MANAGING CATTLE FOR INTEGRAL BENEFIT IN INTERNATIONAL PERSPECTIVE

by John Wibberley[1]

Abstract

Two contrasting trajectories of developing farm management are applied to cattle. There is widespread media vilification of cattle as harmfully contributing to global warming through gases they naturally emit. Agricultural and environmental management considerations must be sustainably integrated. Cattle are major converters of human-inedible food from grasslands into forms for human consumption as meat, milk and dairy products, along with important by-products of dung and urine, hides, skins, hoofs and horns. However, cattle production can also utilise other plant material derived from various arable crops (cereals, oilseeds, pulses) – some grown where climate-protective forests once thrived. Intensive cattle production under controlled conditions of feeding, housing and veterinary care from herds of younger average age can dilute concomitant gases emitted per kilogram of product, and both genetics and diet can be adjusted to reduce generation of these polluting gases through modified cattle metabolism. By contrast, it is reckoned that at least 25% of global land is grassland requiring cattle and other grazing animals as human food producers, for biodiversity of plant, insect and microbial species within them, and for carbon sequestration. Alternative international cattle-keeping systems are considered in the light of the above points and management recommendations suggested accordingly.

KEYWORDS: Cattle; Gases, Grasslands; Management; Agro-ecology; SOC (Soil Organic Carbon)

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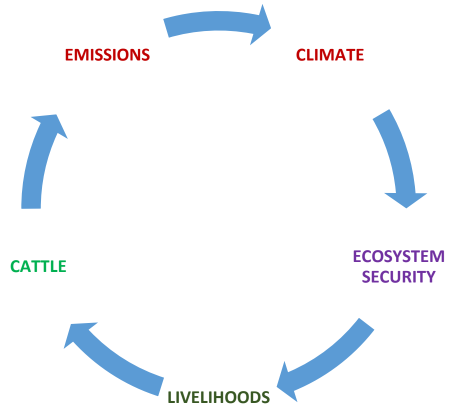
Introduction & Purpose

Cattle provide multiple products and are in themselves a portable source of wealth, hence the linguistically-related term ‘chattel’. In management thinking, it is tempting to isolate that which is managed from its context so that the differential between inputs and outputs can be more clearly controlled and determined. Thus gross margins, net margins and various efficiency ratios are calculated, positive factors enhanced and negative ones reduced. In specialist production scenarios, it becomes desirable to minimise all factors other than the focal product sought. Thus, in specialist cheese-production everything else is deemed inconvenient or at best subsidiary – from dung, urine, greenhouse gases (GHGs), hides and skins, hoofs and horns, and calves to carcasses. The quest is to maximise the margin between desired product and all other factors inevitably associated with its generation. All advances in science and technology are brought to bear in producing the desired output and reducing unwanted by-products, thus improving margins. For cattle (and other ruminants), emphasis has become focused on greenhouse gases (GHGs) emitted as a natural part of their metabolism. By increasing output of the desired product with improved breeding and feeding, gases emitted during production are diluted per kilogram of output. Furthermore, when science and technology are applied through breeding, feeding and biochemical manipulation of rumen metabolism, GHG output per animal can be reduced. Thus is driven the treadmill of intensification and industrialisation of cattle production, with progressive disconnection of cattle from their natural habitats and their roles in ecology and culture (Fig.1). Owing to anthropogenically-attributed (human-induced) climate change and loss of biodiversity, agricultural policy emphasis is now on using public money for public goods (Wibberley, 2020). Past *subsidies* for agricultural production to bolster prices are replaced with *rewards* for management in ways that provide sustainable benefit to society i.e. ‘public goods’. Cattle farming systems which manage animals more directly from a basis of their natural habitats and diets also provide those public goods. Notable among these is the sequestering of soil organic carbon within pastures and grazing lands such as range and savannas, and the encouragement of biodiversity net gain (BNG) with diverse flora, fauna and microbial life. Integral management to deliver these complex benefits is more challenging than simplistic industrialised, intensive management. Thus contrasting cattle management trajectories vie.

Fig.1.Cattle: Global Value & Management	**EITHER:-** **Engineered intensification to**	**OR:-** **Agro-ecological integration of cattle**

	**maximise kilos of meat or milk produced per animal with contrived suppression of methane production**	**within habitats for Biodiversity Net Gain & healthy SOC turnover linked to cultural & economic sustainability**

Cattle are fundamental to agricultural economies worldwide (Youatt, 1834; Porter, 1991; Walling, 2018; Dessie & Mwai, 2019; Rebanks, 2021; Fig.1). FAO reckons around 25% of the total surface area of our planet is made up of **grasslands,** and 70% of the **world** agricultural area. Grasslands are key to carbon capture to mitigate global warming and ruminant blame for it (www.pastureforlife.org).

Carbon, Climate change and Cattle reviewed

Carbon dioxide (CO_2) occupies 0.03% of air, while gaseous nitrogen (N) occupies over 79% - leaving over 20% to oxygen, plus a trace to the 'inert' gases. Air has a relatively constant ratio of one trillion normal 12C atoms to one radioactive 14C atom. 'Net zero' carbon is the result of balancing carbon release into the atmosphere by various human-induced means with carbon sequestration in plants, animals, micro-organisms and soils. The UK target is to attain 'net zero' by 2050 while the NFU in England and Wales has set 2040 as its target year for agriculture (IfA,2021; www.rase.org/reports).

Changes in climate in relation to agriculture have long been documented (Baker, 1883). In Britain, warm periods meant vineyards were planted one thousand years ago. Then in the seventeenth century, there were times of cold winters when even the River Thames in London and many waterways in The Netherlands and Denmark froze over. After all, climate is the long-term trend of weather patterns. Current global warming seems beyond doubt; that this is at least exacerbated by activities of us 8 billion humans is widely agreed. In particular, burning of fossil fuels while expanding industrialisation is blamed for increasing emissions of the 'greenhouse gases' (GHGs) i.e. those which tend to trap warmth within the atmosphere such as carbon dioxide, nitrous oxide and methane, as well as toxically concentrated chlorofluorocarbons (CFCs) which are largely banned as a result.

Carbon dioxide, nitrous oxide and methane are widely found within natural cycles. There are some 1.4 billion cattle worldwide, plus some 1.1 billion sheep, 0.9 billion goats and 0.2 billion Asian buffalos, and other ruminants such as deer – all of which produce these gases.
The 100-year global warming potential (GWP) of methane (CH_4) is 21 times that of CO_2, and the GWP of nitrous oxide (N_2O) is 310 times that of CO_2 (EPA, 2014). Cattle generate CO_2, CH_4 and N_2O and are thus simplistically vilified by some as prime culprits causing global warming (see for instance the powerful but exaggerated video *Cowspiracy*, Andersen & Kuhn, 2014); however, they had to retract their original grossly exaggerated claim that animal agriculture – cattle especially vilified - is responsible for 51% of GHG emissions; they replaced this with the still over-estimated suggestion of 18%. This was probably based on the FAO (2006) overestimate that 18% of human-induced GHG emissions come from livestock. IPCC (2014) reckoned that **agriculture as a whole produced about 10–12% of man-made GHG emissions in 2010.** In the UK, where two-thirds of farmland is only suitable for grazing livestock, 56 per cent of the roughly 49m tonnes of CO_2 equivalent emitted annually comes from methane; nitrous oxide accounts for a further 33 per cent and carbon dioxide 11 per cent, according to UK government statistics (Defra, 2017). FAO (2019) now reckons livestock contribute 10% of anthropogenic GHG emissions. The USA Environmental Protection Agency reckons it to be 9% - still a challenge to be mitigated by improved management of cattle, of course. Land Use, Land-Use Change, and Forestry in the USA is a net sink and removes approximately 12 percent of all GHG emissions (EPA,2014). Initial calculations of the carbon footprint of cattle used by the IPCC did not recognise the variety of management systems globally for rearing cattle and seemed to simply use global figures for cattle numbers coupled to the output of carbon dioxide, nitrous oxide and methane from these numbers without considering the whole farming system – or indeed the agro-ecosystem. The FAO says animal agriculture is only responsible for 14.5 percent of greenhouse gas emissions, in a report published in 2018. Considering data from 245 countries since 1990, the world's food systems are responsible for more than one-third of global anthropogenic GHG emissions, according to FAO (2021 @Nature; @ FAO, co-author Francesco Tubiello).

Importantly, improved and fairer assessment of GWP* (global warming potential star) is needed to adjust the established climate metric of GWP100 because GWP* better describes actual warming caused by methane (CH_4) emissions. For instance, using GWP100, over 100 years a constant annual rate of CH_4 emissions may be misinterpreted as having a 3-4 times higher impact on warming than is actually observed. Allen *et al* (2018) were instrumental in the development of the GWP* model, and are now urging its adoption in global climate policy since it more fairly accounts for differences between various types of emission in favour of actual warming potential.

Measuring Carbon Footprints of Cattle Farming

Capper (2012) advised that carbon footprint of cattle systems be measured per kilogram of product, and on that basis it has favourably declined over recent decades. She cites the USA where dairy cattle numbers are roughly one-third of 70 years ago yet milk produced per cow has quadrupled owing to better genetics, feeding and management. *Arla* Foods — a dairy co-operative of 11,000 farmers in seven European countries, including the UK — has reduced its carbon footprint by over 22 per cent since 2005, while milk production has risen by 40 per cent, by using renewable energies, reducing waste to landfill, and improving yields from dairy herds. *Arla* recently set more ambitious targets: to reduce GHG emissions by 30 per cent per kilo of milk over the next decade, and to work towards net zero by 2050.

Life Cycle Assessment (LCA) is needed to quantify whole livestock systems in environmental context (Pelletier *et al* 2010; McAuliffe *et al* 2018a, 2020). SEEBALANCE® is a software tool developed by BASF Corporation to analyse whole systems and was used to quantify USA beef sustainability – taking account of economic, social and ecological impacts along all segments of the beef value chain.

The Global Platform set up in 2012 (www.globalfarmplatform.org**)** aims for sustainable and responsible production of healthy food from healthy ruminants.

Defending Climate Change accusations against Cattle

Huge research efforts are ongoing to assess the climate impacts of cattle systems, pioneered by such as Pitesky *et al* (2009). What factors constitute responsible cattle management systems?

Beef production generates a carbon footprint ranging from 10.7 to 22.6 kg of carbon dioxide equivalent/kg of live carcass weight depending on diet and system of production (Desjardins *et al*, 2012). The cow-calf stage is the major contributor of GHGs. However, results reported are contradictory. According to Boadi *et al* (2004) cattle fed high-grain, low-forage diets produce 42% more methane than those fed low-grain, high-forage diets, although the higher roughage (fibre) content of a barley-based finishing diet generated more methane than one based on maize. Grass-finished animals use foodstuffs inedible to humans often found on land unsuitable for arable cropping. These grasslands and pastures sequester carbon dioxide from the atmosphere, helping to mitigate global warming. Research has shown there is an advantage for grass-finished over grain-finished beef production if feed conversion is expressed as human edible energy returned per unit of human edible energy consumed by the cattle (Wilkinson, 2011). Accounting for carbon sequestration by pasture land, grass-finished beef could lower the carbon footprint by 42% (Pelletier *et al*, 2010). Stanley *et al* (2018) suggest that adaptive multi-paddock (AMP) grazing can contribute to climate change mitigation through soil organic carbon (SOC) sequestration and challenge existing conclusions that only feedlot-intensification reduces the overall beef GHG footprint through greater productivity.

Understanding to Manage the Carbon Cycle

Cattle manures, urine and volatile methane act as primers of the natural carbon cycle. Soil organisms are crucial to soil organic carbon (SOC) sequestration in pastures (Lal, 2004). It has long been understood that soil organic matter (OM) as it decomposes to form humus, develops a Carbon to Nitrogen (C:N) ratio of approximately 10:1. Cattle manure and urine is a rich source of the nitrogen which is generally deficient in plant material entering soils as crop residues; furthermore, grazing cattle are their own manure-spreaders! Nineteenth-century agriculturalists expressed the wisdom that a pasture's fertility and thus productivity of meat or milk was proportional to the weight of earthworms within its soil. In NZ, Schon and Dominati (2020) have been evaluating earthworm contributions to ecosystem services, including carbon sequestration. In African soils both earthworms and termites are important operators within the Organic Cycle, as are dung beetles ubiquitously. Cattle kept in pasture-based systems and within integrated farming systems are net capturers of carbon into the soil to boost its fertility. Not only does that OM boost nutrient-holding capacity but also improves the infiltration of plant-available water, and the soil's capacity to resist erosion. Over 25% of the world's land is grassland, and cattle are key creatures in its proper ecology and utilisation. Grazing livestock are crucial to maintain the ecosystems of all of the UK's National Parks which are conserved for their habitat qualities and required to provide public access and education. They demonstrate the utter inter-connectedness of natural systems and require freedom of policy for experienced farmers to manage their cattle to deliver these benefits sustainably (Wibberley, 2019). Microbiology is fundamental to soil management (Wibberley, 1987); the activity of soil organisms in continually decomposing and replenishing soil organic matter is crucial to its quality, as with the capital in a business. It is not the amount of capital in a business that signifies its health but rather the turnover of that capital.

Methane is a GHG produced by methanogens in the cattle gastrointestinal microbiome, as a by-product during microbial fermentation of feed in the rumen. Methane is released into the atmosphere via manure and mainly through cattle belching; indeed, failure to do so leads to bloat which requires use of a trocar and cannula inserted into the animal's flank behind the last rib to release the trapped gas. Methane belched by cattle does not accumulate but breaks down in the atmosphere in about 10 - 12 years (Mitloehner, UC Davis, CA, USA).

However, it is clear that relevant management strategies will include:-

a) Reducing methane and nitrous oxide output from cattle farming systems
b) Better capturing (sequestering) of carbon within soils of pasture land

McAuliffe et al (2018) note that poorly performing beef animals generate emissions which become exponentially greater as their average daily live-weight gain decreases. Thus, all measures to manage livestock against drought, hunger and disease help to mitigate their negative climate impacts.

For Agriculture to combat climate change, policymakers need to both penalise excessive carbon emissions and promote carbon storage (Helm, 2015).

Improved Cattle Feeding Management & Feed supplements versus Methane

All measures of good husbandry and stockmanship need to be applied to optimise feeding and management of cattle (Stansfield, 1983), as well as choosing ecologically adapted breeds.

Certain feed supplements can modify rumen methane production. The EU rightly banned hormone growth promoters in 1981. In 2006, the EU also banned a rumen additive, monensin sodium, which is both an antibiotic produced by *Streptomyces cinnamonensis* and effective in sodium salt form as a coccidiostat taking out the rumen protozoa which produce methane. Without these protozoa, feed efficiency improved by around 5% and so on similar diets the cattle given monensin sodium grew faster than the controls (Crabtree, 2021). Monensin sodium is somewhat controversially still used in some countries, including the USA and since 2019 there as Monovet 90, the first generic monensin for use in cattle.

Bovaer® is a **feed additive for cows** and other ruminants, researched and developed over 10 years by DSM. Just a quarter teaspoon of Bovaer® per cow per day suppresses the enzyme methyl coenzyme M reductase (MCR) that triggers methane production in a cow's rumen and consistently reduces enteric methane emission by approximately 30%. Its active ingredient is 3-NOP **(3-Nitro-oxypropanol)** which breaks down to natural compounds during digestion.

Natural materials used directly, such as seaweed and tannins, can be added to feed to reduce methane. One certain type of seaweed has been found to reduce methane production by 80% in Australian cattle (agric.wa.gov.au). At the University of California, Davis, Ermias Kebreab showed that there is up to a 60 percent reduction in methane emissions by using 1 percent of seaweed in the diet. It is unlikely that wild harvesting of this red seaweed (*Asparagopsis taxiformis*) could provide enough supply for broad adoption. Other scientists are looking for ways to grow it to scale, to supply increasing demand for natural methanogenesis-suppressing feed additives.

Cattle Management Systems found internationally

These can be summarised as:-

- **Nomadic pastoralism**: where much indigenous knowledge is involved in matching cattle to resources although many pressures are exerted on the system by urbanisation and climate change (Fre, 2018)
- **Range management**: where managing grassland ecology is key for livestock, livelihoods, and for biodiversity including wildlife (Roberts & Wibberley, 2019)
- **Ranching –** when cattle are more closely controlled, typically fenced rather than herded (Smith, 2006)

- **Rotational grazing** e.g. Adaptive Multi-Paddock grazing with fences or herdsmen, whereby mobs of cattle are moved systematically around the pasture to allow for it to recover and for cattle to avoid their own parasite build-up (Teague *et al*, 2016). This system helps develop soil biology, improving soil organic carbon (SOC), rainfall infiltration, and soil fertility. More carbon dioxide equivalents are sequestered into the soil than are emitted by cattle under such management; in Texas, this amounted to soil carbon (SOC) increasing at a rate of 2.5 tonnes per hectare per year.
- **Zero-grazing or stall feeding** – in which cattle can be rationed with locally-grown feed and crop/vegetable by-products such as sweet potato tops; in integrated mixed farming small-holder systems cattle are valued for their manure, urine (for natural pesticide making as well as for its nutrients), for their milk, meat, hides, horns, calves to sell and as an asset (chattel) in themselves (Kinengyere-Mango & Wibberley, 2006); net positive carbon capture is some 2.5 times greater than cows' emissions.
- **Tethered House Cows and domesticated draft oxen** – as above for zero-grazing and with strong relationship built up between keeper and animal.
- **Intensive, high input/high output feedlot systems** emulating USA and globalised approaches, although this may be only used for the last 80-85% of a beef animal's life in order to finish it for market; close control of feeding, health and live-weight gain plus possible use of feed supplements can reduce carbon release per kilo of product.

Improving Management of Cattle Systems

Kasyoka (2018) describes the Sustainable Livestock Systems programme of ILRI, with research at the Mazingira Centre in Kenya and elsewhere in East Africa. It focuses on understanding and managing the environmental footprint of agricultural systems without hindering productivity.

In Zimbabwe's Africa Centre for Holistic Management (AHCM) focus is on ecological processes, low-stress herding and livestock handling, water infrastructure for large herds, lion-proof kraals, elephant-deterrent cropfields, and other aspects of management which improve profitability sustainably, including carbon capture (Savory & Butterfield, 2016).

In Scotland (SRUC, 2020), measures which generated the greatest reductions in carbon emissions included:

- Reducing age at slaughter to 18 months,

- Reducing age at first calving from 3yrs to 2yrs,
- Improving grassland management,
- Use of nitrification inhibitors in artificial fertiliser.

Also in Scotland, research by Kamilaris *et al* (2020) suggests that more intensive shorter duration systems have the lowest environmental impact of all the systems investigated. However, medium duration (i.e. 18–24 months) pasture-based beef production systems in Scotland were found to achieve a balance between financial returns and environmental performance.

In Wales, strategies advocated by *Farming Connect* to reduce carbon footprint at farm level include:-

- Increase number of calves reared from 80 to 85%
- Reduce cow size from 700 kg to 500 kg
- Increase lambs reared from 120% to 140%
- Eradicate BVD (Bovine Viral Diarrhoea) from a beef herd
- Prevent Johne's Disease affecting 10% of a dairy herd
- Pay attention to agricultural soil health

Thus, as well as advocating life cycle accounting, pasture-based beef systems can be carbon negative depending on the organic matter captured in the soil and there is much that can be done by better management towards that.

Conclusions

Carbon sequestration is now a key criterion when comparing agricultural systems for their capacity to either aggravate or to mitigate global warming. Post-COP26 in 2021, 'net zero carbon' is now a target of governments and organisations though pursued with varying degrees of ardour and completion dates. Research and data on this are both ideologically susceptible *per se* and also liable to isolated treatment as the sole criterion of policy by those who espouse climate alarmist views. Neither human panic nor climate alarmism seem appropriate ways forward to mitigate and manage climate change, but rather pursuit of responsible lifestyles and caring management (conservation). While those who wish to espouse a vegetarian or even a vegan diet from deeply held beliefs should be respected to choose, so also should they respect choices of the omnivore majority who value the ecological role of cattle and choose to enjoy their products. 'Conservation Agriculture-based Veganic Agroecology' (Kassam & Kassam,

2021) is not an inclusive rallying cry for concerted agroecology championing by the omnivore majority – which is so urgently needed.

Conservation Agriculture (CA) aims to regenerate soil health and to develop resilient agro-ecology, to improve net profitability, and to enhance water management (Kassam, 2020). Proper integration of livestock within CA hugely enhances its success. Sometimes claims for specific but unmeasured scientific benefits of holistic management by enthusiastic practitioners such as Savory & Butterfield (2016) have led to controversy with some scientists. Nevertheless, farmland-specific sustainable grazing management has been shown vital for ecosystem security - maintaining habitats, biodiversity and livelihoods. As per the adage, *the proof of the pudding is in the eating*! Intelligent management of cattle is required so that they can graze relatively intensively in mobs and then allow periods for the grassland to recover itself before they return to it. Balance between overgrazing and undergrazing is achieved by the art of good husbandry. Replacement of tropical rainforest with huge-scale cattle feedlots and annual crops to feed them is clearly 'carbon footprint disastrous'. However, while treasuring trees (Wibberley, 2014), it is a mistake to perceive planting trees as a 'cure-all' for global warming mitigation along with peatland restoration, while ignoring the more than equivalent per hectare potential of well-managed pastures to sequester carbon, and to do so while producing food and with less risk of wildfire losses.

Properly managed cattle in grassland ecosystems are not a threat owing to their carbon emissions but rather they offer a vital agro-ecological opportunity as net capturers of soil organic carbon. Their dung and urine nurtures species-rich grasslands! Consumers increasingly seek proven environmentally-friendly livestock products.

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