IJARETY

International Journal of Advanced Research in Education and TechnologY (IJARETY)

Volume 11, Issue 2, March 2024

Impact Factor: 7.394

www.ijarety.in editor.ijarety@gmail.com

International Journal of Advanced Research in Education and TechnologY(IJARETY)

| ISSN: 2394-2975 | www.ijarety.in| | Impact Factor: 7.394| A Bi-Monthly, Double-Blind Peer Reviewed & Referred Journal |

|| Volume 11, Issue 2, March 2024 ||

Sustainable Crop and Livestock Production System for Current Scenario: An Updated Review

[1]AVANISH KUMAR SINGH & [2]VIVEK PRATAP SINGH

[1]DEPARTMENT OF AGRONOMY, MAHAYOGI GORAKHNATH KRISHI VIGYAN KENDRA , GORAKHPUR, UTTAR PRADESH, INDIA

[2]DEPARTMENT OF ANIMAL SCIENCE, MAHAYOGI GORAKHNATH KRISHI VIGYAN KENDRA , GORAKHPUR, UTTAR PRADESH, INDIA

ABSTRACT: Livestock are the domesticated animals raised in an agricultural setting in order to provide labour and produce diversified products for consumption such as meat, eggs, milk, fur, leather, and wool. The term is sometimes used to refer solely to animals who are raised for consumption, and sometimes used to refer solely to farmed ruminants, such as cattle, sheep, and goats.[1] Horses are considered livestock in the United States.[2] The USDA classifies pork, veal, beef, and lamb (mutton) as livestock, and all livestock as red meat. Poultry and fish are not included in the category.[3] The latter is likely due to the fact that fish products are not governed by the USDA, but by the FDA.The breeding, maintenance, slaughter and general subjugation of livestock, called animal husbandry, is a part of modern agriculture and has been practiced in many cultures since humanity's transition to farming from hunter-gatherer lifestyles. Animal husbandry practices have varied widely across cultures and time periods. It continues to play a major economic and cultural role in numerous communities.Livestock farming practices have largely shifted to intensive animal farming.[4] Intensive animal farming increases the yield of the various commercial outputs, but also negatively impacts animal welfare, the environment, and public health.[5] In particular, beef, dairy and sheep are an outsized source of greenhouse gas emissions from agriculture.Sustainable agriculture is farming in sustainable ways meeting society's present food and textile needs, without compromising the ability for current or future generations to meet their needs.[1] It can be based on an understanding of ecosystem services. There are many methods to increase the sustainability of agriculture.

KEYWORDS: livestock, sustainable, crop, farming, pollution, environment, ecosystem

I. INTRODUCTION

Developing sustainable food systems contributes to the sustainability of the human population. For example, one of the best ways to mitigate climate change is to create sustainable food systems based on sustainable agriculture. Sustainable agriculture provides a potential solution to enable agricultural systems to feed a growing population within the changing environmental conditions.[6] Besides sustainable farming practices, dietary shifts to sustainable diets are an intertwined way to substantially reduce environmental impacts.[8][9][10][11] Numerous sustainability standards and certification systems exist, including organic certification, Rainforest Alliance, Fair Trade, UTZ Certified, GlobalGAP, Bird Friendly, and the Common Code for the Coffee Community (4C).[12]

Definition

The term "sustainable agriculture" was defined in 1977 by the USDA as an integrated system of plant and animal production practices having a site-specific application that will, over the long term:[13]

- satisfy human food and fiber needs
- enhance environmental quality and the natural resource base upon which the agriculture economy depends
- make the most efficient use of nonrenewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls
- sustain the economic viability of farm operations

- enhance the quality of life for farmers and society as a whole.[1,2,3]

Yet the idea of having a sustainable relationship with the land has been prevalent in indigenous communities for centuries before the term was formally added to the lexicon.[14]

Aims

A common consensus is that sustainable farming is the most realistic way to feed growing populations. In order to successfully feed the population of the planet, farming practices must consider future costs–to both the environment and the communities they fuel.[15] The fear of not being able to provide enough resources for everyone led to the adoption of technology within the sustainability field to increase farm productivity. The ideal end result of this advancement is the ability to feed ever-growing populations across the world. The growing popularity of sustainable agriculture is connected to the wide-reaching fear that the planet's carrying capacity (or planetary boundaries), in terms of the ability to feed humanity, has been reached or even exceeded.[16]

Key principles

There are several key principles associated with sustainability in agriculture:[17]

1. The incorporation of biological and ecological processes such as nutrient cycling, soil regeneration, and nitrogen fixation into agricultural and food production practices.
2. Using decreased amounts of non-renewable and unsustainable inputs, particularly environmentally harmful ones.
3. Using the expertise of farmers to both productively work the land as well as to promote the self-reliance and self-sufficiency of farmers.
4. Solving agricultural and natural resource problems through the cooperation and collaboration of people with different skills. The problems tackled include pest management and irrigation.

It "considers long-term as well as short-term economics because sustainability is readily defined as forever, that is, agricultural environments that are designed to promote endless regeneration".[18] It balances the need for resource conservation with the needs of farmers pursuing their livelihood.[19]

It is considered to be reconciliation ecology, accommodating biodiversity within human landscapes.[20]

Oftentimes the execution of sustainable practices within farming comes through the adoption of technology and environmentally-focused appropriate technology.

Environmental factors

Traditional farming methods have a low carbon footprint.

Practices that can cause long-term damage to soil include excessive tilling of the soil (leading to erosion) and irrigation without adequate drainage (leading to salinization).[21][22]

| ISSN: 2394-2975 | www.ijarety.in| | Impact Factor: 7.394| A Bi-Monthly, Double-Blind Peer Reviewed & Referred Journal |

|| Volume 11, Issue 2, March 2024 ||

Conservation farming in Zambia

The most important factors for a farming site are climate, soil, nutrients and water resources. Of the four, water and soil conservation are the most amenable to human intervention. When farmers grow and harvest crops, they remove some nutrients from the soil. Without replenishment, the land suffers from nutrient depletion and becomes either unusable or suffers from reduced yields. Sustainable agriculture depends on replenishing the soil while minimizing the use or need of non-renewable resources, such as natural gas or mineral ores.

A farm that can "produce perpetually", yet has negative effects on environmental quality elsewhere is not sustainable agriculture. An example of a case in which a global view may be warranted is the application of fertilizer or manure, which can improve the productivity of a farm but can pollute nearby rivers and coastal waters (eutrophication).[23] The other extreme can also be undesirable, as the problem of low crop yields due to exhaustion of nutrients in the soil has been related to rainforest destruction.[24] In Asia, the specific amount of land needed for sustainable farming is about 12.5 acres which include land for animal fodder, cereal production as a cash crop, and other food crops. In some cases, a small unit of aquaculture is included (AARI-1996).

Soil

Walls built to avoid water run-off, Andhra Pradesh, India

Land degradation is becoming a severe global problem. According to the Intergovernmental Panel on Climate Change: "About a quarter of the Earth's ice-free land area is subject to human-induced degradation (medium confidence). Soil erosion from agricultural fields is estimated to be currently 10 to 20 times (no tillage) to more than 100 times (conventional tillage) higher than the soil formation rate (medium confidence)."[53] Almost half of the land on earth is covered with dry land, which is susceptible to degradation.[54] Over a billion tonnes of southern Africa's soil are being lost to erosion annually, which if continued will result in halving of crop yields within thirty to fifty years.[55] Improper soil management is threatening the ability to grow sufficient food. Intensive agriculture reduces the carbon level in soil, impairing soil structure, crop growth and ecosystem functioning,[56] and accelerating climate change.[56] Modification of agricultural practices is a recognized method of carbon sequestration as soil can act as an effective carbon sink.[57]

Soil management techniques include no-till farming, keyline design and windbreaks to reduce wind erosion, reincorporation of organic matter into the soil, reducing soil salinization, and preventing water run-off.[58][59]

Land

According to the UC Davis Agricultural Sustainability Institute, several steps must be taken to develop drought-resistant farming systems even in "normal" years with average rainfall. These measures include both policy and management actions:[72]

1. improving water conservation and storage measures[72]
2. providing incentives for selection of drought-tolerant crop species[72]
3. using reduced-volume irrigation systems[72]
4. managing crops to reduce water loss[72]
5. not planting crops at all.[72]

Indicators for sustainable water resource development include the average annual flow of rivers from rainfall, flows from outside a country, the percentage of water coming from outside a country, and gross water withdrawal.[73] It is estimated that agricultural practices consume 69% of the world's fresh water. [74]

Social factors

Rural economic development

Sustainable agriculture attempts to solve multiple problems with one broad solution. The goal of sustainable agricultural practices is to decrease environmental degradation due to farming while increasing crop–and thus food–output. There are many varying strategies attempting to use sustainable farming practices in order to increase rural economic development within small-scale farming communities. Two of the most popular and opposing strategies within the modern discourse are allowing unrestricted markets to determine food production and deeming food a human right. Neither of these approaches have been proven to work without fail. A promising proposal to rural poverty reduction within agricultural communities is sustainable economic growth; the most important aspect of this policy is to regularly include the poorest farmers in the economy-wide development through the stabilization of small-scale agricultural economies.[75]

In 2007, the United Nations reported on "Organic Agriculture and Food Security in Africa", stating that using sustainable agriculture could be a tool in reaching global food security without expanding land usage and reducing environmental impacts.[76] There has been evidence provided by developing nations from the early 2000s stating that when people in their communities are not factored into the agricultural process that serious harm is done. The social scientist Charles Kellogg has stated that, "In a final effort, exploited people pass their suffering to the land."[76] Sustainable agriculture mean the ability to permanently and continuously "feed its constituent populations".[76]

There are a lot of opportunities that can increase farmers' profits, improve communities, and continue sustainable practices. For example, in Uganda, Genetically Modified Organisms were originally illegal. However, with the stress of banana crisis in Uganda, where Banana Bacterial Wilt had the potential to wipe out 90% of yield, they decided to explore GMOs as a possible solution.[77] The government issued the National Biotechnology and Biosafety bill, which will allow scientists that are part of the National Banana Research Program to start experimenting with genetically modified organisms.[78] This effort has the potential to help local communities because a significant portion live off the food they grow themselves,[4,5,6] and it will be profitable because the yield of their main produce will remain stable.

Not all regions are suitable for agriculture.[79][80] The technological advancement of the past few decades has allowed agriculture to develop in some of these regions. For example, Nepal has built greenhouses to deal with its high altitude and mountainous regions.[31] Greenhouses allow for greater crop production and also use less water since they are closed systems.[81]

Desalination techniques can turn salt water into fresh water which allows greater access to water for areas with a limited supply.[82] This allows the irrigation of crops without decreasing natural fresh water sources.[83] While desalination can be a tool to provide water to areas that need it to sustain agriculture, it requires money and resources. Regions of China have been considering large scale desalination in order to increase access to water, but the current cost of the desalination process makes it impractical.[84]

Women

Selling produce at an American farmers market

Women working in sustainable agriculture come from numerous backgrounds, ranging from academia to labour.[85] From 1978-2007, in the United States, the number of women farm operators has tripled.[79] In 2007, women operated 14 percent of farms, compared to five percent in 1978. Much of the growth is due to women farming outside of the "male dominated field of conventional agriculture".[79]

Growing your own food

The practice of growing food in the backyard of houses, schools, etc., by families or by communities became widespread in the US at the time of World War I, the Great Recession and World War II, so that in one point of time 40% of the vegetables of the USA was produced in this way. The practice became more popular again in the time of the COVID-19 pandemic. This method permits to grow food in a relatively sustainable way and at the same time can make it easier for poor people to obtain food.[86]

Economic factors

Costs, such as environmental problems, not covered in traditional accounting systems (which take into account only the direct costs of production incurred by the farmer) are known as externalities.[17]

Netting studied sustainability and intensive agriculture in smallholder systems through history.[87]

There are several studies incorporating externalities such as ecosystem services, biodiversity, land degradation, and sustainable land management in economic analysis. These include The Economics of Ecosystems and Biodiversity study and the Economics of Land Degradation Initiative which seek to establish an economic cost-benefit analysis on the practice of sustainable land management and sustainable agriculture.

Triple bottom line frameworks include social and environmental alongside a financial bottom line. A sustainable future can be feasible if growth in material consumption and population is slowed down and if there is a drastic increase in the efficiency of material and energy use. To make that transition, long- and short-term goals will need to be balanced enhancing equity and quality of life.[88]

Challenges and debates

Barriers

The barriers to sustainable agriculture can be broken down and understood through three different dimensions. These three dimensions are seen as the core pillars to sustainability: social, environmental, and economic pillars.[89] The social pillar addresses issues related to the conditions in which societies are born into, growing in, and learning from.[89] It deals with shifting away from traditional practices of agricultural and moving into new sustainable practices that will create better societies and conditions.[89] The environmental pillar addresses climate change and focuses on agricultural practices that protect the environment for future generations.[89] The economic pillar discovers ways in which sustainable agriculture can be practiced while fostering economic growth and stability, with minimal disruptions to livelihoods.[89] All three pillars must be addressed to determine and overcome the barriers preventing sustainable agricultural practices.[89]

Social barriers to sustainable agriculture include cultural shifts, the need for collaboration, incentives, and new legislation.[89] The move from conventional to sustainable agriculture will require significant behavioural changes from both farmers and consumers.[90] Cooperation and collaboration between farmers is necessary to successfully transition to sustainable practices with minimal complications.[90] This can be seen as a challenge for farmers who care about competition and profitability.[91] There must also be an incentive for farmers to change their methods of

agriculture.[92] The use of public policy, advertisements, and laws that make sustainable agriculture mandatory or desirable can be utilized to overcome these social barriers.[93]

Pesticide use remains a common practice in agriculture.

Environmental barriers prevent the ability to protect and conserve the natural ecosystem.[89] Examples of these barriers include the use of pesticides and the effects of climate change.[89] Pesticides are widely used to combat pests that can devastate production and plays a significant role in keeping food prices and production costs low.[94] To move toward sustainable agriculture, farmers are encouraged to utilize green pesticides, which cause less harm to both human health and habitats, but would entail a higher production cost.[95] Climate change is also a rapidly growing barrier, one that farmers have little control over, which can be seen through place-based barriers.[96] These place-based barriers include factors such as weather conditions, topography, and soil quality which can cause losses in production, resulting in the reluctance to switch from conventional practices.[96] Many environmental benefits are also not visible or immediately evident.[97] Significant changes such as lower rates of soil and nutrient loss, improved soil structure, and higher levels of beneficial microorganisms take time.[97] In conventional agriculture, the benefits are easily visible with no weeds, pests, etc..., but the long term costs to the soil and surrounding ecosystems are hidden and "externalized".[97] Conventional agricultural practices since the evolution of technology have caused significant damage to the environment through biodiversity loss, disrupted ecosystems, poor water quality, among other harms.[92]

The economic obstacles to implementing sustainable agricultural practices include low financial return/profitability, lack of financial incentives, and negligible capital investments.[98] Financial incentives and circumstances play a large role in whether sustainable practices will be adopted.[89][98] The human and material capital required to shift to sustainable methods of agriculture requires training of the workforce and making investments in new technology and products, which comes at a high cost.[89][98] In addition to this, farmers practicing conventional agriculture can mass produce their crops, and therefore maximize their profitability.[89] This would be difficult to do in sustainable agriculture which encourages low production capacity.[89]

Community gardening is a promising method of sustainable agriculture.

The author James Howard Kunstler claims almost all modern technology is bad and that there cannot be sustainability unless agriculture is done in ancient traditional ways.[99] Efforts toward more sustainable agriculture are supported in the sustainability community, however, these are often viewed only as incremental steps and not as an end.[92] One promising method of encouraging sustainable agriculture is through local farming and community gardens.[92] Incorporating local produce and agricultural education into schools, communities, and institutions can promote the consumption of freshly grown produce which will drive consumer demand.[92]

Some foresee a true sustainable steady state economy that may be very different from today's: greatly reduced energy usage, minimal ecological footprint, fewer consumer packaged goods, local purchasing with short food supply chains, little processed foods, more home and community gardens, etc.[100]

Different viewpoints about the definition[7,8,9]

There is a debate on the definition of sustainability regarding agriculture. The definition could be characterized by two different approaches: an ecocentric approach and a technocentric approach.[101] The ecocentric approach emphasizes no- or low-growth levels of human development, and focuses on organic and biodynamic farming techniques with the goal of changing consumption patterns, and resource allocation and usage. The technocentric approach argues that sustainability can be attained through a variety of strategies, from the view that state-led modification of the industrial system like conservation-oriented farming systems should be implemented, to the argument that biotechnology is the best way to meet the increasing demand for food.[101]

One can look at the topic of sustainable agriculture through two different lenses: multifunctional agriculture and ecosystem services.[102] Both of approaches are similar, but look at the function of agriculture differently. Those that employ the multifunctional agriculture philosophy focus on farm-centered approaches, and define function as being the outputs of agricultural activity.[102] The central argument of multifunctionality is that agriculture is a multifunctional enterprise with other functions aside from the production of food and fiber. These functions include renewable resource management, landscape conservation and biodiversity.[103] The ecosystem service-centered approach posits that individuals and society as a whole receive benefits from ecosystems, which are called "ecosystem services".[102][104] In sustainable agriculture, the services that ecosystems provide include pollination, soil formation, and nutrient cycling, all of which are necessary functions for the production of food.[105]

It is also claimed sustainable agriculture is best considered as an ecosystem approach to agriculture, called agroecology.[106]

Ethics

Most agricultural professionals agree that there is a "moral obligation to pursue [the] goal [of] sustainability."[76] The major debate comes from what system will provide a path to that goal because if an unsustainable method is used on a large scale it will have a massive negative effect on the environment and human population.

Methods

Countries' evaluation of trends in the use of selected management practices and approaches

Other practices include polyculture, growing a diverse number of perennial crops in a single field, each of which would grow in separate seasons so as not to compete with each other for natural resources.[107] This system would result in increased resistance to diseases and decreased effects of erosion and loss of nutrients in the soil. Nitrogen fixation from legumes, for example, used in conjunction with plants that rely on nitrate from the soil for growth, helps to allow the land to be reused annually. Legumes will grow for a season and replenish the soil with ammonium and nitrate, and the next season other plants can be seeded and grown in the field in preparation for harvest.

Sustainable methods of weed management may help reduce the development of herbicide-resistant weeds.[108] Crop rotation may also replenish nitrogen if legumes are used in the rotations and may also use resources more efficiently.[109]

Rotational grazing with pasture divided into paddocks

There are also many ways to practice sustainable animal husbandry. Some of the tools to grazing management include fencing off the grazing area into smaller areas called paddocks, lowering stock density, and moving the stock between paddocks frequently.[110]

Intensification

An increased production is a goal of intensification. Sustainable intensification encompasses specific agriculture methods that increase production and at the same time help improve environmental outcomes. The desired outcomes of the farm are achieved without the need for more land cultivation or destruction of natural habitat; the system performance is upgraded with no net environmental cost. Sustainable Intensification has become a priority for the United Nations. Sustainable intensification differs from prior intensification methods by specifically placing importance on broader environmental outcomes. By 2018; it was predicted in 100 nations a combined total of 163 million farms used sustainable intensification. The amount of agricultural land covered by this is 453 million ha of land. That amount of land is equal to 29% of farms worldwide.[111] In light of concerns about food security, human population growth and dwindling land suitable for agriculture, sustainable intensive farming practises are needed to maintain high crop yields, while maintaining soil health and ecosystem services. The capacity for ecosystem services to be strong enough to allow a reduction in use of non-renewable inputs whilst maintaining or boosting yields has been the subject of much debate. Recent work in irrigated rice production system of east Asia has suggested that – in relation to pest management at least – promoting the ecosystem service of biological control using nectar plants can reduce the need for insecticides by 70% whilst delivering a 5% yield advantage compared with standard practice.[112]

Vertical farming is a concept with the potential advantages of year-round production, isolation from pests and diseases, controllable resource recycling and reduced transportation costs.[113]

Water

Water efficiency can be improved by reducing the need for irrigation and using alternative methods. Such methods include: researching on drought resistant crops, monitoring plant transpiration and reducing soil evaporation.[114]

Drought resistant crops have been researched extensively as a means to overcome the issue of water shortage. They are modified genetically so they can adapt in an environment with little water. This is beneficial as it reduces the need for irrigation and helps conserve water. Although they have been extensively researched, significant results have not been achieved as most of the successful species will have no overall impact on water conservation. However, some grains like rice, for example, have been successfully genetically modified to be drought resistant.[115]

Soil and nutrients

Soil amendments include using compost from recycling centers. Using compost from yard and kitchen waste uses available resources in the area.

Abstinence from soil tillage before planting and leaving the plant residue after harvesting reduces soil water evaporation; It also serves to prevent soil erosion.[116]

Crop residues left covering the surface of the soil may result in reduced evaporation of water, a lower surface soil temperature, and reduction of wind effects.[116]

A way to make rock phosphate more effective is to add microbial inoculates such as phosphate-solubilizing microorganisms, known as PSMs, to the soil.[32][80] These solubilize phosphorus already in the soil and use processes like organic acid production and ion exchange reactions to make that phosphorus available for plants.[80] Experimentally, these PSMs have been shown to increase crop growth in terms of shoot height, dry biomass and grain yield.[80]

Phosphorus uptake is even more efficient with the presence of mycorrhizae in the soil.[117] Mycorrhiza is a type of mutualistic symbiotic association between plants and fungi,[117] which are well-equipped to absorb nutrients, including phosphorus, in soil.[118] These fungi can increase nutrient uptake in soil where phosphorus has been fixed by aluminum, calcium, and iron.[118] Mycorrhizae can also release organic acids that solubilize otherwise unavailable phosphorus.[118]

Pests and weeds

Sheet steaming with a MSD/moeschle steam boiler (left side)

Soil steaming can be used as an alternative to chemicals for soil sterilization. Different methods are available to induce steam into the soil to kill pests and increase soil health.

Solarizing is based on the same principle, used to increase the temperature of the soil to kill pathogens and pests.[119]

Certain plants can be cropped for use as biofumigants, "natural" fumigants, releasing pest suppressing compounds when crushed, ploughed into the soil, and covered in plastic for four weeks. Plants in the Brassicaceae family release large amounts of toxic compounds such as methyl isothiocyanates.[120][121]

Location

Relocating current croplands to environmentally more optimal locations, whilst allowing ecosystems in then-abandoned areas to regenerate could substantially decrease the current carbon, biodiversity, and irrigation water footprint of global crop production, with relocation only within national borders also having substantial potential.[122][123]

Plants

Sustainability may also involve crop rotation.[124] Crop rotation and cover crops prevent soil erosion, by protecting topsoil from wind and water.[31] Effective crop rotation can reduce pest pressure on crops, provides weed control, reduces disease build up, and improves the efficiency of soil nutrients and nutrient cycling.[125] This reduces the need for fertilizers and pesticides.[124] Increasing the diversity of crops by introducing new genetic resources can increase yields by 10 to 15 percent compared to when they are grown in monoculture.[125][126] Perennial crops reduce the need for tillage and thus help mitigate soil erosion, and may sometimes tolerate drought better, increase water quality and help increase soil organic matter. There are research programs attempting to develop perennial substitutes for existing annual crops, such as replacing wheat with the wild grass Thinopyrum intermedium, or possible experimental hybrids of it and wheat.[127] Being able to do all of this without the use of chemicals is one of the main goals of sustainability which is why crop rotation is a very central method of sustainable agriculture.[125]

Related concepts

Organic agriculture

Organic agriculture can be defined as:
an integrated farming system that strives for sustainability, the enhancement of soil fertility and biological diversity whilst, with rare exceptions, prohibiting synthetic pesticides, antibiotics, synthetic fertilizers, genetically modified organisms, and growth hormones.[128][129][130][131]

Some claim organic agriculture may produce the most sustainable products available for consumers in the US, where no other alternatives exist, although the focus of the organics industry is not sustainability.[124]

In 2018 the sales of organic products in USA reach $52.5 billion[132] According to a USDA survey two-thirds of Americans consume organic products at least occasionally.[133]

Certain principles unique to ecological farming need to be considered.

- Food production should be ecological in both origin and destiny (the term destiny refers to the post-harvest ecological footprint which results in getting produce to the consumer).
- Integration of species that maintain ecosystem services whilst providing a selection of alternative products.[144]
- Minimise food miles, packaging, energy consumption and waste.
- Define a new ecosystem to suit human needs using lessons from existing ecosystems from around the world.[145][146][147]
- Apply the value of a knowledge-base (advanced data base) about soil microorganisms so that discoveries of the ecological benefits of having various kinds of microorganisms encouraged in productive systems such as Forest Gardens can be assessed and optimised; for example in the case of naturally occurring microorganisms called denitrifiers.[148]

Traditional agriculture

Practice of Traditional Agriculture

Often thought of as inherently destructive, slash-and-burn or slash-and-char shifting cultivation have been practiced in the Amazon for thousands of years.[149]

Some traditional systems combine polyculture with sustainability. In South-East Asia, rice-fish systems on rice paddies have raised freshwater fish as well as rice, producing an additional product and reducing eutrophication of neighboring rivers.[150] A variant in Indonesia combines rice, fish, ducks and water fern; the ducks eat the weeds that would otherwise limit rice growth, saving labour and herbicides, while the duck and fish manure substitute for fertilizer.[151]

Raised field agriculture has been recently revived in certain areas of the world, such as the Altiplano region in Bolivia and Peru. This has resurged in the form of traditional Waru Waru raised fields, which create nutrient-rich soil in regions where such soil is scarce. This method is extremely productive and has recently been utilized by indigenous groups in the area and the nearby Amazon Basin to make use of lands that have been historically hard to cultivate.

Other forms of traditional agriculture include agro forestry, crop rotations, and water harvesting. Water harvesting is one of the largest and most common practices, particularly used in dry areas and seasons. In Ethiopia, over half of their GDP and over 80 percent of their exports are attributed to agriculture; yet, it is known for its intense droughts and dry periods.[152] Rain water harvesting is considered to be a low-cost alternative. This type of harvesting collects and stores water from roof tops during high-rain periods for use during droughts.[153] Rainwater harvesting has been a large practice to help the country survive by focusing on runoff irrigation, roof water harvesting, and flood spreading.

Indigenous Agriculture in North America

Indigenous Agriculture

Native Americans in the United States practiced sustainable agriculture through their subsistence farming techniques. Many tribes grew or harvested their own food from plants that thrived in their local ecosystems. Native American farming practices are specific to local environments and work with natural processes.[154] This is a practice called Permaculture, and it involves a deep understanding of the local environment.[155] Native American farming techniques also incorporate local biodiversity into many of their practices, which helps the land remain healthy.[156]

Many indigenous tribes incorporated Intercropping into their agriculture, which is a practice where multiple crops are planted together in the same area. This strategy allows crops to help one another grow through exchanged nutrients, maintained soil moisture, and physical supports for one another. The crops that are paired in intercropping often do not heavily compete for resources, which helps them to each be successful. For example, many tribes utilized intercropping in ways such as the Three Sisters Garden. This gardening technique consists of corn, beans, and squash. These crops grow in unity as the corn stalk supports the beans, the beans produce nitrogen, and the squash retain moisture.[157] Intercropping also provides a natural strategy for pest management and the prevention of weed growth.

Intercropping is a natural agricultural practice that often improves the overall health of the soil and plants, increases crop yield, and is sustainable.[155]

One of the most significant aspects of indigenous sustainable agriculture is their traditional ecological knowledge of harvesting. The Anishinaabe tribes follow an ideology known as "the Honorable Harvest". The Honorable Harvest is a set of practices that emphasize the idea that people should "take only what you need and use everything you take."[158] Resources are conserved through this practice because several rules are followed when harvesting a plant. These rules are to never take the first plant, never take more than half of the plants, and never take the last plant.[159] This encourages future growth of the plant and therefore leads to a sustainable use of the plants in the area.

Native Americans practiced agroforestry by managing the forest, animals, and crops together. They also helped promote tree growth through controlled burns and silviculture. Often, the remaining ash from these burns would be used to fertilize their crops. By improving the conditions of the forest, the local wildlife populations also increased. Native Americans allowed their livestock to graze in the forest, which provided natural fertilizer for the trees as well.[155]

Regenerative agriculture

Regenerative agriculture is a conservation and rehabilitation approach to food and farming systems. It focuses on topsoil regeneration, increasing biodiversity,[160] improving the water cycle,[161] enhancing ecosystem services, supporting biosequestration, increasing resilience to climate change, and strengthening the health and vitality of farm soil. Practices include, recycling as much farm waste as possible, and adding composted material from sources outside the farm.[79][162][31][163]

Alternative methods

Permaculture

A garden cultivated on permaculture principles

Permaculture is an approach to land management and settlement design that adopts arrangements observed in flourishing natural ecosystems. It includes a set of design principles derived using whole-systems thinking. It applies these principles in fields such as regenerative agriculture, town planning, rewilding, and community resilience. The term was coined in 1978 by Bill Mollison and David Holmgren, who formulated the concept in opposition to modern industrialized methods, instead adopting a more traditional or "natural" approach to agriculture.[164][165][166]
Permaculture has been criticised as being poorly defined and unscientific.[167] Critics have pushed for less reliance on anecdote and extrapolation from ecological first principles, in favor of peer-reviewed research to substantiate productivity claims and to clarify methodology. Peter Harper from the Centre for Alternative Technology suggests that most of what passes for permaculture has no relevance to real problems.[168]

Polyculture

There is limited evidence polyculture may contribute to sustainable agriculture. A meta-analysis of a number of polycrop studies found that predator insect biodiversity was higher at comparable yields than conventional in certain two-crop systems with a single cash crop combined with a cover crop.[169]

One approach to sustainability is to develop polyculture systems using perennial crop varieties. Such varieties are being developed for rice, wheat, sorghum, barley, and sunflowers. If these can be combined in polyculture with a leguminous

cover crop such as alfalfa, fixation of nitrogen will be added to the system, reducing the need for fertilizer and pesticides.[127]

Local small-scale agriculture

The use of available city space (e.g., rooftop gardens, community gardens, garden sharing, organopónicos, and other forms of urban agriculture) may be able to contribute to sustainability.[170] Some consider "guerrilla gardening" an example of sustainability in action[171] – in some cases seeds of edible plants have been sown in local rural areas.[172]

Hydroponics or soil-less culture

Hydroponics is an alternative to agriculture that creates the ideal environment for optimal growth without using a dormant medium. This innovative farming technique produces higher crop yields without compromising soil health. The most significant drawback of this sustainable farming technique is the cost associated with development.[173]

Standards

II. DISCUSSION

Policy

Delaware Valley University's "Roth Center for Sustainable Agriculture", located in Montgomery County, Pennsylvania

Sustainable agriculture is a topic in international policy concerning its potential to reduce environmental risks. In 2011, the Commission on Sustainable Agriculture and Climate Change, as part of its recommendations for policymakers on achieving food security in the face of climate change, urged that sustainable agriculture must be integrated into national and international policy.[179] The Commission stressed that increasing weather variability and climate shocks will negatively affect agricultural yields, necessitating early action to drive change in agricultural production systems towards increasing resilience.[179] It also called for dramatically increased investments in sustainable agriculture in the next decade, including in national research and development budgets, land rehabilitation, economic incentives, and infrastructure improvement.[179]

At the global level

The program includes the next targets:

- Making 25% of EU agriculture organic, by 2030.
- Reduce by 50% the use of pesticides by 2030.
- Reduce the use of fertilizers by 20% by 2030.
- Reduce nutrient loss by at least 50%.
- Reduce the use of antimicrobials in agriculture and antimicrobials in aquaculture by 50% by 2030.
- Create sustainable food labeling.
- Reduce food waste by 50% by 2030.
- Dedicate to R&I related to the issue €10 billion.[185]

United States

Policies from 1930 – 2000[10,11]

The New Deal implemented policies and programs that promoted sustainable agriculture. Under the Agriculture Adjustment Act of 1933, it provided farmers payments to create a supply management regime that capped production of important crops.[186][187][188] This allowed farmers to focus on growing food and not competing in the market based

system. The New Deal also provided a monetary incentive for farmers that left some of their fields unsown or ungrazed to order to improve the soil conditions.[186] The Cooperative Extension Service was also established that set up sharing funding responsibilities amongst the USDA, land-grant universities, and local communities.[187]

The 1950s to 1990s was when the government switched its stance on agriculture policy which halted sustainable agriculture. The Agricultural Act of 1954 passed which supported farmers with flexible price supports, but only to commodity programs.[189] The Food and Agricultural Act of 1965 had new income support payments and continued supply controls but reduced priced supports.[189] Agriculture and Consumer Protection Act of 1973 removed price supports and instead introduced target prices and deficiency payments.[189] It continued to promote commodity crops by lowering interest rates. Food Security Act of 1985 continued commodity loan programs.[188][189] These policies incentivized profit over sustainability because the US government was promoting farms to maximize their production output instead of placing checks.[189] This meant that farms were being turned into food factories as they became bigger in size and grew more commodity crops like corn, wheat, and cotton. From 1900 to 2002, the number of farms in the US decreased significantly while the average size of a farm went up after 1950.[189][188]

Current Policies

In the United States, the federal Natural Resources Conservation Service (USDA) provides technical and financial assistance for those interested in pursuing natural resource conservation along with production agriculture. With programs like SARE and China-UK SAIN to help promote research on sustainable agriculture practices and a framework for agriculture and climate change respectively.

Future Policies

Currently, there are policies on the table that could move the US agriculture system into a more sustainable direction with the Green New Deal. This policy promotes decentralizing agrarian governance by breaking up large commodity farms that were created in the 1950s to 1980s.[186] Decentralized governance within the farming community would allow for more adaptive management at local levels to help focus on climate change mitigation, food security, and landscape-scale ecological stewardship.[186] The Green New Deal would invest in public infrastructure to support farmers transition from industrial food regime and acquire agroecological skills.[186] Just like in the New Deal, it would invest in cooperatives and commons to share and redistribute resources like land, food, equipment, research facilities, personnel, and training programs.[186] All of these policies and programs would break down barriers that have prevented sustainable farmers and agriculture from taking place in the United States.[188]

Asia

China

In 2016, the Chinese government adopted a plan to reduce China's meat consumption by 50%, for achieving more sustainable and healthy food system.[190][191]

In 2019, the National Basic Research Program or Program 973 funded research into Science and Technology Backyard (STB). STBs are hubs often created in rural areas with significant rates of small-scale farming that combine knowledge of traditional practices with new innovations and technology implementation. The purpose of this program was to invest in sustainable farming throughout the country and increase food production while achieving few negative environmental effects. The program was ultimately proven to be successful, and the study found that the merging of traditional practices and appropriate technology was instrumental in higher crop yields.[192]

India

In collaboration with the Food and Land Use Coalition (FOLU), CEEW (council for energy, environment and water), has given an overview of the current state of sustainable agriculture practices and systems (SAPSs) in India.[193] India is aiming to scale-up SAPs, through policymakers, administrators, philanthropists, and other which represent a vital alternative to conventional, input-intensive agriculture. In idea these efforts identify 16 SAPSs – including agroforestry, crop rotation, rainwater harvesting, organic farming and natural farming – using agroecology as an investigative lens. In a conclusive understanding it is realised that sustainable agriculture is far from mainstream in India. Further proposals for several measures for promoting SAPSs, including restructured government support and rigorous evidence generation for benefits and implementation of sustainable farming are ongoing progress in Indian Agriculture.

An example of initiatives in India towards exploring the world of sustainable farming has been set by the Sowgood foundation which is a nonprofit founded by educator Pragati Chaswal.[194] It started by teaching primary school children about sustainable farming by helping them farm on small farm strips in suburban farmhouses and gardens. Today many

government and private schools in Delhi, India have adopted the sowgood foundation curriculum for sustainable farming for their students.

In 2012, the Israeli Ministry of Agriculture found itself at the height of the Israeli commitment to sustainable agriculture policy. A large factor of this policy was funding programs that made sustainable agriculture accessible to smaller Palestinian-Arab communities. The program was meant to create biodiversity, train farmers in sustainable agriculture methods, and hold regular meetings for agriculture stakeholders.[195] This plan was not well-accepted by all as opposers argue that the plan creates a new social construct and a tool for the government to hold more power.[196]

In 1907, the American author Franklin H. King discussed in his book Farmers of Forty Centuries the advantages of sustainable agriculture and warned that such practices would be vital to farming in the future.[197] The phrase 'sustainable agriculture' was reportedly coined by the Australian agronomist Gordon McClymont.[198] The term became popular in the late 1980s.[157] There was an international symposium on sustainability in horticulture by the International Society of Horticultural Science at the International Horticultural Congress in Toronto in 2002.[199] At the following conference at Seoul in 2006, the principles were discussed further.[200]

This potential future inability to feed the world's population has been a concern since the English political economist Thomas Malthus in the early 1800s, but has become increasingly important recently.[201] Starting at the very end of the twentieth and early twenty-first centuries, this issue became widely discussed in the U.S. because of growing anxieties of a rapidly increasing global population. Agriculture has long been the biggest industry worldwide and requires significant land, water, and labor inputs. At the turn of the twenty-first century, experts questioned the industry's ability to keep up with population growth.[16] This debate led to concerns over global food insecurity and "solving hunger".[202]

III. RESULTS

Micro-livestock

Micro-livestock is the term used for much-smaller animals, usually mammals. The two predominant categories are rodents and lagomorphs (rabbits). Even-smaller animals are kept and raised, such as crickets and honey bees. Micro-livestock does not generally include fish (aquaculture) or chickens (poultry farming).

Farming practices[edit]

Goat family with one-week-old kid

Farrowing site in a natural cave in northern Spain

Traditionally, animal husbandry was part of the subsistence farmer's way of life, producing not only the food needed by the family but also the fuel, fertiliser, clothing, transport and draught power. Killing the animal for food was a

secondary consideration, and wherever possible their products, such as wool, eggs, milk and blood (by the Maasai) were harvested while the animal was still alive.[17]

In the traditional system of transhumance, humans and livestock moved seasonally between fixed summer and winter pastures; in montane regions the summer pasture was up in the mountains, the winter pasture in the valleys.[18]

Animals can be kept extensively or intensively. Extensive systems involve animals roaming at will, or under the supervision of a herdsman, often for their protection from predators. Ranching in the Western United States involves large herds of cattle grazing widely over public and private lands.[19] Similar cattle stations are found in South America, Australia and other places with large areas of land and low rainfall. Ranching systems have been used for sheep, deer, ostrich, emu, llama and alpaca.[20] In the uplands of the United Kingdom, sheep are turned out on the fells in spring and graze the abundant mountain grasses untended, being brought to lower altitudes late in the year, with supplementary feeding being provided in winter.[21]

In rural locations, pigs and poultry can obtain much of their nutrition from scavenging, and in African communities, hens may live for months without being fed, and still produce one or two eggs a week.[17] At the other extreme, in the more Western parts of the world, animals are often intensively managed; dairy cows may be kept in zero-grazing conditions with all their forage brought to them; beef cattle may be kept in high density feedlots;[22] pigs may be housed in climate-controlled buildings and never go outdoors;[23] poultry may be reared in barns and kept in cages as laying birds under lighting-controlled conditions. In between these two extremes are semi-intensive, often family-run farms where livestock graze outside for much of the year, silage or hay is made to cover the times of year when the grass stops growing, and fertiliser, feed and other inputs are bought onto the farm from outside.[24]

Predation

Livestock farmers have often dealt with natural world animals' predation and theft by rustlers. In North America, animals such as gray wolves, grizzly bears, cougars, and coyotes are sometimes considered a threat to livestock. In Eurasia and Africa, predators include wolves, leopards, tigers, lions, dholes, Asiatic black bears, crocodiles, spotted hyenas, and other carnivores. In South America, feral dogs, jaguars, anacondas, and spectacled bears are threats to livestock. In Australia, dingoes, foxes, and wedge-tailed eagles are common predators, with an additional threat from domestic dogs who may kill in response to a hunting instinct, leaving the carcass uneaten.[25][26]

Disease

Good husbandry, proper feeding, and hygiene are the main contributors to animal health on farms, bringing economic benefits through maximised production. When, despite these precautions, animals still become sick, they are treated with veterinary medicines, by the farmer and the veterinarian. In the European Union, when farmers treat the animals, they are required to follow the guidelines for treatment and to record the treatments given.[27]

Animals are susceptible to a number of diseases and conditions that may affect their health. Some, like classical swine fever[28] and scrapie[29] are specific to one population of animals, while others, like foot-and-mouth disease affect all cloven-hoofed animals.[30] Where the condition is serious, governments impose regulations on import and export, on the movement of livestock, quarantine restrictions and the reporting of suspected cases. Vaccines are available against certain diseases, and antibiotics are widely used where appropriate.

At one time, antibiotics were routinely added to certain compound foodstuffs to promote growth, but this is now[specify] considered poor practice in many countries because of the risk that it may lead to antibiotic resistance.[31] Animals living under intensive conditions are particularly prone to internal and external parasites; increasing numbers of sea lice are affecting farmed salmon in Scotland.[32] Reducing the parasite burdens of livestock results in increased productivity and profitability.[33]

According to the Special Report on Climate Change and Land, livestock diseases are expected to get worse as climate change increases temperature and precipitation variability.[34]

Transportation and marketing

Pigs being loaded into their transport

Since many livestock are herd animals, they were historically driven to market "on the hoof" to a town or other central location. The method is still used in some parts of the world.[35]

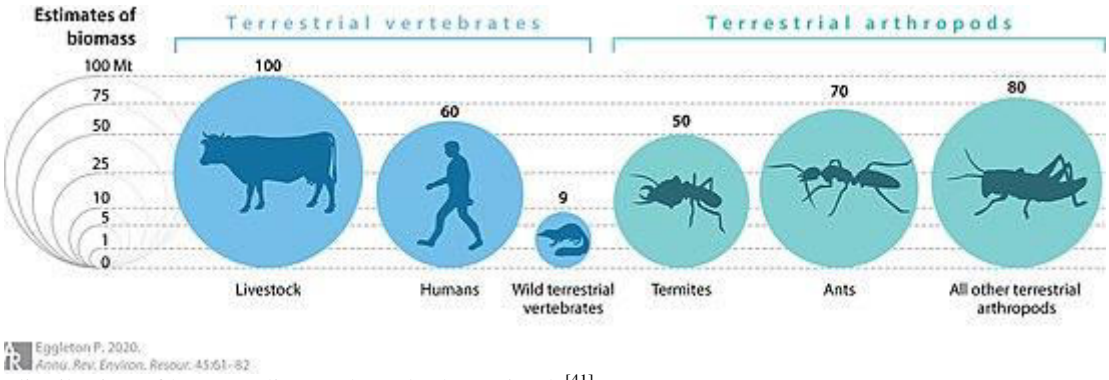
Truck transport is now common in developed countries.[36]

Local and regional livestock auctions and specialized agricultural markets facilitate trade in livestock. In Canada at the Cargill slaughterhouse in High River, Alberta, 2,000 workers process 4,500 cattle per day, or more than one-third of Canada's capacity. It closed when some of its workers became infected with coronavirus disease 2019.[37][38] The Cargill plant together with the JBS plant in Brooks, Alberta and the Harmony Beef plant in Balzac, Alberta represent fully three-quarters of the Canadian beef supply.[38] In other areas, livestock may be bought and sold in a bazaar or wet market, such as may be found in many parts of Central Asia.

In non-Western countries, providing access to markets has encouraged farmers to invest in livestock, with the result being improved livelihoods. For example, the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) has worked in Zimbabwe to help farmers make their most of their livestock herds.[39]

In stock shows, farmers bring their best livestock to compete with one another.[40]

Biomass



Biomass distribution of humans, livestock, and other animals[41]

Humans and livestock make up more than 90% of the biomass of all terrestrial vertebrates, and almost as much as all insects combined.[41]

Economic and social benefits

Global distribution data for cattle, buffaloes, horses, sheep, goats, pigs, chickens and ducks in 2010

The value of global livestock production in 2013 has been estimated at 883 billion dollars, (constant 2005–2006 dollars).[42] However, economic implications of livestock production extend further: to downstream industry (saleyards, abattoirs, butchers, milk processors, refrigerated transport, wholesalers, retailers, food services, tanneries, etc.), upstream industry (feed producers, feed transport, farm and ranch supply companies, equipment manufacturers, seed companies, vaccine manufacturers, etc.) and associated services (veterinarians, nutrition consultants, shearers, etc.).

Livestock provide a variety of food and non-food products; the latter include leather, wool, pharmaceuticals, bone products, industrial protein, and fats. For many abattoirs, very little animal biomass may be wasted at slaughter.

Many studies have found evidence of the social, as well as economic, importance of livestock in non-Western countries and in regions of rural poverty, and such evidence is not confined to pastoral and nomadic societies.[44][49][50][51]

Social values in developed countries can also be considerable. For example, in a study of livestock ranching permitted on national forest land in New Mexico, US, it was concluded that "ranching maintains traditional values and connects families to ancestral lands and cultural heritage", and that a "sense of place, attachment to land, and the value of preserving open space were common themes". "The importance of land and animals as means of maintaining culture and way of life figured repeatedly in permittee responses, as did the subjects of responsibility and respect for land, animals, family, and community."[52]

In the US, profit tends to rank low among motivations for involvement in livestock ranching.[53] Instead, family, tradition and a desired way of life tend to be major motivators for ranch purchase, and ranchers "historically have been willing to accept low returns from livestock production".[54]

Environmental impact

Animal husbandry has a significant impact on the world environment. It is responsible for somewhere between 20 and 33% of the fresh water usage in the world,[56] and livestock, and the production of feed for them, occupy about a third of Earth's ice-free land.[57] Livestock production is a contributing factor in species extinction, desertification,[58] and habitat destruction.[59] Meat is considered one of the prime factors contributing to the current sixth mass extinction.[60][61][62][63] Animal agriculture contributes to species extinction in various ways. Habitat is destroyed by clearing forests and converting land to grow feed crops and for animal grazing (for example, animal husbandry is responsible for up to 91% of the deforestation in the Amazon region[64]), while predators and herbivores are frequently targeted and hunted because of a perceived threat to livestock profits. The newest report released by the Intergovernmental Panel on Climate Change (IPCC) states that between the 1970s and 2000s agricultural emission increases were directly linked to an increase in livestock. The population growth of livestock (including cattle, buffalo, sheep, and goats) is done with the intention of increasing animal production, but in turn increases emissions.[65]

Livestock production requires large areas of land.

In addition, livestock produce greenhouse gases. The IPCC has estimated that agriculture (including not only livestock, but also food crop, biofuel and other production) accounted for about 10 to 12 percent of global anthropogenic greenhouse gas emissions (expressed as 100-year carbon dioxide equivalents) in 2005[66] and in 2010.[67] Cattle produce some 79 million tons of methane per day.[68][69][70] Livestock enteric methane account 30% of the overall methane emissions of the planet.[68][69][70] Livestock are responsible for 34% of all human-related emissions of nitrous oxide, through feed production and manure.[68][69][70] Livestock offer significant potential for reducing GHG emissions.[68][69][70] Best production practices are estimated to be able to reduce livestock emissions by 30%[11,12]

IV. CONCLUSION

There are numerous interlinked effects of climate change on livestock rearing. This activity is both heavily affected by and a substantial driver of anthropogenic climate change due to its greenhouse gas emissions. As of 2011, some 400 million people relied on livestock in some way to secure their livelihood.[73]:746 The commercial value of this sector is estimated as close to $1 trillion.[74] As an outright end to human consumption of meat and/or animal products is not

currently considered a realistic goal,[75] any comprehensive adaptation to effects of climate change must also consider livestock.

The observed adverse impacts on livestock production include increased heat stress in all but the coldest nations.[76][77] This causes both mass animal mortality during heatwaves, and the sublethal impacts, such as lower quantity of quality of products like milk, greater vulnerability to conditions like lameness or even impaired reproduction.[73] Another impact concerns reduced quantity or quality of animal feed, whether due to drought or as a secondary impact of CO2 fertilization effect. Difficulties with growing feed could reduce worldwide livestock headcounts by 7–10% by midcentury.[73]:748 Animal parasites and vector-borne diseases are also spreading further than they had before, and the data indicating this is frequently of superior quality to one used to estimate impacts on the spread of human pathogens.[73]

While some areas which currently support livestock animals are expected to avoid "extreme heat stress" even with high warming at the end of the century, others may stop being suitable as early as midcentury.[73]:750 In general, sub-Saharan Africa is considered to be the most vulnerable region to food security shocks caused by the impacts of climate change on their livestock, as over 180 million people across those nations are expected to see significant declines in suitability of their rangelands around midcentury[12]

REFERENCES

1. "livestock". Britannica.com.
2. ^ "Congress Clarifies That Horses are Not "Pets," Advances Landmark Livestock Health Measures". American Horse Council. Retrieved 19 January 2019.
3. ^ "Fresh Pork from Farm to Table". fsis.usda.gov.
4. ^ "NASS – Census of Agriculture – Publications – 2012". USDA. Archived from the original on 22 November 2017. Retrieved 29 November 2017.
5. ^ Anomaly, Jonathan (1 November 2015). "What's Wrong With Factory Farming?". Public Health Ethics. 8 (3): 246–254. doi:10.1093/phe/phu001. hdl:10161/9733. ISSN 1754-9973. PMC 9757169. PMID 36540869. S2CID 39813493.
6. ^ "Livestock definition". Dictionary.com. Retrieved 23 November 2015.
7. ^ "Merriam-Webster: Definition of Livestock". Merriam-Webster. Retrieved 18 January 2019.
8. ^ "Agriculture: A Glossary of Terms, Programs, and Laws" (PDF). 2005. Archived from the original (PDF) on 12 February 2011. Retrieved 10 December 2011.
9. ^ cbc.ca: "Police launch investigation into Aylmer Meat Packers", 28 August 2003
10. ^ Larson, G.; Bradley, D. G. (2014). "How Much Is That in Dog Years? The Advent of Canine Population Genomics". PLOS Genetics. 10 (1): e1004093. doi:10.1371/journal.pgen.1004093. PMC 3894154. PMID 24453989.
11. ^ Chessa, B.; Pereira, F.; Arnaud, F.; Amorim, A.; Goyache, F.; Mainland, I.; Kao, R. R.; Pemberton, J. M.; Beraldi, D.; Stear, M. J.; Alberti, A.; Pittau, M.; Iannuzzi, L.; Banabazi, M. H.; Kazwala, R. R.; Zhang, Y.-p.; Arranz, J. J.; Ali, B. A.; Wang, Z.; Uzun, M.; Dione, M. M.; Olsaker, I.; Holm, L.-E.; Saarma, U.; Ahmad, S.; Marzanov, N.; Eythorsdottir, E.; Holland, M. J.; Ajmone-Marsan, P.; Bruford, M. W.; Kantanen, J.; Spencer, T. E.; Palmarini, M. (24 April 2009). "Revealing the History of Sheep Domestication Using Retrovirus Integrations". Science. 324 (5926): 532–536. Bibcode:2009Sci...324..532C. doi:10.1126/science.1170587. PMC 3145132. PMID 19390051.
12. ^ Vigne, J. D.; Zazzo, A.; Saliège, J. F.; Poplin, F.; Guilaine, J.; Simmons, A. (2009). "Pre-Neolithic wild boar management and introduction to Cyprus more than 11,400 years ago". Proceedings of the National Academy of Sciences of the United States of America. 106 (38): 16135–8. Bibcode:2009PNAS..10616135V. doi:10.1073/pnas.0905015106. PMC 2752532. PMID 19706455.

International Journal of Advanced Research in Education and Technology

ISSN: 2394-2975 Impact Factor: 7.394

www.ijarety.in editor.ijarety@gmail.com