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Research Article

Sustainability-Key Element for Future Dairying

Jörn Hamann*

Institute of Food Quality and Safety, University of Veterinary Medicine Hannover, Hannover, Germany

Abstract

Milk production has to be increased in relation to the increasing demand for milk and milk production. The goal for sufficient milk production can be reached based only on conventional dairy farming. The marked changes in our environment (e.g., climate, soil degradation, water quality and availability, deforestation, greenhouse gas emissions, waste quantity, biodiversity) indicate that conventional farming, at least to some extent, should be changed to sustainable production systems. Sustainable smallholder dairy production systems will get a dominant role for the increase in the global milk production. Such dairy production systems are characterized by the following criteria:

Efficiency in the management of natural resources

- No evidence of resource degradation, e.g., soil fertility
- Promotes maximum use of indigenous materials and high degree of self-reliance
- Maximizes the use of available labor and creates employment opportunities
- Improved livelihoods of the rural poor

Keywords: Food insecurity; Future dairying; Sufficient milk production; Sustainability; UN sustainable goals

Introduction

The current world population amounts to 7.6 billion people of which 4.2 billion (54.9 %) are living in urban areas [1]. In 2022 India's population will become the largest population in the world [2].

***Corresponding author:** Jörn Hamann, Institute of Food Quality and Safety, University of Veterinary Medicine Hannover, Hannover, Germany, Tel: +49 4315837488; Fax: +49 4315901904; E-mail: jha911@hamann-kronshagen.de

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Climate change and globalization are the main factors influencing nearly all areas of life. The main global question consists in evaluating factors influencing the future food security. What this means: Can we really feed a world population of more than nine billion people? The key bases of our agricultural systems are soil, water and climate. Improvement of agriculture efficacy in combination with keeping the status of the key elements at the given level or better is necessary to take care for food security for further generations sustainability. The demand for food will be about 60 percent higher in 2050 compared with 2005-2007 [3]. Table 1 gives the trends in World population and used arable land (A hectare (Symbol ha) is an area equal to 10.000 square metres) based on different calculations [4-6].

Year	Population (billion)	ha/capita
1950	2.5	0.56
1975	4.0	0.36
2000	6.0	0.24
2007	6.7	0.22
2017	7.6	0.20
2030	8.5	0.18
2050	9.7	0.16

Table 1: World population and arable land/capita.

The stabilization of the actual volume of global food production (e.g., milk: 817 Mio metric tons [7]; grain: 2600 Mio metric tons [8] and the required increase related to the population growth can only be achieved by increase in agricultural productivity. Especially in smallholder dairy farms sustainable dairying offers in comparison with conventional dairy farming advantages for productivity increase. The majority (> 80 %) of the food demand increase must be compensated by improvement of agricultural productivity (e.g., following the principles of sustainable agriculture), because the potential to increase the arable land is very marginal (about 5 %) [9,10]. Actually, there are worldwide 815 million people undernourished [11]. Overall, the elimination of hunger reached great progress, especially over the last 15 years, yet the absolute number of hungry people are also today too high. If the Global Hunger Index (GHI) score of a country (e.g., the percentage of the undernourished population) increases, the hunger situation is worsening [12].

Sustainability

Around 30 years ago, the World Commission on Environment and Development [13] defined the term sustainability as follows: "Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs". Despite the widely accepted definition, it seems difficult to come to a generally acceptable version of the term sustainability. Sustainability includes very different aspects, what as an interactive compound resulting in a balanced planet to ensure survival of all biological systems for future generations [14].

The inventor of the term sustainability, Hans Carl von Carlowitz, has stressed about 300 years ago, economy, social welfare and Mother Nature are equal parts of this term [15]. It has been and it is actually time by a multifactorial scale of aspects to come to an international agreement to realize and to achieve sustainability. This is the only way for a successful control of global hunger, including also future aspects for the humankind [16]. This statement was confirmed by many scientists and organizations such as: The German Farmer's Association stressed that sustainable agriculture is the key for the world nutrition [17]. The NEWFORESIGHT, [18], stated," sustainable intensification is an absolute necessity". As early as 2011, the OECD defined six key thematic areas of sustainable development, shown in table 2 [19].

	Six key thematic areas
1	Sustainable consumption and production
2	Climate change and sustainable development
3	Sustainable trade and foreign investment
4	Subsidy reform and sustainable development
5	Education for sustainable development
6	Environment and health

Table 2: OECD work on sustainable development.

Sustainable Dairying

In front of tremendous changes in world population, arable land availability and all global climate activities must be directed to increase the overall food production by almost 70 % by 2050, corresponding to an annual increase of 1.75 % in productivity to meet the future demand [20]. Only by following the principles of sustainability [21], the most countries have a realistic chance to reach by 2050 the goal to produce demand related quantities of food.

Problems that may counteract sustainable dairy production consist in a wide variation in agro-climatic conditions, biodiversity and ecology, socio-economic and cultural background of people and types/breeds of dairy cattle reared [22]. In connection with introducing sustainable dairying the related information level of all people involved in the milk production and the communication between the farmers are very important. Moreover, there is a strong need for establishing farmer's co-operatives societies and or similar institutions. Learning and education centers in such organizations are key elements as pillars for initiation and performance of sustainable dairying systems. The SAI publication [23] details a set of principles and practices for sustainable dairy farming. The most important key words of this paper are summarized in table 3 [23].

1	Sustainable farming system
2	Economic sustainability
3	Social sustainability
4	Environmental sustainability

Table 3: Principles & practices for sustainable dairy farming.

Sustainable farming systems cover items as farm site selected needs to appropriate for dairy farming activities, sustainable practices for arable feed production (e.g., cultivation/fertilizer management) and milking hygiene and milk storage (e.g., milk protection from any contamination). Moreover, breed selection and health planning (e.g., bio-security) and animal husbandry (e.g., appropriate feed, water, housing, space and behavioral/comfort) are detailed. Chapter 2 consists mainly in viability of business (e.g., potential of increasing output, mix of farming enterprises, food quality and safety and market access). The third chapter deals with social sustainability (social and human capital, what means all people must have appropriate skills and knowledge to take over responsibilities; the working environment must be adequate) and local community/economy (e.g., farming business) must contribute to the resilience and vibrancy of the local community. Aspects of the environmental sustainability (e.g., soil fertility & soil loss, sustainable water management) are discussed in chapter 4. In any case, dairy farming should not impair biodiversity and minimize the amount of waste. Waste handling and treatment must not cause pollution [23]. In addition, the FAO has published a very useful and easy to understand booklet for sustainable dairying in smallholder dairy farms [24].

Knowledge and Skill Level of People Working on the Smallholder Dairy Farms

The total number of farms worldwide amounts to 570 million units. There from, more than 500 million (about 90 %) family farms produce more than 80 % of the world's food in value terms [25]. Most of these small farms are located in the rural areas of the developing world. The majority of the family farmers are poor
and food insecure and have little access to markets and services.

Knowledge and skill level of all people working on a small dairy farm are the most important factors with regard to the acceptance of changing from the traditional mode of dairying to the new mode of sustainable dairy farming. A similar statement resulted from a workshop in Bangkok [26], what identified the developing human resources and knowledge management in the smallholder dairy sector and its supporting organizations as the first key priority [26]. This observation was confirmed during the last 10 years in a lot of developing countries, especially India. The emergence of private service provider in the Indian livestock production sector has modified the face of extension. Very often, public, co-operative and private service providers like para-veterinarians, feed companies, dairy co-operative managers, milk vendors, etc. have taken over the classical extension tasks and roles.

The implication is that the traditional institutions providing training and extension (Universities, veterinary colleges, institutions of the government) have a new role as coordinator and facilitator of special training [27]. This new situation may contribute to decreasing confidence of the adviser's proposals by the smallholders. Changing the mode of dairying needs some financial investment. To say it simple: No money, no change in mode of dairying. There seems to be very often a certain restriction of the formal banking sector concerning providing loans to dairy farmers. Probably, this situation could improve only by a link between credit for animals and a functional livestock insurance system [27]. Another possibility for faster change from the classical mode of dairying to a sustainable type could consist in a much stronger funding by state, regional or local institutions. Furthermore, companies from abroad will contribute markedly to the further development of the dairy sector in developing countries. The Indian National Dairy Research Institute assumed a marked change

in the structure of dairy herds, so that by 2050 the average herd size will be 250 dairy animals [28]. Bram Prins, chairperson of the Global Dairy Farmers (GDF) pointed out: "At some point the strong growth in demand for good quality milk will create room for the international business world to contribute to up scaling, production efficiency and milk quality improvement" [29].

Environmental Sustainability

For this topic, some examples from India are given. In India are 150 million hectares (ha) of land affected by water and wind erosion what corresponds to 46 % of the total geographical area of 329 million ha [30]. The total cultivated area amounts to 170 million ha [31]. About 6000 million metric tons of soil may get lost annually by water induced soil erosion [32]. Furthermore, land degradation (such as salinization, drought, water logging and desertification) may affect large areas of India [33]. Desertification occurs mainly in semi-arid areas. The vulnerability to desertification depends on factors such as fragile soil, population density and a low-input form of agriculture. Different areas (in percent of the total area of India) had the following vulnerabilities: Low: 42, 96 %, moderate: 25, 03 %, high: 6, 94 % and very high: 5, 58 % [34]. Salinization causes reduced plant growth and little microbial activity by osmotic stress and toxic ions [35]. High microbial activity takes care for mineralization of organic matter into plant available nutrients [35]. There is an interaction between soil content of water and salinity what is determining the microbial activity. The understanding of these interactions is important for crop production, sustainable land use and maintaining the soil health [35]. Overall, sustainable land use is able to reduce further soil loss through land degradation. In addition, it is important to stress that in connection with planning of sustainable farming sufficient land and water is available.

Feed and Water Supply

Water has many fundamental functions in living animals. Cattle have continuously a problem of slow dehydration, as the intake of water is intermittent, while water loss (especially during dry periods very strong) is acting permanently. Cattle prefer soft water of rivers or lakes compared to hard water from deep wells. Cattle water requirements depend on factors such as breed, age, body weight, dry matter intake, ambient temperature and milk yield level. Overall, the daily minimum of water per cattle is about 30 l for body maintenance and 3-4 l/kg milk. In some regions is water quality a big problem. Table 4 shows different types of water properties used as quality indicators [36].

Property	Factor, component
Organoleptic	Odor, taste
Physicochemical	pH, dissolved solids & oxygen
Toxic compounds	Heavy metals, toxic minerals
Excess minerals	Nitrates, iron, sodium sulfates
Microbial	Bacteria, algae

Table 4: Properties of water used as quality indicators.

Poor water quality can cause problems in cattle health such as decreasing immunity, reduction in milk yield, infertility etc. Feed costs are for many farmers a main factor for profitability. Green fodder and dry straw are necessary throughout the year as feeding components. This becomes very difficult during dry summer periods or when the monsoon falls. As commercial concentrates are not financially feasible for smallholders, an alternative consist in homemade TMR (Total Mixed Ration) plus green fodder. TMR components are e.g., groundnuts, sesame, and red gram with molasses, salt and vitamins. A 300 kg cattle yielding 20 kg of milk daily requires 13-14 kg of this homemade TMR plus 5 kg of green fodder (fresh basis). This TMR is not too expensive and the quantity of green fodder or dry straw as supplement is small. This is a coming concept for most of the dairy smallholders [37].

Productivity Improvement Under Sustainable Dairying Condition

Overall, financial support for the dairy farms is needed to improve the productivity. This money should be spent for information and education of dairy farmers, the installation of new techniques and modern farming concepts to harvest feed of high quality. There is no doubt that imbalanced and inadequate feeding is the main reason for insufficient productivity in dairying. A second aspect to correspond to the increasing demand for dairy products due to more consumers, higher incomes and changed consumption behavior [38], is the improvement of the genetic potential for milk production in dairy animals [39].

The needed increase in milk production productivity has to consider also potential risks with regard to climate change, water pollution, soil degradation, etc. Therefore, it is very important to find the golden midway between increasing the productivity and sustaining the environment.

Waste Management

In addition to the topic of agricultural waste management at farm level, we should keep in mind the big global problem of food waste as a tremendous risk for sustainable solutions of quite a lot of different areas. The majority of food waste is unnecessary and avoidable. Food waste and losses occur along the food chain (from production, harvest, storage, transport, processing, retail to the consumer [40]). The global waste amounts to a third of our food [41]. The implication is that 30 % of farmland is ploughed, planted, fertilized, irrigated and harvested without any benefit. In addition, considerable environmental and economic impacts may occur. Good practices at the production level and technical solutions for nearly all other steps in the food chain to avoid or at least reduce the losses are available. The most crucial point is the question of investment for such technical solutions. Therefore, policy has the responsibility to regulate this problem [40].

The main goal of agricultural waste management consists in avoidance or reduction of livestock production- related release of noxious gases, harmful pathogens and odor. Livestock waste recycling into biogas, compost and vermicompost can markedly contribute to increase crop yield and sustainability. Experimental biogas bottling plants in India could pure up biogas to 98 % methane content [42]. This can run engines and diesel motor cars.

Under the aspect of sustainability, the agricultural waste management has a high priority to practice a very careful handling with these substrates.

Sustainable Veterinary Medicine

Animal welfare

The importance of animal welfare has been underestimated for long periods. Yet, during the last two decades, more and more it became obvious that animal welfare is not only of interest under academic consideration, but also under practical aspects of animal health, productivity and profitability. In so far, animal welfare is part of the agricultural sustainability. There is no commonly accepted definition for animal welfare. The difficulty in defining welfare consists in the balancing act of implementing the two aspects, i.e., needs and desires (so - called "wants"), and observing both public consideration and scientific issues at the same time [43]. Since welfare includes, to an important degree, emotionally based reflections to exogenous impairment and individual reactions, complete welfare of an animal can be determined on an individual basis only. An application of mean value characteristics will fail to improve the true welfare status of a dairy herd. This means that the cow-individual determination of welfare-related parameters is essential to detect the influence of any treatment or factor. The establishment of minimum requirements consists, on one hand, in attempting to keep a certain degree of homoeostasis as a precondition for a self-regulating effective immune system and on the other hand, in applying a routine status evaluation of every individual cow to improve its welfare. Overall, the control of all factors of influence, especially produced by new technical applications, should enhance the interaction between animal welfare, longevity and economics [44].

For a certain degree of animal welfare, the following "five freedoms" describing the fundamental needs [45]:

- Free from thirst, hunger and malnutrition
- Free from discomfort
- Free from pain, injury and disease
- Free from fear and distress, and also
- Able to engage in normal patterns of animal behavior

The IDF has published a "Guide to Good Animal Welfare in Dairy Production" [45]. Farmers with their overall responsibility for health of their dairy herds should incorporate relevant requirements in their dairy farm system. Table 5 gives the main topics of the IDF Guide.

The five areas for good animal welfare	
1	Stockmanship
2	Feed and water
3	Physical environment
4	Husbandry practices
5	Health management

Table 5: IDF Guide to good animal welfare in dairy production.

Animal hygiene

Max von Pettenkofer (1818 – 1901) has defined hygiene as follows: "Hygiene has the goal to eliminate the negative influences of our environment on our health, to enhance the positives. Therefore, hygiene means to create an environment that enforces the health". This definition shows that hygiene is much more than cleanliness and disinfection. In addition, this definition includes all actual hygienic problems of modern husbandry systems. The changes in animal husbandry for the production of food of animal origin (e.g., meat, milk) has changed also the tasks of veterinary medicine from "traditional healing of diseases" to prevention [46]. This is very important in connection with multifactorial diseases such as "production diseases". Yet, the single animal treatment is necessary in all clinical cases. The reasons are animal welfare consideration (avoidance of pain) and clinical aspects (support of the diseased animal). Animal hygiene as veterinary discipline focuses not on diseases, but on animal health, that means enhancing disease prevention and continuously adaption of the prevention tools in relation to the changing dairy farm conditions [47]. Furthermore, the International Society for Animal Hygiene [48] has broadened the scope of "animal hygiene" to the following topics:

- Animal health and animal welfare
- Food safety at herd level
- Environmental protection

Based on this new definition, the term "animal welfare" includes all challenges that the dairy farm community is increasingly facing. Therefore, all aspects of the section before (animal welfare) belong now to the term animal hygiene. The integration of animal hygiene in modern husbandry systems is a major component of sustainable dairying.

Therapy

The majority of diseases in dairy cattle has bacterial organisms as causative agents. The implication is that the veterinarians mostly use antibiotics and chemotherapeutics as drugs. An important goal of a chemotherapeutic therapy consists in increasing the efficacy of the immunological defense mechanisms as self-cure by reducing the number of pathogens. Therefore, pharmacological criteria as well as physiological and immunological factors may have an enormous influence on the success of a medication.

Especially throughout the last 10 years antimicrobial resistance occurred worldwide. As early as 2005, the Codex Alimentarius Committee CCRVDF published a paper on use of antimicrobial drugs and resistance [49]. This document stressed the important role of such drugs for controlling a great number of infectious diseases in both humans and animals. In addition, the article points out the necessity for any country to implement a system for observation concerning the adequate responsibility from the manufacturing process up to the application by the veterinarian. The IDF presented the "Guide to Prudent Use of Antimicrobial Agents in Dairy Production" [50]. Meantime, several countries-initiated programs to control antimicrobial resistance and to reduce the use of antimicrobials in human and veterinary medicine. The Dutch Minister of Agriculture stated in 2010 the goal to reduce the use of antibiotics by 50 % in 2013 compared to the antibiotic use in 2009 [51]. The assumption behind this statement was the expectation of a decrease in antimicrobial resistance by reduction in antibiotic use. Actually, nearly all countries worldwide have agreed to initiate measures such as intensification of research for alternative drugs to antibiotics, initiating of surveillance programs, stronger regulation for antibiotic application in human and veterinary medicine.

Overall, the consequences of the above-mentioned trends are asking for changes in the application of antimicrobials at farm level.

First, a reduction of the use of these drugs appears necessary. Second, the hygienic standard at all sites of dairy farming has to be increased. Furthermore, new concepts of treatments of infection diseases in connection with new alternative drugs should be elaborated. The reduction of the occurrence of resistant bacteria in public water systems (swimming pools, water pipelines) can prevent the further distribution in the area of human and animal population. Moreover, also as a contribution to sustainability, the reduction of the risk of contamination with antibiotic residues in soil, air and water is very important.

Veterinary records

The documentation of every veterinary treatment and any other measure to prevent diseases in a dairy herd is necessary. Based on such documentation it is much easier to follow the trend of the health status in a particular dairy. This is helpful to minimize the costs for veterinary actions and to eliminate the repetition of drug applications what were not successful. It is well known, that herd specific factors are able to determine the function of the defense mechanisms largely [52].

Conclusion

Sustainable dairy farming is often performed under tropical and subtropical condition in form of integrated farming systems such as integrated crop-livestock farming systems or integrated crop-livestock-forestry systems. These farming systems are essentially cyclic (organic resources-livestock-land-crops). The integrated crop-livestock-forest-system integrates the crop, livestock and forest components in rotation, combination or succession in the same area. These systems are a feasible production alternative to recover altered or degraded areas. A lot of extension attention is required to educate farmers on utilization of crop-livestock production systems. The process of transferring knowledge and technologies is paramount. Public institutions (National government, ministries, universities and farmer organization), IFAD (The International Fund for Agriculture Development), Fund of the European Union and industrial companies should work together to get maximum success. The training courses should include practical demonstration of handling modern equipment (e.g., milking machines, equipment for milking hygiene etc.,)

Financial support to start off dairy farming can get from special programs initiated by national governments. Very often, industrial companies and/or IFAD sponsor such programs.

A sustainable milk production is only one part of the complete sustainable development that consists of a multi-factorial complex of factors. The goal "Sustainability" can only be reached by achieving a certain balance between nature and humankind. This means, sustainability is a global question, a question on the future of the whole humankind. As described in this paper nearly all preconditions for sustainable dairying are principally available. In the Dairy Declaration of Rotterdam, signed on 19 October 2016, the dairy community accepted sustainability changes [53]. IDF and FAO stressed their efforts to ensure that the global dairy sector supports the UN Sustainable Development Goals by 2030 and that the sectorial work considers the social, economic, health and environmental dimensions. Yet the main question is not answered, whether the needed money to establish a sustainable development, including sustainable dairying, will be available.

Only changes in the opinion of everybody in regards to the responsibility for the planet earth and the related global initiated action and reaction of the politicians in connection with a new fairer, flexible, resilient and sustainable financial system, will allow us, to have the chance as humankind to overcome the actual global problems. A first step in the right direction can be summed up in the quote of Mahatma Gandhi: "There is enough on earth for everybody's need, but not for everybody's greed".

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