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1. Abstract

There is an urgent need for sustainable animal production systems. A system or procedure is sustainable if it is acceptable now and if its expected future effects are acceptable, in particular in relation to resource availability, consequences of functioning, and morality of action. What might make any animal usage system unsustainable? The system might involve depletion of resources such that a resource becomes unavailable or a product of the system might accumulate to a degree that prevents the functioning of the system. However, any effect which the general public find unacceptable makes a system unsustainable and some of these are discussed here. Animal welfare is a component of sustainability and of product quality. Like health, welfare means exactly the same for humans and non-humans. The one-health and one-welfare concepts are important. Semi-intensive silvopastoral systems can improve use of world resources, farm economics, the environment and animal welfare.

2. Sustainability

Systems were initially called unsustainable when a resource was depleted so much that it became unavailable to the system, or when a product of the system accumulated to a degree that prevented the functioning of the system. Now, the meaning of the term is much wider; for example, a system can be unsustainable because of negative impacts on human health, animal welfare, or the environment. A definition of sustainability is: a system or procedure is sustainable if it is acceptable now and if its expected future effects are acceptable, in particular in relation to resource availability, consequences of functioning, and morality of action (Broom, 2014 modified after Broom 2001, 2010). The development of new, sustainable systems is urgently needed because of industrial and livestock production practices. Consumers now include the ethics of food production in their evaluation of product quality (Broom, 2010). Methodologies to use include those of life history studies and evaluation of externalities. The opinion of the public is based on a range of components of sustainability, described briefly below.

3. Efficient use of world resources

At present, some food for humans and for farmed animals is wasted. Much food that humans could eat is given to animals that will be eaten by people, a much less efficient process than for the humans to eat the food directly. What can be done in animal production

to exploit existing resources better (Herrero et al., 2010)? The most important animals for food production are those that eat food that humans cannot eat. Hence, herbivores eating forage plants, not cereals, are much more important than pigs or poultry, which compete with humans for food (Broom et al., 2013). Similarly, herbivorous fish are more important than those fish that eat other fish.

Land and water used for agriculture are sometimes not exploited efficiently and too much energy from fossil fuels is used in cultivation and transport of feed and products. A study of land and water use in four beef production systems (Broom in prep) took account of keeping the animals and the food produced for them. It showed that total land use was similar for feedlot systems and fertilized pasture but 2-3 times more for extensive pasture and 4-5 times less for semi-intensive silvopastoral systems. Water use was lowest for the silvopastoral systems, a little higher for extensive pasture and very much higher for fertilized pasture and feedlots. Maintaining resources, such as soil with good structure, and retaining water that might be lost from the soil are important objectives, as is minimising usage of carbon-based energy and imported fertilisers. Soil is often damaged by tillage and greenhouse gases emitted (Pagliai et al., 2004).

4. Adverse effects on human health

Some foods are regarded as being better for the health of the consumers because of the nutrients present in them. A major effect on animal production in recent years, of attempts to provide a healthy diet, has been the dramatic increase in the production of farmed fish, in part because they contain poly-unsaturated fats (Wall et al., 2010). As open-water fish management has failed in most parts of the world, fish-farming has increased and is likely to increase further. In the future, for resource-usage reasons, herbivorous fish are likely to be the most important species and the welfare of fish and impact of farms on the environment will have to be fully considered. In all aspects of farming, antibiotic use will have to decrease. This is because of the development of antibiotic resistance, largely because of misuse of antibiotics in human medicine, but partly because of use for livestock growth promotion, rather than therapeutic use (Ungemach et al., 2006).

5. Negative impacts on animal welfare

Poor animal welfare is probably the third most important reason for unsustainable livestock production. Welfare is the state of the individual as regards its attempts to cope with its environment (Broom, 1986), so it can be measured scientifically. Measures of animal disease are often important, because health is a key part of welfare. Other measures, for example of behaviour, physiology, immune system function, and body damage, are described by Broom (2014) and Broom and Fraser (2015). Like health, 'welfare' means exactly the same for humans and non-humans and medical and veterinary studies are relevant to one another. Poor welfare is associated with immunosuppression and hence linked to disease and anti-microbial use and some widely-used animal housing systems are unsustainable (Broom, 2017).

6. Harmful environmental effects

Agricultural methods that result in low biodiversity are a consequence of widespread herbicide and pesticide use and perceived to be the norm by many farmers and others. However, biodiversity on farmland can be much increased in some systems. Livestock production can

also result in pollution, locally and on a world-wide scale, e.g., via greenhouse gas production. Greenhouse gas production should be reduced and may have to be balanced against efficiency of use of world resources (Broom et al., 2013, Balmford et al 2018).

7. Unacceptable genetic modification

Many people in the world are unwilling to accept the use of genetically modified plants and few people accept the use of genetically modified or cloned animals. One reason for this is dislike of modifying what is natural. Another is that modified organisms may have allergenic proteins and many of the public do not believe that proper checks on such possibilities are in place. Genetically modified animals may have major welfare problems so there should be checks using a wide range of welfare indicators before they are used for any purpose (Broom, 2008, 2014). There are always welfare problems when farm animals are cloned.

8. Not being “fair trade”

In recent years, consumers in many countries have been appalled to find that food producers in poor countries are often not properly rewarded for their work. Most profits from the sale of some basic products bought by many people are found to go to large companies. As a consequence of publicity about unfairness to poor producers, products like coffee, cocoa, and fruit are among those that are independently checked and have a Fair Trade label (Nicholls and Opal, 2005). The producers then receive a larger part of the money paid by shoppers in relatively rich countries.

9. Damage to rural communities

When small-scale rural farmers are out-competed by large-scale production, local communities may disappear. The general public often find this unacceptable; so, schemes are introduced by governments to safeguard such communities. Consumers may also buy locally produced products, regarding this as a part of product quality. In the European Union, subsidies to preserve rural communities have prevented large cities from increasing in size (Gray, 2000; Broom, 2010).

10. Semi-intensive silvopastoral systems

The production of leaves and other materials that can be eaten by farmed animals is much greater in silvopastoral systems than in pasture-only systems. Results from tropical and sub-tropical studies, especially in Mexico and Colombia, show that cattle production can be better. Three-level forage production produces more usable plant material than pasture only. Nitrogen-fixing plants are used; so, less artificial fertiliser is needed. Three-level silvopastoral systems generally have better soil structure, better water retention, and less soil loss (Murgueitio et al., 2008; Broom et al., 2013). They have much greater biodiversity than monoculture, single-level systems. Animal welfare is better in various ways than that on pasture-only systems.

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