CLIMATE CHANGE AND LIVESTOCK PRODUCTIONS SYSTEMS: A CASE STUDY IN NIGER OF TECHNICAL AND DIDACTIC ACTIVITIES

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Abstract

Livestock systems in Sahelian countries are changing rapidly in response to a variety of drivers, such as growth of human population and urbanization and a huge increase of the global demand for livestock products. Such changes will impact on the future availability of natural resources, with negative consequences on animal and human health. Moreover, the climate changes will have significant consequences on food production and food security. This paper reports the results of some cooperation projects aimed both to optimize livestock management and productivity in a context of environmental stress and to strengthen the educational offer of local universities.

1. Introduction

As a result of the continued growth of the human population (with an estimated of more than 9 billion in 2050) (Cohen, 1995), a huge increase in the demand of animal production is expected in the next decades. Food and water security will be one of the priorities for humankind in the 21st century.

Over the same period the world will experience a change in the global climate that will cause shifts in local climate that will impact on local and global agriculture.

In this context, we have to expect that the livestock systems based on grazing and the mixed farming systems will be more affected by global warming than an industrialized system. This will be due to the negative effect of lower or irregular rainfall and more severe droughts on crops and on pasture growth and of the direct effects of high temperature and solar radiation on animals.

These systems exist mainly in developing countries where the human demand for animal products is increasing due to the higher and continuous growth in the population and per capita consumption. A loss of 25% of animal production by global warming is foreseen in these countries (Nardone *et al.*, 2010).

A worse scenario is foreseen for Africa, and in particular for sub-Saharan Africa, where extensive or pasture based systems remain the norm.

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The challenge will be how to better balance either the increase in the number of stock or the productivity per head, at the same time improving the sustainability of the livestock sector.

Indeed, animal production has to increase in the next decades to satisfy the growing need, according to the trends in consumption of livestock products, as showed in figure 1.

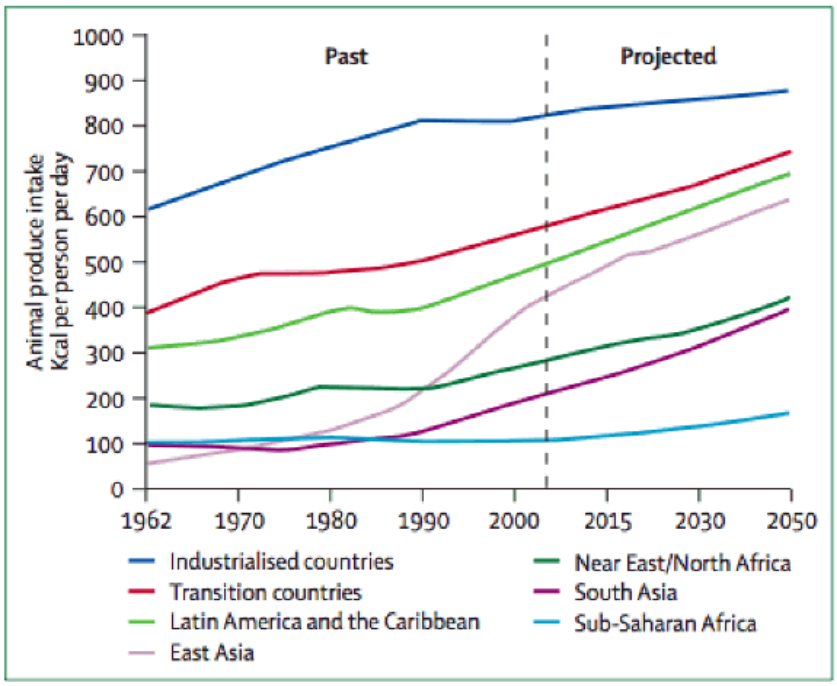

Figure 1. Trends in consumption of livestock products per person in different regions. Source: McMichael et al. (2007).

For more than 10 thousand years, farm animals have contributed to human needs for food and agricultural products: meat, dairy products, eggs, fibre and leather, draft power and transport, and manure to fertilize crops and for fuel. These animals have always played a large cultural role for livestock keepers. Livestock also play an important economic role as capital and for social security.

In most parts of the developing world, difficult environmental conditions and a lack of availability of capital, technology, infrastructure and human resources have not allowed intensification of agriculture, including development of genetic resources. On the other side, harsh climate, insufficient feed of low nutritional value, irregular feed availability, diseases and lack of education and infrastructure have kept the agricultural output per animal at a low and rather unchanged level for a long time. However, livestock breeds in the tropical parts of the world during thousands of years have become adapted to cope with harsh environments, including disease challenges, and to produce under conditions in which breeds developed in more favourable environments will not even survive. Such differences among animal populations have a genetic background and are the result of the interaction between genetic constitution and environment. This has evolved over time from natural and human selection of animals for performance in different environments that originated such a variety of indigenous breeds. However, when appropriately utilized in pure or cross-breeding programmes, indigenous breeds can contribute to increased productivity in smallholder production systems.

Figure 2. A transhumant herd in Niger (photo C. Semita, 2009)

The challenge now is to find ways to exploit the potential for improved and sustainable livestock production. This result could be obtained enhancing the variability among and within the indigenous breeds and the different environments and production systems in various parts of the tropics and sub-tropics.

Non-structured cross-breeding of indigenous breeds with imported high yielding breeds has been practised too often in the tropics, sometimes with disastrous results (Philipsson *et al.*, 2011).

Moreover, it is rightly argued that animal production systems, especially with ruminants, contribute to undesired methane emissions. However, it is also well established that these greenhouse emissions can be substantially reduced by increasing productivity and lowering the number of animals kept for a given total amount of produce. Hence, increased productivity per animal concentrating production on fewer but more valuable animals is a further way in reducing the negative environmental impacts of livestock production. This intensification, however, must also be designed to effectively manage all other risks to environmental degradation of land and water.

Another problem that affects livestock and pastoralism as dominant economies of sub-Saharan countries is social and political insecurity: the Northern parts of the Sahel and the Sahara have seen a rapid recrudescence of trafficking and other illegal activities. Some areas are now home to extremist groups, several of which are involved in terrorist activities. The insecurity and instability in these areas lead directly to increasing poverty for already poor pastoralists, and have a ripple effect on the economic wellbeing of the entire population of the Sahelian countries. While only a very small part of the population is thought to be directly and actively involved in these criminal activities, it is critical to understand whether that large part of dry land peoples, that is not directly involved, is vulnerable to these kinds of activities.

The development of pastoral economies and livelihoods is indeed an important element contributing to stabilization in the Sahel, and in particular to acquire the

cooperation of the pastoral population in the control of illicit and extremist activities (De Haan *et al.*, 2016).

This paper presents an analysis of some relevant effects of global warming on livestock production, the adaptation perspectives and strategies and the results of some international cooperation projects carried out in West African Countries, and in particular in Niger, by the Interdepartmental Centre of Research and Technical and Scientific Cooperation with Africa (CISAO) of the University of Turin (Italy).

2. Climate characterization, variability and change in West Africa

A main characteristic of the West African region is the strong variation (spatially and temporally) in rainfall quantity and distribution, long-term averages ranging from 150 to 1,200 mm year-1: under 150 mm in the Saharan zone, 150–400 mm in the Sahelian zone, 400–600 mm in the Sudano-Sahelian zone, 600–900 mm in the Sudanian zone and 900–1,200 mm in the Sudano-Guinean zone.

Prolonged dry seasons (up to 10 months annually) with high evaporation rates rotate with short rainy seasons, but regularity is not assured.

For all West African arid environments, rainfall data for the period 1960–1990 show a rather dramatic decline in average precipitation: analysis of rainfall variability and drought risk for this period revealed a high drought risk due to reduced precipitation.

The same trend, but with greater speed, occurred from 1990 to 2010.

Projections for future changes are mixed, however recent studies suggest a trend with a severe increase in drought risk, due to a reduction in the duration of the rainy season, but increasing of the amount of rain fall and consequently a drying trend that will affect rural productions (Nardone *et al.*, 2010).

3. Impact of climate changes on livestock

Climate change, particularly global warming, may strongly affect production performances of farm animals and impact worldwide on livestock production. Heat stress is a major source of production loss in the dairy and beef industry and whereas new knowledge about animal responses to the environment continues to be developed: managing animals to reduce the impact of climate remains a challenge.

3.1. Impact of climate changes on livestock production systems

Climate change and variability will affect land-use and land cover as a result of strong interactions between environmental and socioeconomic drivers of land-use, which define vulnerability and resilience of each productive system.

Adaptability represents the key tool to improve sustainability of livestock production systems under the pressure of climate and weather factors. An advanced planning of production management systems is required, with an understanding of animal responses to thermal stress and ability to provide management options to prevent or mitigate adverse consequences.

The main questions regarding the influence of climate change on livestock systems are: how much the different livestock systems are dependent on climate, which components of these systems will be mainly affected and what can we do to cope with these effects.

The level of dependence on climate estimates the quality of animal performance, health, welfare, nutrition and production may be affected by the climatic conditions in a short or in a medium period in each system.

In the extensive production systems constraints due to climate stress are substantial, aggravated by current degradation of natural resources, poor access to technologies and lack of investments in production (e.g. infrastructures). The increase of climatic variability will exert a strong influence on pastoral systems, even though they have developed the capability to cope and adapt to climate uncertainty.

However, since pastoral systems are totally dependent on availability of natural resources, the increase of inter-annual and seasonal variation of forage availability will contribute to reduce the overall sustainability, both from a socio-economic and from an ecological perspective.

Figure 3. Bororo cattle in Niger, a local breed (photo C. Semita, 2005)

The reduction of vulnerability of grazing/pastoral systems to climate changes should be based on the analysis of specific characteristics of the systems adopting new technologies (i.e. remote sensing) to evaluate feed and water availability, movement of the flocks, to establish feeding strategies to be adopted during exceptional events in connection with local decision-making processes.

The efficiency of water utilization will be another primary mission necessary to achieve sustainability of animal agriculture in expectation of increasing water scarcity and worsening quality (Nardone *et al.*, 2010).

3.2. Impact of climate change on animal health

Climate change, in particular global warming, affects the health of farm animals, both directly and indirectly. Direct effects include temperature-related illness and death, and the morbidity of animals during extreme weather events. Indirect impacts follow more intricate pathways and include those deriving from the attempt of animals to adapt to thermal environment or from the influence of climate on microbial populations,

distribution of vector-borne diseases, host resistance to infectious agents, feed and water shortages, or food-borne diseases.

The acclimation of the animals to meet the thermal challenges results in the reduction of feed intake and alteration of many physiological functions that are linked with impaired health and the alteration of productive and reproductive efficiency.

3.3. Impact of climate change on reproduction

High environment temperatures may compromise reproductive efficiency (hormone secretion, fertility, embryo development, lactation, etc.) of farm animals in both sexes and hence negatively affect milk, meat and egg production and the results of animal selection.

Over 50% of the bovine population is located in the tropics and it has been estimated that heat stress may cause economic losses in about 60% of the dairy farms around the world (Nardone *et al.*, 2010).

4. Inter-academic Cooperation to increase animal production and to ensure food security

Considering these assumptions that concerns lots of Sahelian Countries, included the Republic of Niger, improving the productivity becomes a goal to achieve in order to meet the population needs of animal products on one hand and to improve the incomes of farmers and cattle breeders on the other hand.

One way to improve animal production in the extensive systems is to develop selection programmes of animals, well adapted to pre-existing environmental conditions, to increase the strategic use of such breeds applying simple technologies and to strengthen feeding and management practices.

The use of reproductive technologies, in particular artificial insemination (AI), will become increasingly important to meet the growing demand for accelerated genetic improvement of extensively managed herds in Sahelian regions.

Numerous breeding programs using local breeds, based on first-generation biotechnologies (such as AI, a powerful tool for disseminating widely used genetic material in the world), are being developed to increase the productions (milk and meat) of local cattle breeds.

AI is a breeding technique consisting of collecting the sperm in the male and introducing it into the female's genital tract. The collected semen may be used immediately or after a period of preservation in refrigerated or frozen form.

AI has multiple advantages including technical advantages (a rapid diffusion in time and space of high genetic animals, biodiversity preservation); economic benefits (decreasing the number of breeding sires on the farm, saving feed and maintenance costs and reducing their environmental impact on pastures, and improving herd productions); health benefits (prevention of contagious and/or venereal diseases and better control and early diagnosis on the herd).

Despite these advantages, an uncontrolled use of AI may present disadvantages of several kinds: genetic (increasing consanguinity, loss of biodiversity); economic (high genetic animals are more demanding for maintenance, in particular food and health monitoring); sanitary (dissemination of certain diseases and genetic defects).

The need for clear strategies on the improvement and maintenance of indigenous cattle genetic resources is required along with clear breeding programs for sustainable genetic improvement. To date, AI is recognized as the best biotechnological technique for increasing reproductive capacity and has received widespread application in farm

animals. Despite the wide application of AI and its success throughout the developed world, as a matter of fact, the success rate in Sub-Saharan Africa is still low owing to a number of technical, financial, infrastructural and managerial problems (Mekonnen *et al.*, 2010; Thornton, 2010).

Although decades have been passed since AI started also in Africa, there are few statistics about the worldwide distribution of AI and there are field studies made to evaluate the reproductive performance of cows/heifers subsequent to AI and the sustainability of the use of this technology in Africa (Mekonnen *et al.***,** 2010).

World statistics for AI in cattle reports that the diffusion in Sub-Saharan Africa, considering semen doses processing (semen collection centres, local production and importation) and total number of inseminations, is only marginal, except for the Republic of South Africa (Thibiera *et al.*, 2002; AFCAS-FAO, 2015).

The factors that influence the success, the diffusion and the sustainability of the AI include:

a) Reliability of services;

b) Availability of trained staff and farmers in all the steps of AI breeding programs;

c) Source of bulls or semen, not only imported but also locally produced;

d) Affordable prices and charges of equipments and services (Mpofu, 2002).

Improvements in animal health and livestock management, and training of farmers and officers are the requirements for AI can be fully exploited.

To increase and strengthen livestock in Niger, the Faculty of Veterinary Medicine and the CISAO (Interdepartmental Centre of Research and Technical and Scientific Cooperation with Africa) of the University of Turin, in collaboration with the Faculty of Agronomy of the Abdou Moumouni University of Niamey and in agreement with the Ministry of Animal Resources, initiated and implemented some projects to strengthen the livestock sector in Niger, to promote the diffusion of AI to increase local breeds productions (Azawak zebu and Kouri cattle), financially supported by the Piedmont Region and the Italian Cooperation.

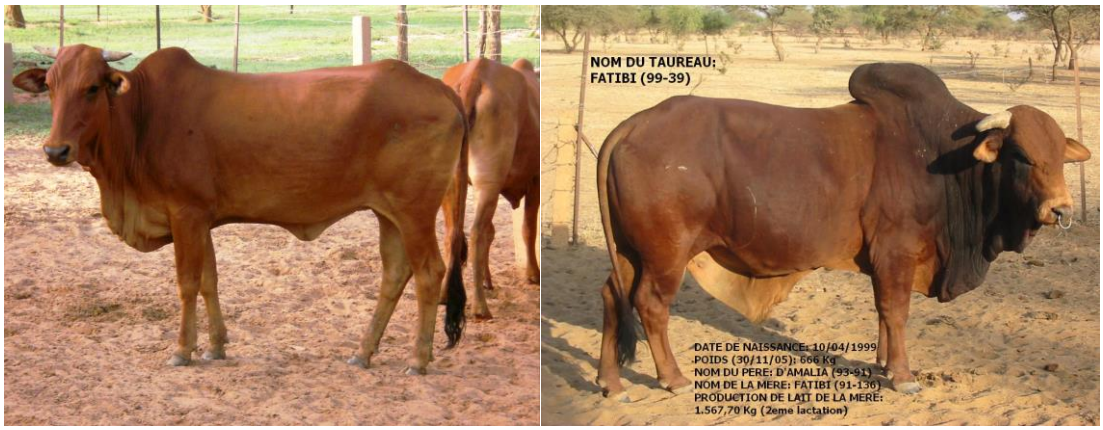

Figure 4. A cow and a bull of the Azawak zebu in Niger (photo C. Semita, 2005)

The overall objective of these projects is to participate in the national food security programmes by improving livestock production (Cristofori *et al.*, 2005; Marichatou *et al.*, 2010; Issa *et al.*, 2010a; Issa *et al.*, 2010b; Issa *et al.*, 2013; Semita *et al.*, 2014a).

Specific objectives are:

- The creation of the scientific and technical bases for the future modernization of milk and meat production methods in the cattle breeds of Niger;
- The establishment of a sperm bank for the Azawak breed and other local breeds;
- The dissemination of a performed genetic using selected breeders in AI programmes;
- The extension of the practice of AI and the organization of educational programmes for local technicians;
- The dissemination of project results and replication of experience in other contexts and other races (e.g., project to preserve the Kouri taurine race, typical of the Lake Chad area) (Semita *et al.*, 2011).

The achieved results are:

- The diffusion of the AI technique to improve animal productions;
- The progress of herd management (both for selection, nutrition and health programmes);
- The improvement of milk and meat production, increasing social and economic conditions of the rural population;
- The development of animal production systems with a particular focus on sustainable natural resources management;
- The contribution to the preservation of autochthonous breeds and the cultural identities of local populations of breeders that depends on these animals;
- The training of technicians able to perform semen collection of selected bulls, semen processing and freezing and the AI with a wider consciousness of the links between the different areas involved in rural development (natural resources management, water availability, grazing and soils management, human and animal health, food conservation, transformation and commercialisation, etc.) (Nervo *et al.*, 2014).

On the basis of the positive experiences of these projects and following the inputs from numerous other partners and funders, some national or international programs for the improvement of livestock production have been processed and activated by the government authorities in Niger.

For example, the West African Agricultural Productivity Program - WAAPP (in French *Programme de Productivité Agricole en Afrique de l'Ouest - PPAAO*, was initiated by the Economic Community of West African States (ECOWAS) with the financial support of the World Bank, to improve agricultural productivity while promoting regional integration as instruments for promoting poverty reduction in West Africa. The general objective of WAAPP is to contribute to increasing the agricultural productivity of priority sectors at both national and regional levels. In particular, the program aims at generating and disseminating improved technologies in the priority sectors of the region as listed in the strategic plan 2007-2016 (roots and tubers, rice, dry grains, livestock / meat, cotton, fruit and vegetables, etc.) and to create favourable conditions for regional collaboration. Therefore, identifying mechanisms and best practices to improve diffusion and adoption

of technologies and innovations is paramount for their better access by end-users in order to increase agricultural productivity diffusion.

In Niger, this programme supports the livestock sector, in particular strengthening meat and milk productions, promoting and developing AI.

Another program that promotes the breeding in Niger is the National Program for Genetic Improvement / Local Bovine (*Programme National d'Amélioration Génétique / Bovins Locaux PNAG / BL*), adopted in March 2011 with the aims to contribute to the preservation and improvement of the genetic potential of local cattle breeds while increasing their milk and meat production performance.

The implementation of this national program is based on a pilot phase of 14 years, in two programming cycles of 7 years each. The program is built on five components:

- genetic improvement,
- feed and forage production,
- animal health,
- capacity building,
- management (Marichatou *et al*., 2011).

In the context of sustainable development programs the role of universities as engines of development is undeniable. However, African higher education institutions (HEIs) are facing enormous financial and social problems: a low schooling rate, outdated infrastructures, inadequate financial, political and logistical support and occasional relationships between industry, government, social and productive sectors of the economy. For these reasons, under the project RUSSADE (FED/2013/320-115) (Semita *et al.*, 2014b; Barge *et al.*, 2015) founded by the EU in the ACP-EU cooperation programme in higher education (EDULINK II), the CISAO of the University of Turin, in collaboration with the universities of Burkina Faso, Chad and Niger, organized a specific Master to prepare a skilled staff for strategic positions in the technical structures of ministries, training and research institutions, enterprises and NGOs in the fields of rural development. Educational multidisciplinary programs should face challenges and difficulties of the agriculture in the Sahelian region to enhance capacities in various strategic fields: livestock productions, food security and safety, environmental preservation. The Master trains technicians able to contribute to the development process considering the interactions between different issues and increasing the awareness towards a sustainable management of environmental resources.

Courses and training activities take place in an innovative higher education vision, offering an integrated and interdisciplinary handling of themes concerning sustainable rural development in cyclical vision structure, coordinated and shared by Italian and African teachers together.

Moreover, the project recommends measures designed to strengthen the capacity and effectiveness of higher education, to promote basic and applied scientific research, to improve educational quality through updated teaching methodologies and to improve administrative management of the HEIs (Semita *et al.*, 2015a).

Another main methodological concern is the dissemination of sustainable and appropriate technologies. To achieve these results a network between the HEIs are reinforced, also encouraging the exchange of academic staff and students, creating a more favourable environment for debate and innovative research and promoting a greater

awareness of the connections between human choices, natural processes and environmental modifications.

The main result of this training is the acquisition not only of technical skills, but also of a deep awareness of local issues, taking into account that a local intervention affects the entire region.

Both theoretical and practical training strategies were adopted to transfer competences to all educational levels: higher education, technicians and farmers. The didactic methodology always developed a multidisciplinary and interdisciplinary approach.

The didactic and educational approach was evaluated submitting questionnaires to students, teachers and responsible for internships with regard to both technical and pedagogical analysis methods in relation to the improvement of the impact of a such learning process.

Teaching evaluation included collecting feedback for teaching improvement, developing a portfolio for job applications, and verify the relevance of this didactic programme.

Courses and training activities will take place in an innovative higher education vision, offering an integrated and interdisciplinary handling of themes concerning sustainable rural development in cyclical vision structure, coordinated and shared by Italian and African teachers together.

This evaluation showed a really good impact of the education and a good recruitment rate of the students of the first promotion.

Figure 5. The students of the Master implemented in the Project RUSSADE during a study tour in the Transnational Park W (Niger, Burkina Faso, Benin)

Teachers and researchers are stimulated to master the latest scientific and methodological knowledge in their own fields and also to create a positive interdependence with students by promoting teamwork (Semita *et al.*, 2015b).

This procedure aims to develop a sense of personal responsibility, encourages the acquisition of cognitive and social skills and increases the motivation to learn and solve complex problems Understanding the links between learning, research and professional

practice opens new perspectives: the capacity to face problems in a systemic way in different contexts and to acquire professional skills to respectfully work on different environmental components (Ferrero *et al.*, 2016).

5. Conclusions

Artificial insemination is a comparatively sophisticated method of animal husbandry. Its impact on cattle development is closely linked to the simultaneous introduction of reasonable standards of animal nutrition, disease control and husbandry, linked to a sustainable management of natural resources, in particular pasture and water. Unfortunately this has not always been recognized, and in some cases A.I. has been adopted purely as a technical method of getting cows in calf. The aim of cattle improvement has usually failed in such cases.

Anyway, the results from the AI programme in Niger indicate that it is highly feasible to introduce AI at "local level", taking same cautions. For example, to guarantee their sustainability, these systems must emphasize effective resource input/output ratios and more integration of livestock and crop production rather than industrialized mono-cultural production systems that seriously challenge the wise use and care of our natural resources.

Figure 6. A Kouri cattle bull, local breed in Niger.

Another important aspect is connected with training and educating technicians and farmers in the really benefits and constraints of the use of new technologies in livestock systems in Sahelian countries and their connections with all the other areas involved in rural development.

Farmer training is an important tool widely utilized by development programs in the Sahel, by matching workshops and seminars, on farm training and demonstrations and field visits.

Training in animal management (health, reproduction and nutrition) is desirable to farmers as they are often eager to improve their knowledge and practices and to have their knowledge affirmed by professionals.

Farmer training and support seem to have had an impact on animal health, livestock consumption, and sale. Trainings are an avenue for development workers to pass on new information and to correct miss-conceptions concerning animal management. Organizations that give animals to farmers usually require that the farmers receive some training before they are given the animals (Ampaire *et al.*, 2010).

Moreover, awareness creation on farming community is necessary to promote a enhanced herd management and the utilization of AI and different strategy for a sustainable use of natural resources to improve animal productions.

An emphasis should be also placed on the importance of the relationship between traditional knowledge, acquired from centuries of experience of the local population , and scientific awareness, by applying scientific knowledge to useful traditional practices.

The evaluation of the didactic and pedagogical approach is another important step to create educational programmes able to respond to the local needs and requirements in term of skilled professionals and technicians.

For the success of similar projects, where university research plays a major role, it is crucial that innovative actions and results do not remain confined to the academic world but that they are also disseminated to a larger scale to social and productive sectors of society.

Only in this way, the application of new and proper technologies could become a useful key element in the progress of development in Sahelian countries to ensure food security and environmental sustainability.

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