ENVIRONMENTAL SCIENCES & PRACTICES
http://mlsjournals.com/Environmental-Science-Practices

(2024) Environmental Sciences & Practices, 2(1), 7-21.

Sustainable agricultural development to optimize productivity through good soil management in Benguela-Angola

Desarrollo agrícola sostenible para optimizar la productividad a través del buen manejo del suelo en Benguela-Angola

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Manuscript information:

Received/Recibido: 25/09/23
Reviewed/Revisado: 15/01/24
Accepted/Aceptado: 25/01/24

Keywords:
Agricultural development, sustainability, soils, agricultural production.

ABSTRACT

The research is based on an exhaustive review of the literature using the qualitative documentary method, consulting national and international authors, as well as national educational plans and programs. The main objective of this research is to evaluate the state of the soils in the province of Benguela-Angola and propose strategies to improve the quality of arable soils. This would contribute to sustainable agricultural development and encourage environmentally friendly soil management practices. The Benguela-Angola region offers great opportunities to improve soil quality and achieve sustainable production. The results obtained highlight the urgent need to implement preventive and corrective measures to stop soil contamination and remediate already affected soils. The implementation of sustainable agricultural practices is proposed, such as organic agriculture and the responsible use of chemicals. In addition, the adoption of soil conservation techniques is suggested, such as crop rotation, planting vegetative covers and building terraces. Implementing the proposals mentioned above, in collaboration with farmers, industries, local governments and communities, can make a significant difference. The adoption of sustainable agricultural practices, proper waste management, protection of natural vegetation areas and community awareness are key elements to achieve sustainable production and optimize productivity through proper soil management in the study region.

Palabras clave:
desarrollo agrícola, sostenibilidad, suelos, producción agrícola.

RESUMEN

La investigación se basa en una revisión exhaustiva de la literatura utilizando el método cualitativo documental, consultando autores nacionales e internacionales, así como planes y programas educativos nacionales. El objetivo principal de esta investigación es evaluar el estado de los suelos en la provincia de Benguela-Angola y proponer estrategias para mejorar la calidad de los suelos cultivables. Esto contribuiría al desarrollo agrícola sostenible y fomentaría prácticas de manejo del suelo

	respetuosas con el medio ambiente. La región de Benguela-Angola ofrece grandes oportunidades para mejorar la calidad del suelo y lograr una producción sostenible. Los resultados obtenidos resaltan la necesidad urgente de implementar medidas preventivas y correctivas para detener la contaminación del suelo y remediar los suelos ya afectados. Se propone la implementación de prácticas agrícolas sostenibles, como la agricultura orgánica y el uso responsable de productos químicos. Además, se sugiere la adopción de técnicas de conservación del suelo, como la rotación de cultivos, la siembra de coberturas vegetales y la construcción de terrazas. La implementación de las propuestas mencionadas anteriormente, en colaboración con agricultores, industrias, gobiernos locales y comunidades, puede marcar una diferencia significativa. La adopción de prácticas agrícolas sostenibles, la gestión adecuada de residuos, la protección de áreas de vegetación natural y la concienciación comunitaria son elementos clave para lograr una producción sostenible y optimizar la productividad a través del manejo adecuado del suelo en la región de estudio.

Introduction

Agriculture plays a crucial role in society by providing the food necessary to satisfy the basic needs of human beings, thus becoming the most important economic sector. In Angola, important changes have been implemented in recent years with the aim of reducing the economy's excessive dependence on mineral resources and oil, and promoting the development of other sectors, where agriculture plays a decisive role.

However, there is a trend in the country towards an almost doubled annual expansion of the cultivated area towards natural and marginal areas. This expansion is mainly due to the low yields obtained per unit area. Unfortunately, in most cases, this expansion leads to significant environmental damage, such as soil erosion, salinity, desertification, deforestation, and threats to biodiversity and water scarcity.

Addressing these challenges is critical to ensure the sustainability of agriculture in Angola. Proper management of natural resources and careful planning are required to minimize negative impacts on the environment. In addition, it is necessary to implement sustainable agricultural practices that increase yields per unit area without compromising soil health and biodiversity.

Agriculture in Angola plays a key role in the country's economic development. However, it is necessary to address the challenges related to the expansion of cultivated area in natural and marginal areas, which entails significant environmental damage. The implementation of sustainable agricultural practices and the proper management of natural resources are key to ensuring the long-term sustainability of agriculture in Angola.

Soil, as a fundamental resource for the survival of mankind and other species, provides 95% of the food we consume. Despite its importance, its environmental protection has long been neglected. Insufficient attention has been paid to the threat posed by human activities to soil, an increasingly scarce and invaluable natural resource due to its central role in the interaction between the geosphere and the biosphere. Soil degradation leads to the loss of ecosystem services, which has serious consequences.

In this context, soil protection has become increasingly important in Angola, in line with Africa's efforts to achieve a sustainable territory. The Angolan government has made a strong commitment to soil preservation and is working on the implementation of increasingly advanced sustainability criteria in various areas, such as land use and urban planning, agriculture, livestock, forestry, management of natural areas and remediation of contaminated soils.

To coordinate these interventions, Angola has developed the Soil Protection Strategy, established by Presidential Decree No. 177/20 of June 23. This strategy, approved by the Ministry of Agriculture and Fisheries, proposes to meet the objectives set by working in a collaborative and coordinated manner with all stakeholders involved in the protection of this natural resource. The strategy addresses the most pressing environmental concerns, such as climate change and biodiversity loss, and integrates them with traditional challenges, such as the loss of water and air quality. The resulting approach is a combination of integrative concepts that allow environmental protection to be addressed while incorporating social and economic aspects.

The challenge is to rehabilitate degraded soils and minimize land degradation and occupation in net terms. Healthy soils are essential for achieving climate neutrality, a circular and clean economy, reversing biodiversity loss, ensuring healthy food, protecting human health and combating desertification and land degradation. Humans and other species that inhabit the Earth need direct contact with the soil and terrestrial ecosystems.

It is essential to take measures to protect and preserve the soil as a vital resource. Angola is committed to this task and has established a comprehensive strategy that addresses

environmental challenges and promotes collaboration between different sectors. Only through the rehabilitation of degraded soils and the adoption of sustainable practices can we ensure a healthy and sustainable future for our planet.

Despite the launching of the RETESA (Rehabilitation of Land and Management of Pasture Areas in Smallholder Farming Systems in Southwest Angola) project by the United Nations Agency, which is recognized as a starting point for the development of activities focused on the promotion and management of pasture areas, the reality is that Angola continues to face significant soil loss due to erosion. According to the advisor of the United Nations Food and Agriculture Fund (FAO), it is estimated that the country loses around 20 million tons of soil per year, which is equivalent to a loss of capacity to feed approximately 50,000 people.

Land for agricultural production is often obtained through the traditional slash-and-burn process of native forests. This practice, known as slash-and-burn agriculture, has long been employed and is considered the first step in the transition from a society based on food gathering to a society that produces its own food (Zhang, Y., Ram, MK, Stefanakos, EK and Goswami, DY (2012)). Although still practiced in several regions of the world, this technique has significant negative impacts on the environment.

Slash-and-burn agriculture is economically viable and offers advantages to farmers by allowing them to prepare new land for planting and other agricultural activities. However, it also has serious consequences for the environment. It decreases biodiversity and increases soil erosion, thus contributing to the problem of deforestation and soil impoverishment. Fires resulting from this practice often get out of control and spread, destroying large areas of forest.

Alterations to the natural land cover due to human activities also influence the hydrological system. Some land use changes do not immediately alter the hydrologic response, but occur progressively over time (Schulze, 2003 cited by Wartbuton, 2012). The practice of slash-and-burn to obtain agricultural land has economic and cultural advantages for farmers, but also has negative impacts on the environment, such as reduced biodiversity and increased soil erosion. It is important to promote sustainable agricultural practices that minimize these impacts and promote the conservation of natural resources.

Degradation of vegetation cover and deforestation of woody plants and shrubs are processes widely linked to desertification. Desertification is defined as land degradation in arid, semi-arid and dry areas, which occurs as a result of climatic changes and/or human activities (UNCCD 1994 cited by Dawelbait and Morari 2012). In these regions, natural resources such as land, water and vegetation are extremely fragile and highly susceptible to degradation (CCD/UNEP 1995). Population growth and the increasing demand for food, feed and energy have generated a series of interconnected economic, social and environmental problems related to soil degradation. In essence, desertification is the result of land degradation.

Currently, one of the main challenges related to inadequate soil management lies in poor conservation practices, especially with regard to land preparation, fertilization, crop rotation and association, as well as irrigation. (Giraldo, S. C. (2016)). Through the proper use and management of the chemical, physical and biological properties of the soil, together with the implementation of conservation practices, it is possible to guarantee its balance and recovery, thus increasing its fertility and avoiding degradation problems and, consequently, food shortages. Soil degradation currently represents a considerable threat to the future of humanity, which is of great concern to the scientific community and poses the triple challenge of intensifying soil conservation in an appropriate manner in order to maintain its balance and fertility, which contributes to guaranteeing food availability and preserving natural resources for future generations. It is necessary to implement sustainable soil management practices, promoting education and awareness of the importance of soil conservation.

It is essential to integrate sustainable land management into all agricultural, pastoral and forestry development initiatives in southwest Angola. This involves not only the

rehabilitation of grazing areas through improved pasture and herd management, but also the implementation of project monitoring strategies and dissemination of best practices. In addition, the capacities of farming communities must be strengthened to reduce the impact of land degradation processes and achieve their rehabilitation.

The objective of this research is to evaluate the state of soils in the province of Benguela-Angola and to develop strategies to improve the quality of arable soils. This study aims to contribute to sustainable agricultural development and promote environmentally friendly soil management practices.

Method

This research is the result of a thorough review of the literature following the method: Qualitative documentary. Several national and international authors and even national educational plans and programs were consulted, an exploratory-descriptive research was conducted, with the main objective of this research is to assess the state of soils in the province of Benguela-Angola and propose strategies to improve the quality of arable soils. In this way, it seeks to contribute to sustainable agricultural development and promote environmentally friendly soil management practices.

Characteristics of Benguela Province

Benguela, a city and municipality located in the province of Benguela, western Angola, is recognized as the capital of the province. The municipality is made up of only the headquarters municipality, which is divided into six zones. According to population projections prepared by the National Institute of Statistics for 2018, Benguela has a population of 623,777 inhabitants and a territorial area of 2,100 km^2, making it the most populous municipality in the province and the tenth most populous in the country. . It is bordered to the north by the municipality of Catumbela, to the east by the municipalities of Bocoio and Caimbambo, to the south by the municipality of Baía Farta and to the west by the Atlantic Ocean.

Its climate is dry and hot in the coastal zone, with an average temperature of 24.2 degrees Celsius. Minimum Celsius and maximum 35 degrees Celsius. Vegetation is concentrated in the western part of the province and from time to time this part has been greatly reduced in the coastal zone due to deforestation. There are approximately 1 million hectares of potential agricultural land, and it can produce a variety of products thanks to its fertile soil and water resources. The main products are bananas, corn, potatoes (reindeer and sweet potatoes), wheat, coconut, beans, fruits, citrus fruits, mangoes, sugar cane, etc.

The province of Benguela has a high agricultural and livestock potential, which has been historically proven. This is due to a unique soil structure and a favorable climatic diversity, combined with a hydrographic network of enviable quality. With about one million hectares of arable land, the province has great capacity for the development of agricultural activity in this area. Benguela represents an important agricultural region in Angola, with great potential for the development of agricultural and livestock activities. It is known nationally for the variety of its production and for cattle breeding, where it ranks fourth. It currently cultivates an area of approximately 214,000 hectares and the main products amount to some 247,000 tons.

In addition, the average annual temperature in Angola is around 20 degrees Celsius, with lows of 14 degrees and highs of 28 degrees. These moderate temperatures, together with 12 to 13 hours of daylight, provide a favorable environment for the development of various crops and agricultural activity in general.

Soils in Angola are characterized by being predominantly loamy, clayey and sandy. These soil types provide a suitable base for agriculture and other uses. Average annual rainfall

in Angola is around 1100 mm, although there are regions where figures can reach 2500 mm. These favorable rainfall conditions contribute to soil fertility and crop growth.

The predominant soils in the Benguela locality are mainly of the ferralitic type, but paraferralitic and lithosols are also present. The latter, although not very representative, are associated with the lower part and the base of the mountain slopes (Diniz 1993; cited by Matas et al., 2007). Paraferralitic soils and lithosols have significantly higher fertility than ferralitic soils and are mainly used for drought crops such as wheat.

In addition, alluvial soils associated with the larger valleys are also found in the Benguela region. These soils, known as "nakas" and "mbalas" by local farmers, are relatively fertile areas that are exploited mainly during the dry season through regulated irrigation of the water table. Vegetables and corn are grown in these areas, taking advantage of the existence of numerous water sources on the mountain slopes (Ramos Noriega, M. I. (2019)).

It is important to highlight the diversity of soils and agricultural characteristics of the Benguela locality. The ferralitic, paraferralitic and lithosol soils present in the region offer different possibilities for the development of sustainable agricultural practices. It is essential to implement soil conservation and water management strategies, as well as to take advantage of soil fertility to ensure long-term agricultural production (Diniz 1993; Matas et al., 2007; Sardinhas 2006).

In summary, Angola has loamy, clayey and sandy soils, with average annual rainfall of around 1100 mm, average annual temperatures of 20 degrees Celsius and 12 to 13 hours of daylight. These conditions are favorable for agriculture and food production in the country.

It is essential to implement strategies and policies that promote the rehabilitation of agricultural activity in Benguela. This involves mine clearance and deactivation, as well as the implementation of support and training programs for farmers to promote sustainable land use and maximize the province's agricultural potential.

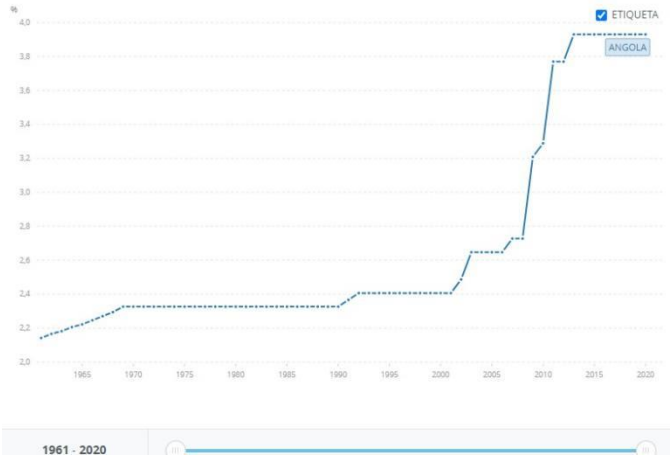
According to the Food and Agriculture Organization of the United Nations (FAO), Angola is among the five countries with the greatest agricultural potential in the world. The country has 58 million hectares of arable land, equivalent to an area larger than France. However, only 10% of this land is currently in use, mainly due to the lack of adequate irrigation systems.

In the province of Kwanza del Sur, the country's largest agricultural facility is located at 1,400 meters above sea level in the highlands. With an area of 10,000 hectares, only one third of this area is currently under cultivation. Despite this, 50 different species are currently produced in this area, generating an annual turnover of US$5 million.

It is important to note that, although large private landowners represent approximately 15% of agricultural producers in Angola, they manage to exploit about half of the country's arable land (Table 1). This underscores the need to promote investment in the agricultural sector and encourage the participation of small farmers to take full advantage of Angola's agricultural potential.

Figure 1

Arable land (% of land area) - Angola



Benguela, Angola's vegetable garden

Agricultural production in this region is diverse and abundant (Table 2). The main crops include sisal, cotton, sugar cane, arabica coffee, avocado, banana, potato, sweet potato, sesame, macundé bean, sunflower, guava, papaya, mango, passion fruit, massambala, massango, corn, aromatic plants, vegetables, castor beans, tobacco, eucalyptus and pine.

Approximately 1 million hectares of the total area of 39,826.83 km^2 are suitable for agricultural activity. Rehabilitation programs are currently being implemented to improve infrastructure to support agriculture, livestock and irrigation. Priority is given to the cultivation of corn, beans, bananas, palm and various vegetables. Gross production is estimated at 80,000 tons.

In addition, we seek to rehabilitate irrigation systems in the interior of the province to benefit farmers. Agricultural inputs are being distributed and training is being provided to support and strengthen agricultural production in at least 6 inland municipalities.

Data provided by medium-sized farms reveal that this region is betting on large-scale food production. Despite the crisis, the local market is flooded with vegetables and this has stimulated the entrepreneurial capacity of farmers.

Benguela has the ideal climatic conditions to be considered the best area in the country (Table 3), and even in the world, for banana production. It is estimated that large producers in the area release around 15,000 tons of bananas per year. This crop occupies most of the agricultural land in the Benguela valleys, where another 200 small and medium-sized producers also work, mainly in the Culango and Canjala valleys.

Figure 2

NDVI profile compared to LTA (1984-2015) and previous year

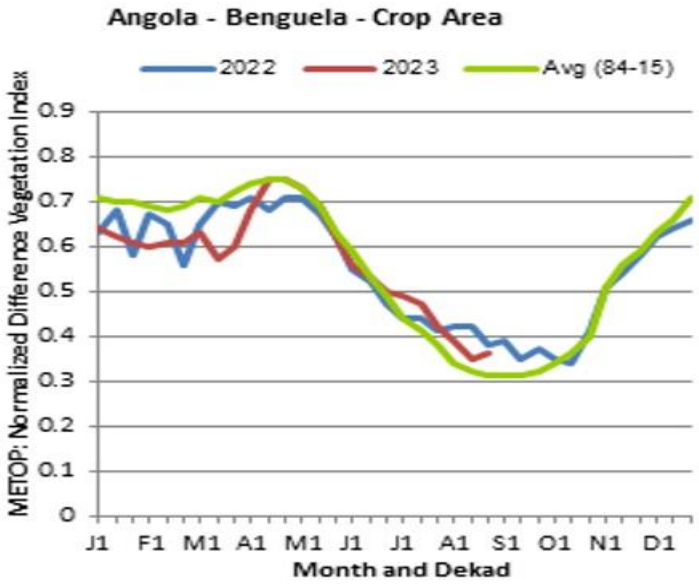
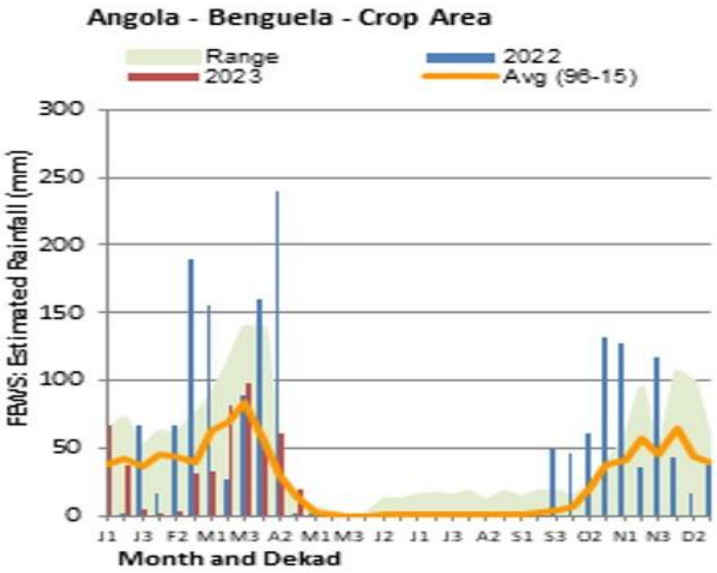


Figure 3

Estimated rainfall compared to LTA and previous year



The NDVI Profile compared to LTA is a tool that compares the long-term moving average (LTA) of the Normalized Difference Vegetation Index (NDVI) with the current NDVI, allowing to identify anomalies in the vegetation over time.

However, the goals for Benguela are even more ambitious. Over the next three years, the province plans to reach an annual production of at least 24,000 tons of bananas. Experts assure that, by reaching 50,000 tons, the country's needs could be met and a continuous flow of exports to the world's most demanding markets could be guaranteed.

On the domestic market, approximately 70% of the tomatoes, onions and bananas sold in Luanda come from Benguela, while 20% come from Namibe and 10% from other nearby areas. The Cavaco Valley, the most productive in the province, is where the most ambitious and competitive bets are being made, and where they are increasingly taking the lead in vegetable production.

Today, farmers in this area use modern machinery, seeders, automatic irrigation systems, bulldozers, graders and other advanced equipment. This guarantees the continuity of

the banana business even when there is a generational change and the land passes into the hands of the new generations, who find incentives not to abandon the land and continue with the business.

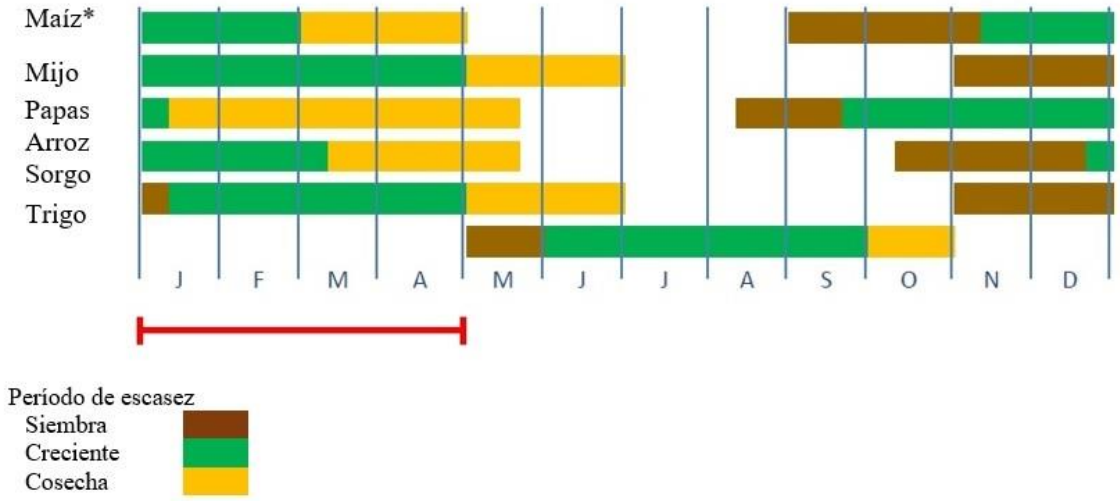
A key factor in the success of agricultural production in Benguela is water. The rehabilitation of the Dungo dam, in the municipality of Cubal, by the Provincial Government of Benguela, has been fundamental in guaranteeing the availability of water for irrigation of the extensive agricultural areas. Twenty years later, farmers in the region have renewed hopes for a return to large-scale production of bananas, onions, tomatoes and corn (which has recently experienced high demand) on the 2,500 hectares of cultivated land.

Results

Cereal production in 2022 was slightly above the five-year average, especially for coarse grains. The main cereal harvest concludes in July and, although official data are not yet available, favorable weather conditions in the main cereal producing areas indicate higher yields (Figure 1). However, in the southern provinces, irregular rainfall and high temperatures have negatively affected cereal production.

Figure 4

*Crop calendar (*main food crop)*



Source: Source: FAO/GIEWS.

In the 2022/23 trading period (April/March), it exceeded the average, which is mainly due to the need to meet about 40% of domestic grain demands. Wheat and rice imports, which represent the largest proportion of cereal imports, increased by 4% and 17%, respectively, compared to the average of the last five years.

As for food inflation, a slowdown was observed in 2022, although levels remain high. The annual headline inflation rate was estimated at 21% in July 2022, the lowest level since mid-2020. Unlike neighboring countries, the country has benefited from high world oil prices, due to its status as an exporter, which has supported an appreciation of the national currency and helped curb inflation caused by imports. In addition, the government's implementation of the Strategic Food Reserve Plan has contributed to stabilizing domestic food supply and containing price increases, thus alleviating inflationary pressure.

Grain production was above average in 2022, along with an increase in grain imports to meet domestic demand. Although the rate of food inflation has slowed, it remains high, but measures have been implemented to contain price increases and stabilize the domestic food supply.

Angola: Soil loss and contamination in agriculture

In Angola, it has been revealed that the country loses about 20 million tons of soil per year due to erosion, which is equivalent to a loss of capacity to feed 50,000 people. This worrying situation was made known by Paulo Vicente, advisor to the United Nations Food and Agriculture Organization (FAO), during a conference in Namibe.

The agricultural perimeter of Catumbela, located north of Benguela City, has 3,317 hectares of arable land. The main crops grown in this area are corn, vegetables and bananas, with a total of 520 hectares of corn, 539 hectares of vegetables and 193 hectares of bananas. However, the low flow of the Catumbela River, due to the lack of rainfall, has negatively affected crops in the region.

In addition, agricultural activities in the region have contributed to soil contamination. Hazardous chemicals such as pesticides, persistent organic pollutants, lead and mercury have been used, posing a risk to both environmental and human health. Although the use of these chemicals is banned or controlled in developed countries, their illegal dumping in Africa remains a major challenge for environmental pollution management.

The use of pesticides in agriculture is considered the main factor contributing to soil contamination. Significant levels of endosulfan and Dichloro, Diphenyl, Trichloroethane (DDT) have been detected in the soils of state farms in Ethiopia, and are attributed to historical agricultural practices in the area. In Burkina Faso, endosulfan and profenofos have been found in soils used for cotton production.

Although DDT is banned for agricultural purposes in the region, exceptions have been granted for its use in malaria vector control. However, DDT is sometimes diverted from its intended purpose and sold on the local market for use in agriculture.

Burial of obsolete pesticides in the past has also been a source of soil contamination. This practice can be a diffuse source of groundwater contamination by infiltration. According to the World Bank, about 50,000 tons of obsolete pesticides were identified in Africa in 2018.

Soil loss and pollution in agriculture pose a serious threat to food security and sustainable development in Angola. It is essential to implement sustainable agricultural practices, promote the responsible use of chemicals and encourage soil conservation and restoration to protect natural resources and ensure the well-being of future generations.

As a possible solution, we should begin to respect existing national and international alliances and agreements:

The Global Soil Alliance (GSA) was established in 2012 with the aim of promoting closer and more effective collaboration between stakeholders. Its mandate is to improve the governance of limited soil resources worldwide, ensuring soil health and productivity to ensure food security and support other vital ecosystem services. The WHA recognizes the sovereign right of each state over its natural resources and strives for sustainable land management.

The Voluntary Guidelines for Sustainable Soil Management (VGSSM) were approved by the FAO Council in 2016 and provide technical and policy recommendations for achieving sustainable soil management. These guidelines identify ten threats to soil functioning and health, including soil contamination, and propose a set of principles to minimize and control these threats.

The International Code of Conduct on Pesticide Management, adopted by FAO members in 2013, sets voluntary standards of conduct for all stakeholders involved in the use of

pesticides. The objective of this code is to ensure the rational use of pesticides and to serve as a basis for countries with no or weak legislation to regulate the quality and suitability of pesticide products.

The Global Action Plan on Antimicrobial Resistance, endorsed by the WHO Assembly in 2022, aims to combat antimicrobial resistance, which poses a threat to human and animal health and hinders medical advances in the treatment of infectious diseases. This plan establishes five goals to combat antimicrobial resistance, including increasing awareness, reducing the incidence of infections and optimizing the use of antimicrobial drugs.

The Bamako Convention on the Ban of the Import of Hazardous Wastes into Africa and the Management of Wastes within Africa was adopted within the framework of the Basel Convention. Its main objectives include banning the import of potentially hazardous waste, including radioactive waste, and properly managing waste already present in Africa. However, its acceptance and application have been limited, leading to the Libreville Declaration on Health and Environment in Africa in 2008, promoted by WHO. This declaration seeks to establish a legislative framework, build capacity to address the problems, initiate and coordinate applied research, and ensure effective implementation and follow-up at the national level.

It is essential to improve communication mechanisms on the causes, risks and preventive actions of soil contamination among all stakeholders, especially the general public. The actions undertaken by the Global Soil Partnership following the Global Soil Pollution Symposium and on the occasion of World Soil Day 2023 have demonstrated a strong interest in this topic.

Realizing the importance of professional practices, it is essential to address these challenges and work together to ensure sustainable soil management and protect our natural resources for future generations.

Priority actions to prevent and stop soil contamination and to remediate contaminated soils may include:

Implement appropriate management measures in industrial and agricultural activities to minimize the release of pollutants into the soil. This may include the use of cleaner technologies, the application of good agricultural practices and the promotion of sustainable production methods.

Establish strict environmental regulations and standards to control and monitor soil contamination. This may include the implementation of soil quality monitoring and evaluation programs, as well as sanctions for those who do not comply with established standards.

Promote environmental education and awareness to encourage responsible land management practices. This may include training farmers, industries and local communities on the importance of protecting and conserving soil quality.

Encourage research and development of innovative technologies and methods for the remediation of contaminated soils. This may include the use of bioremediation techniques, where living organisms are used to degrade contaminants, or the application of specific amendments and treatments to restore soil quality.

Establish long-term monitoring programs to evaluate the effectiveness of prevention and remediation actions. This will allow for continuous adjustments and improvements in the strategies implemented.

Promote organic agriculture and gardening: Promoting farming practices without the use of toxic chemicals, such as pesticides and synthetic fertilizers, helps prevent soil contamination. The use of organic techniques, such as crop rotation and composting, improves soil health and reduces reliance on harmful chemicals.

Promote proper waste management: Implement recycling and composting programs to reduce the amount of waste that ends up in landfills. Proper disposal of wastes, including chemicals and hazardous materials, prevents them from contaminating soil and groundwater.

Protect areas of natural vegetation: Conserving and protecting natural ecosystems, such as forests and wetlands, helps maintain soil quality. These areas act as natural filters, absorbing and filtering pollutants before they reach the soil and water.

Promote the responsible use of chemical products: Promote the responsible use of chemical products in industrial and domestic activities, avoiding their release into the soil. This involves the proper use and safe storage of chemicals, as well as the adoption of safer and less toxic alternatives.

Implement erosion control measures: Soil erosion is an important cause of contamination, as it can carry sediments and pollutants into nearby water bodies. Implementing erosion control measures, such as planting vegetative covers, terracing and soil conservation, helps prevent soil loss and associated pollution.

It is important to emphasize that these actions must be carried out in a coordinated manner among different actors, including governments, industries, farmers, scientists and society in general, in order to achieve effective results in soil protection and conservation. Collaboration and commitment from all are essential to address the challenges of soil contamination and create a sustainable environment for future generations.

Strategies for sustainable soil management

In the area of sustainable soil management, a number of key actions have been identified to promote harmonization of standard operating procedures in laboratory methods for soil contaminant analysis. This includes the development of standardized threshold levels of soil contamination, which will allow the establishment of clear criteria for assessing and monitoring soil quality.

It is also essential to promote the inclusion of soil contamination in conventional soil survey data and information in national and global soil information systems. This will help to improve the overall understanding of the challenges and solutions related to soil contamination.

In addition, greater investment is required in specific research on emerging contaminants, addressing aspects such as their detection, fate in the environment, risk assessment and remediation. This will allow the development of effective strategies to meet the new soil contamination challenges.

Regarding the monitoring of point and diffuse soil contamination, it is necessary to establish and strengthen national, regional and global inventory and monitoring systems. This will provide up-to-date and reliable data on soil quality and facilitate informed environmental management decisions.

In parallel, it is essential to establish and strengthen national biosurveillance and epidemiological surveillance systems to identify, assess and control damage and diseases attributable to soil contamination. These systems will be essential to implement preventive actions and mitigate negative impacts on human health and the environment.

To strengthen international cooperation in sustainable soil management, the creation of the Global Soil Pollution Monitoring and Information System is being promoted. This initiative will facilitate the exchange of best practices, data and experiences among countries, promoting joint actions to address global challenges related to soil contamination.

Effective implementation to prevent and remediate soil contamination

It is essential to enforce international agreements on chemicals, persistent organic pollutants, residues and sustainable soil management. This involves ensuring compliance with the Voluntary Guidelines for Sustainable Soil Management and the International Codes of Conduct for the Sustainable Use and Management of Fertilizers and Pesticides.

It is also proposed to establish a system of incentives and recognition for efforts to stop soil contamination. This can include eco-labeling and compliance with schemes such as the Voluntary Guidelines for Sustainable Soil Management, offering a distinctive label to agricultural products that apply sustainable soil management practices.

It is necessary to advocate for a global commitment to prevent, stop and remediate soil contamination, in line with the goals of Zero Pollution/Towards a Pollution-Free Planet. Regional efforts and objectives, such as the European Green Pact, can be used as a basis for establishing clear goals and concrete actions in this area.

It is important to improve national and international regulations on industrial and mining emissions, promoting environmentally friendly production processes. This will contribute to significantly reduce soil contamination generated by these activities.

The implementation of policies that promote the "right to repair" and discourage the planned obsolescence of manufactured materials is also key to reducing waste, including electronic waste. Likewise, the use of single-use articles should be discouraged and reduced, especially in materials and food packaging.

It is necessary to implement adequate waste collection and green management policies that promote recycling and ensure proper treatment of different types of waste within and between countries. This will help reduce waste generation and minimize its impact on the soil and the environment in general.

In the area of sustainable agricultural soil management, policies should be implemented to reduce dependence on agrochemicals and promote the control of irrigation water quality and organic residues. This will minimize the negative impacts of agriculture on soil quality and contribute to the production of healthier and more sustainable food.

It is essential to develop and include in national reporting mechanisms soil contamination targets and indicators related to the achievement of the Sustainable Development Goals. This will make it possible to effectively evaluate and monitor progress in sustainable soil management and ensure accountability in this area.

Finally, there is a need to expand sustainable nature-based and environmentally sound management and remediation technologies, such as bioremediation. These technologies offer effective and environmentally friendly solutions to address soil contamination and restore soil quality in a sustainable manner.

In conclusion, sustainable soil management requires a series of strategic and technical actions, ranging from the harmonization of operational procedures to the implementation of concrete policies and actions. With the collaboration and commitment of all sectors involved, it is possible to prevent and remediate soil contamination, thus protecting our health and the environment for future generations.

Discussion and conclusions

. The objective of the research was to evaluate the state of soils in the province of Benguela-Angola and to develop strategies to improve the quality of arable soils, in order to achieve sustainable production and optimize productivity through good soil management.

During the assessment, several problems affecting soil quality in Benguela-Angola were identified, such as erosion, organic matter degradation, salinization and chemical contamination. These problems represent a significant challenge for food security and sustainable development in the region.

The results obtained highlight the urgent need to implement preventive and corrective measures to stop soil contamination and remediate already affected soils. To achieve this, the implementation of sustainable agricultural practices, such as organic agriculture and the

responsible use of chemicals, is proposed. The adoption of soil conservation techniques, such as crop rotation, planting cover crops and terracing, is also suggested.

In addition, it is essential to promote proper waste management and protect areas of natural vegetation, such as forests and wetlands, which act as natural filters and help maintain soil quality.

The Benguela-Angola region has great potential for improving soil quality and achieving sustainable production. The implementation of the above solution proposals, together with the collaboration of farmers, industries, local governments and communities, can make a significant difference.

Education and environmental awareness also play a key role in this process. It is important to train farmers and the community in general on proper soil management practices and the benefits of soil conservation to achieve sustainable production and optimize productivity.

Urgent measures are needed to improve soil quality in Benguela-Angola. The implementation of sustainable agricultural practices, proper waste management, protection of natural vegetation areas and community awareness are key to achieving sustainable production and optimizing productivity through good soil management in the region.

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