally influenced by animals. Animals, thus, are a connecting link between environment and sustainability. Sustainability is a state of being that ensures to lead us to a future full of promises, affluence and happiness. The sustainability in a human-controlled world is not something like a static picture of socio-economic state. It is a dynamic phenomenon. Amid the state of environmental disruptions culminating into global warming and climate change, it is clearly revealed that our contemporary world is in the state of unsustainability (Singh 2019, 2020). With such a state of gloomy environmental reality, ushering in a sustainable future is impossible.

It is not only human society, even animals are the sufferers of climate change (Singh *et al.* 2017) and this state of the environment is going to be utterly dismal. Evidences are reflected through a flood of scientific reports on the formidable trend of global warming and its consequences, including the most talked-about COVID-19 pandemic. A diversity of animals in the animal kingdom of the biosphere phenomenally contributes to the favourable conditions for life on the planet (Singh 2019). The favourable conditions emanating from the interactions of biotic and abiotic factors in the environment determine the state of sustainability.

Sustainability has many dimensions, such as ecological, social, economic, and cultural, and it may vary from person to person and from society to society. Sustainability, in essence, has ecological roots. There can be no sustainability without ecological sustainability of its own (Singh 2019, 2020). The processes that enhance ecosystem functions (such as carbon sequestration, nutrient flows, productivity etc.) through improving ecosystem structures (level of biodiversity, vegetation type, soil composition etc.) lead to sustainability and such processes take care of regulating the factors constituting a climate nurturing life processes. In natural ecosystems, all the animals, ranging from herbivores to keystone species, phenomenally contribute to strengthen the processes of sustainability. In human-managed or anthropogenic ecosystems, such as cultivated land, the sustainability processes largely pivot on the role of domestic animals. The modern agriculture revolving round external inputs (machinery, chemical fertilizers, pesticides etc.) is certainly flawed by unsustainability (Singh and Jardhari 2001). However, the marginal farming systems such as operating in the Himalayan mountains exhibit many indicators of sustainability (Singh and Tulachan 2002). In

Present address: [1]Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand. [2]Indian Council of Agricultural Research, Krishi Bhawan, New Delhi. ✉Corresponding author email: drvirsingh@rediffmail.com

traditional agricultural systems, such as the typical mountain farming systems, livestock play crucial role vital for realising sustainability.

Livestock at the same time are accused of environmental degradation due to overgrazing and of accentuating global warming by releasing greenhouse gases (GHGs). This negative contribution of livestock that exacerbates the processes of unsustainability is largely attributable to erroneous human management. The negative livestock attributes (the ones that also induce global warming and unsustainability) can be transformed into positive ones (that also reduce global warming and induce sustainability) by means of conscious management and, in this way, the natural animal-sustainability links can be wisely restored and we would effectively arrive at the desirable goal in our livestock production systems.

This perspective paper attempts to analyse the vital animal-environment-sustainability relationships that can be phenomenal in evolving sustainable and global warming reducing livestock production systems.

Soil-Plant-Animal relationships

Soil, plants and animals are integral components of a forest ecosystem, an agro-ecosystem and an animal production system having bearing on each other (Fig. 1). Functional attributes of the three components are different but complimentary to each other. Complex interrelationships between them are vital for the very sustainability of an ecosystem as well as of a socio-economic system, such as livestock production system.

Structure, composition and functioning of the three are influenced due to their ecological relationship and dependence on each other (Singh and Bohra 2005, Singh 2018). Studies relating to soil-plant-animal relationships have been pivotal for soil fertility management, plant growth, crop production and animal health and production. Keulen *et al.* (2000) have shown how interaction between soil, plants and animals influences nutrient cycles and subsequently on the performance of a dairy farming system.

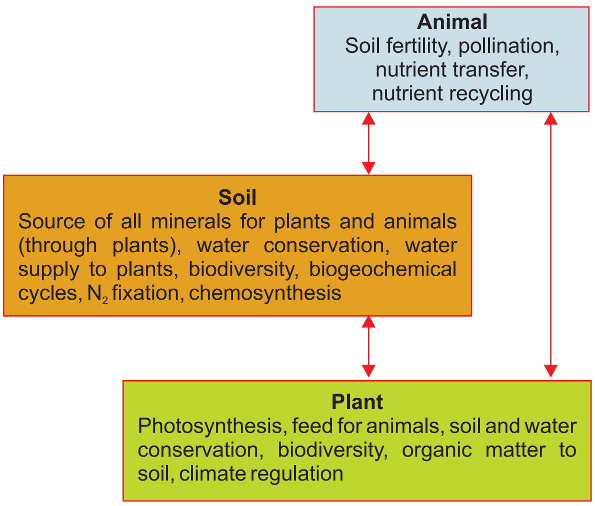

Fig. 1. Soil-plant-animal relationships.

A study by Ramirez-Iglesias *et al.* (2017) established the fact that an improvement in vegetative coverage in an agroecosystem boosts health and productivity of both soil and animals.

Plants derive mineral from the soil and animals from the plants. However, the soil-plant-animal relationship is not linear. It is complex and interdependent. Nutrient reserves and flows in an ecosystem (for example, forest, rangeland, grassland, crop field etc.) depend on the type, physico-chemical characteristics and biology of the soil and vegetation cover etc. The mineral content of the soil is not merely owing to the parent material; it also depends on a complex of pedogenic factors, such as laterization, calcification and salinization. Surface erosion, leaching evaporation and mineral redeposition further influence translocation of the soil minerals. Nutrient flows from soil to plant would again depend on a number of factors, for example, soil environment, plant species, plant physiology (Negi *et al.* 2019, Singh 2020).

Availability of nutrients from plants to animals and their requirements for animals will depend on the type of the plants (grasses, legumes), parts of the plants (whole plant, leaves, stems, seeds etc.), stage of the plant (early stage, mature stage), processed form of the feed/ fodder (green, dry, concentrate, mixed), feeding practice, plane of nutrition, feeding management, health and physiological status of the animal (age, pregnancy, lactation etc.) (Singh and Sharma 1990, Singh *et al.* 2001a, 2001b, Singh 2002b, Yadava *et al.* 2003, Singh and Gaur 2008).

Animal diversity and sustainability

Singh and Gautam (2004), Shiva *et al.* (2005), Singh and Bohra (2005), Singh and Gaur (2008), Singh *et al.* (2014) and Singh (2019, 2020) have presented overwhelming evidences regarding biodiversity-sustainability linkages. Life on earth diversifies itself with distinctive species, genotypes, communities and ecosystems. Biodiversity infuses resilience in an ecosystem. The resilience, i.e., capability to recuperate from biophysical shocks, imparts high degree of sustainability to an ecosystem and/ or a socioeconomic system, including a livestock production system. Diversity among animal species (for example, cows, buffaloes, goats, camels, yak, etc.) contributes to make dairy farming more sustainable. Diversity within animal breeds that reflects distinctive traits such as productivity, behaviour, adaptability and other virtues of individual animal species further strengthens sustainability. In the same way, diversity of fodder-yielding crops contributes to make a livestock production system more sustainable.

In an ecosystem, the top consumers in a food chain (for example, the lion and the tiger) act as keystone species controlling the populations of herbivores and easing pressure on the forest vegetation. The role of keystone animals, thus, is pivotal in maintaining the sustainability of an ecosystem.

A single animal species or a single breed of a species

Table 1. Various attributes of livestock for socio-economic development

Livestock	Milk	Fibre	Draught power	Carting	Riding	Manure	Carry-pack
Bovine (buffaloes and cattle)	√		√	√		√	
Ovine (sheep and goats)	√	√				√	
Equine (horses, mules, donkeys)			√	√	√	√	√
Llama			√	√	√	√	√
Camel	√		√	√	√	√	√
Yak	√	√	√	√	√	√	√
Pig						√	

cannot contribute all needed to human purpose. However, a diversity of livestock in the livestock production systems is of critical importance for fulfilling a variety of products and services, thus ensuring food and livelihood security (Table 1).

Livestock and nutrient flows

Nutrient flows in an ecosystem/ agroecosystem are vital for ecological integrity which is a precondition for sustainability (Singh 2019, 2020). From this perspective, livestock play crucial role by transferring and recycling nutrients in a farming system/ agroecosystem, especially in a traditional agroecosystem involving land use with uncultivated land (forests/ rangelands/ grazing lands/ grasslands) along with cultivated lands.

Singh *et al.* (2017), Rastogi *et al.* (2018) and Singh (2018, 2020) have thrown much light on the role of livestock in striking ecological integrity and enhancing sustainability in a traditional agricultural system. The uncultivated lands covered with vegetation are ecologically more sustainable than the cultivated ones, the later being ecologically more vulnerable. Livestock in traditional agricultural systems, like in the Himalayan mountains, are fed on uncultivated fodders (tree leaves and forest floor vegetation). The nutrients in the fodders are transferred into cultivated land through manures. Again, dry fodders of crop residues (straws) that grow on cultivated lands are also fed to livestock and, thus, the nutrients of the cultivated lands are recycled along with manure (Fig. 2).

Draft animals' contribution to sustainability

Mechanisation of modern agriculture plays a negative role by adding to environmental pollution. Agriculture machinery, for example, tractors, combine harvesters and the motor vehicles used in transporting agricultural produce, are operated by petroleum fuel and, thus, are responsible to pump enormous amounts of greenhouse gases (GHGs) into the atmosphere.

Singh (1998) and Singh and Partap (2000) have elaborated vital contributions of draught animal power (DAP) in mountain agriculture that support the processes to attain sustainability. Indian traditional agriculture based on draught animals does not involve use of fossil fuels. In addition to the socio-economic contributions involved, the draught animals play crucial ecological roles, namely cropping diversification, agrobiodiversity conservation, soil manuring, *in-situ* soil fertilisation, and carbon sequestration all indicative of sustainability (Fig. 3).

Mechanization of agriculture, as the modern agricultural developments would reveal, has promoted monocultures leading to substantial decline in agrobiodiversity. The DAP-dependent cropping systems, however, have always

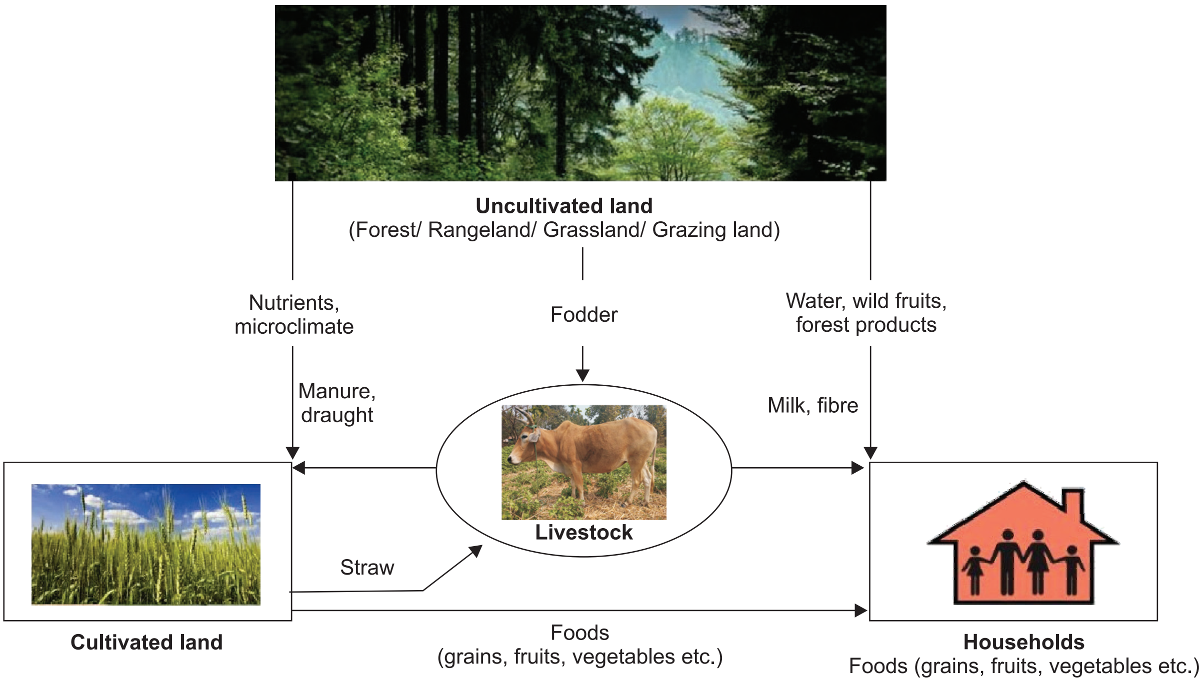

Fig. 2. Nutrient flows mediated by livestock in a traditional agroecosystem.

promoted and managed biodiversity in agriculture. Biodiversity, as a rule of nature, enhances resilience and sustainability (Singh 2002, Singh and Gaur 2007).

One of the by-products of the draught animals is manure obtained by converting cellulose-rich feeds into dung, which, in turn, is used in preparing manure – a critical input for soil fertility amelioration. The draught animals improve soil fertility by voiding dung and urine while working in the fields. *In-situ* fertilization of the soil has been a practice adopted by farmers especially in the Himalayan mountains. Green crops cultivated by using DAP enhance carbon sequestration through photosynthesis, further aiding the process of climate mitigation. Here, one can argue that crops grown by using tractor also contribute to carbon sequestration. However, the tractor, power tiller and other machines used in cultivation involve energy derivable from petroleum products, especially diesel, adding to carbon emission. The other question that can be raised is that ruminants also contribute to global warming by adding methane to the atmosphere. But the role of draught animals in carbon sequestration more than compensates carbon emission by enhancing carbon sequestration.

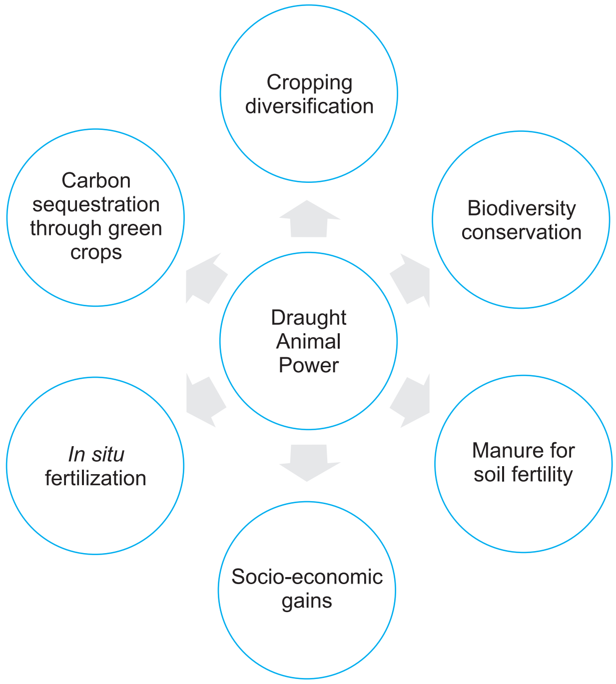

Fig. 3. Attributes of draught animal power for sustainable agriculture.

Environmental impact of overgrazing

All terrestrial animals and those living in lotic ecosystems (creeks, rivers, streams, and canals) and most of those in marine ecosystems and lakes are all dependent on photosynthesis. All herbivorous animals affect ecosystem structure and functioning by browsing photosynthetic plants and/ or the photosynthesizing parts of the plants, thus affecting photosynthetic rates to translate into decreased primary productivity. Grazing livestock are especially accused of ecological damage of the grasslands, pastures and rangelands.

In human-managed grazing systems, the harmful or beneficial effects of grazing are largely determined by how and where the grazing is going on. Type of ecosystem, plant community and specific site conditions are the major factors on which the ecological effects of grazing are dependent.

While moderate grazing or the sort of rotational-cum-deferred grazing are of no serious repercussions as far as their environmental effects are concerned. Uncontrolled grazing or overgrazing by domesticated animals, however, is often of serious environmental consequences. Overgrazing is the state of plant exposure to grazing over extended period or without sufficient time for the plants to recuperate from the damage done by grazing. The overgrazing is assumed under certain specific conditions, such as excessive animal density on the land, lack of proper management of land and animals, grazing at inappropriate times relative to phenology/ productivity cycle.

Grazing animals significantly affect an ecosystem, such as a rangeland, grassland, or a forest by: (i) herbivory, (ii) physical effects, and (iii) deposition. Domesticated ruminants, mainly cattle, sheep and goats, are the grazing animals. While cattle partially subsist on grazing only in a few areas of India, sheep and goat are the classical grazing animals. Large sizes of goat and sheep herds are encountered grazing in all the regions of the country from the Himalayan mountains in the east to the deserts in the west.

The domesticated grazing animals are all herbivores. They defoliate the bushes and small trees and herbs. Intyre *et al.* (2006) in their global synthesis of plant trait responses to grazing reveal the very fact that herbivory by grazing animals is a major driver of global vegetation dynamics. Removal of the chlorophyllous parts of the plants, obviously, results in the diminished rates of photosynthesis. Reduced rates of photosynthesis result in reduced primary productivity, which, consequently, results in fodder paucity and poor animal productivity. Reduced photosynthesis, in addition, has many other negative implications on the environment, including reduced carbon sequestration, contribution to global warming and climate change. Grazing animals consume not only leaves, but also stems, flowers, fruits, seeds and, even roots of the herbaceous plants. In the grasslands, the grazed grasses regrow at the expense of root reserves of energy. Frequent defoliation leads to exhaustion of the root reserves of energy and plants cease to grow. Ovine species are generally close graziers and they also uproot the grass plants, and, thus, accelerate ecological degradation of the grazing lands.

Physical effects of overgrazing include trampling of the vegetation, soil erosion and soil compaction due to hoof action of the grazing animals. Soil erosion rates on mountain slopes are naturally higher than in the plain areas, whereas soil compaction is more likely in the plains. Disturbance to soil leads to deterioration of vegetation cover as well as of soil fauna and flora. The deposition during grazing involves

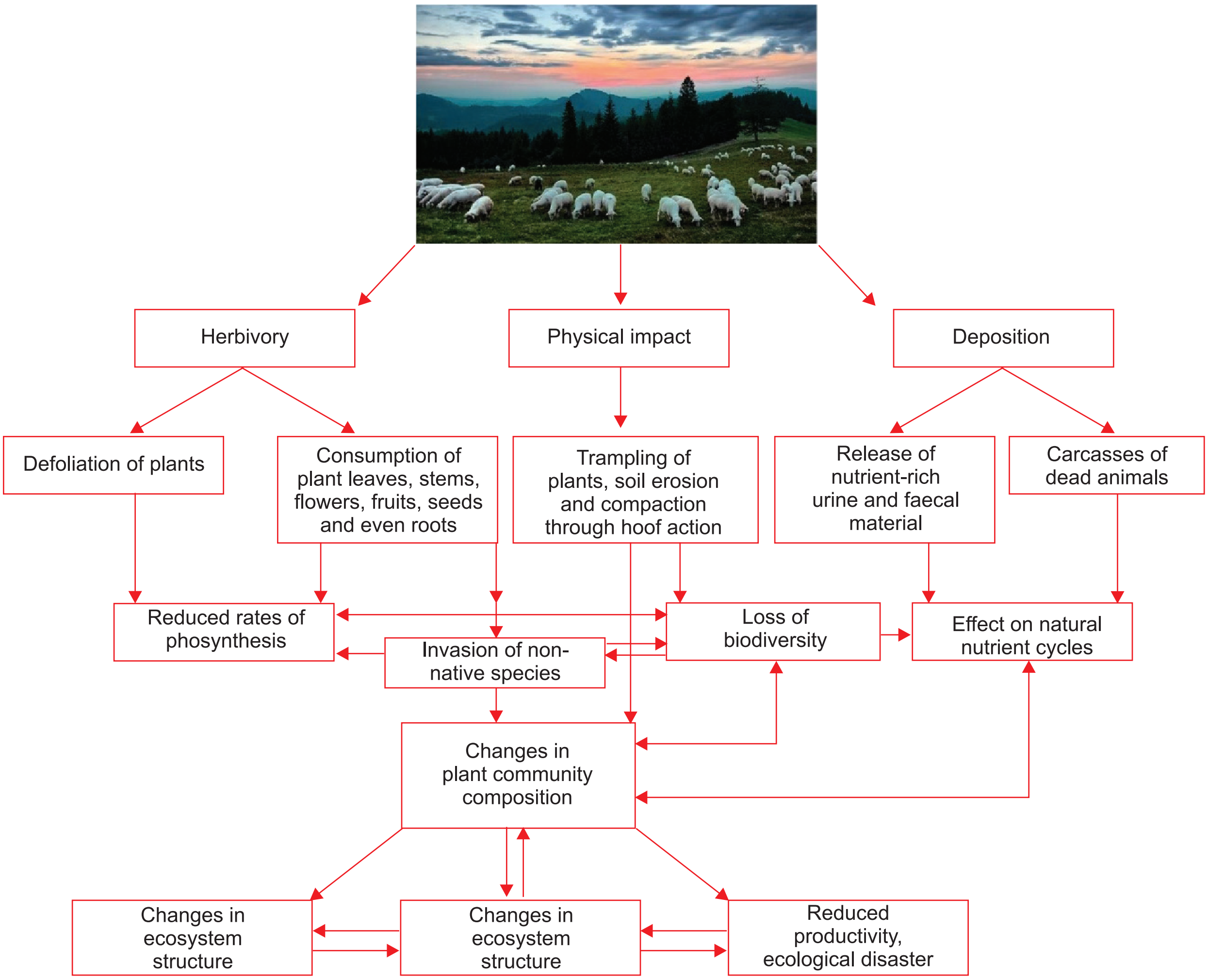

Fig. 4. Environmental impact of overgrazing by farm animals.

release of nutrient-rich faecal material and urine. Addition of these animal wastes induces changes in natural nutrient cycles in the grazing lands.

Revelation of the alteration in the physical structure of plant communities came to the fore through the study by Huntly (1991). His study related that ungrazed pastures harboured higher degree of biodiversity than the grazed ones. Fleischner (1994) in his study on ecological costs of livestock grazing cited several examples as consequences of defoliation, a process that affects plant heights, canopy cover and species composition and overall community structure. Diminished photosynthetic rates, damage of vegetation due to trampling, soil erosion and soil compaction, and invasion of non-native species are the major ecological costs of overgrazing. These changes lead to drastic changes in plant community composition, followed by adverse changes in ecosystem structure and functioning, including reduced productivity of the land followed by that of animals. Triggering environmental impact of grazing has been depicted through Fig. 4.

Farm animals and greenhouse gas emissions

The farm animals are key agents as well as sufferers of the on-going climate change. Singh *et al.* (2017) have extensively reviewed livestock contributions to GHGs on a global scale. Livestock role in land degradation, water pollution, biodiversity erosion and release of GHGs contributes to exacerbate global warming processes (Table 2).

The farm animals play a major role in land use change (overgrazing, deforestation, increased use of cultivated land for feed and fodder production) underlying climate change that connects livestock with the global N and C cycles. The review study by Singh *et al.* (2017) highlights the following facts:

- Farm animals contribute to nearly 18% to the global warming effect. According to FAO, the worldwide emissions contributed by buffaloes, cattle, sheep, goat, camels, horses, pigs and poultry are 7,516 million metric tonnes per year of CO_2 equivalents (CO_2e), that make up 18% of the total global emissions. However, according to the World Watch analysis, livestock and their byproducts actually account for at least 32,564 million tonnes of CO_2e per year, or 50% of annual worldwide GHG emissions.
- Farm animals contribute about 9% of total carbon dioxide (CO_2) emissions, but 37% of methane (CH_4),

Table 2. Farm animals' contributions to environmental degradation leading to global warming and climate change

Land degradation	• The single anthropogenic user of land • The total area occupied by grazing equivalent to 26% of the ice-free terrestrial surface of the planet The total area devoted to feed/ fodder production equal to 33% of total arable land • Expansion of livestock as a key factor in deforestation in many regions of the world • About 20% of the pastures and rangelands (73% rangelands in dry areas) degraded through overgrazing, compaction and erosion triggered by livestock.
Water	• Livestock as key player in increasing water use (about 8% of global human water use, mostly for irrigation of fodder/ feed crops) • One of the largest sources of water pollution contributing to eutrophication, 'dead' zones in coastal areas, degradation of coral reefs, human health problems, emergence of antibiotic resistance, etc. • Animal wastes as a major source of water pollution.
Biodiversity	• Livestock account for about 20% of the total terrestrial biomass and 30% of the Earth's land surface which was once inhabited by wildlife • Livestock as major drivers of deforestation, land degradation, environmental pollution, sedimentation of coastal areas and facilitation of invasion by alien species; etc.—all leading to biodiversity erosion at a faster pace • Out of 825 terrestrial eco-regions (identified by WWF), some 306 reported to be threatened by livestock • As many as 35 global hotspots of biodiversity identified by Conservation International face serious level of habitat loss due to livestock • Most of the world's threatened species are on account of habitat loss with livestock as a major threat, according to an analysis of World Conservation Union (IUCN).
Atmosphere and climate	• Livestock responsible for 18% GHG emissions measured in CO_2 equivalent—a higher share than transport • Livestock sector accounting for 9% of anthropogenic CO_2 emissions • Emission of 37% of anthropogenic CH_4 (with 23 times the global warming potential – GWP – of CO_2) • Emission of 65% N_2O (with 296 times GWP of CO_2) • Responsible for 64% anthropogenic NH_3 emissions contributing significantly to acid rain and acidification of ecosystems.

Source: Singh *et al.* (2017).

and 65% of nitrous oxide (N_2O).

- Annual methane production per cattle head in India (35 kg) is much lower that of a European cattle head (95 kg for a cow in Germany). According to Sirohi and Michaelowa (2007), India's contribution to the annual global methane budget is the highest, which is only owing to its huge animal population.

Conclusion

Farm animals are integral biotic components of the environment and phenomenally influence the processes leading to sustainability. Being the most dynamic entity of the biosphere, the animals exert seminal influence on our environment and, therefore, on sustainability. They play both positive role (for example as revealed through soil-plant-animal relationships, nutrient transfer and recycling, and draught animals' role in sustainable agriculture) and negative role (for example environmental degradation through overgrazing and carbon emissions, especially in the form of methane and nitrous oxide). A diversity of animals in the wilderness play key role for sustainability. The farm animals, however, often involve in adding to environmental degradation and carbon emissions exacerbating global warming and consequent climate change. In traditional agricultural systems, draught animals' contribution more than compensates carbon emissions.

The global warming and unsustainability inducing negative role of the farm animals is not on their own. It is attributable to human management of the animals. A sound ecological management of forests, rangelands, grasslands, grazing lands and other types of uncultivated lands, soil fertility management and livestock management would phenomenally help turn livestock resources into eco-friendly components in agroecosystems. Our humane behaviour and recognition and implementation of animal rights would greatly assist us in evolving sustainable paths with the animals playing central role.

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